

Identification, Assessment and Management of Soilborne Plant Pathogens in Vegetable Production Systems



Biology and Ecology of Soilborne Organisms

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Project LNE10-296



What is soil?

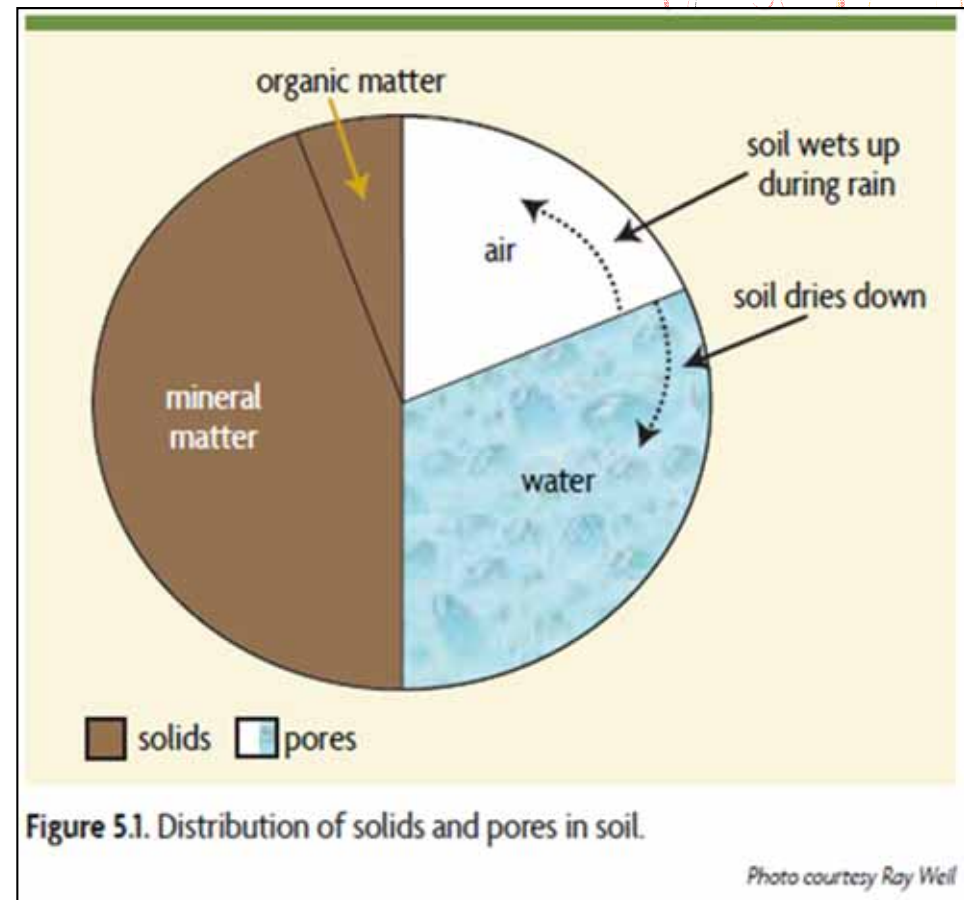
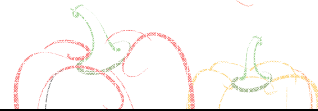
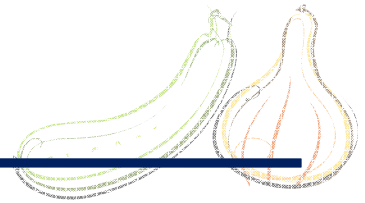
➔ Four basic components:

Mineral solids - stone fragments, sand, silt, & clay

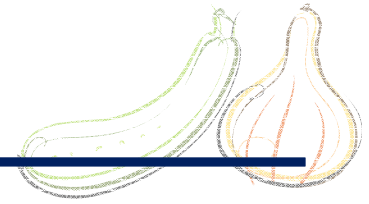
Water – essential for soil life

Air – provides oxygen
critical for aerobic
organisms

Organic matter – any
material that is part of or
originated from living
organisms



Functions of agricultural soils



- ➔ Anchorage of plant roots
- ➔ Infiltration and storage of water
- ➔ Retain and cycle nutrients
- ➔ Detoxification of harmful chemicals
- ➔ Pest and weed suppression
- ➔ Sequestration of carbon



Think of an ecosystem teeming with life...



What comes to mind?

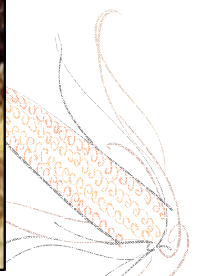
Rainforest?



Coral reef?



Savannah?



Another ecosystem teeming with life...



Diversity of soil organisms

- ➔ Soil organisms can be grouped on the basis of:
- ✓ **Size**: How big they are



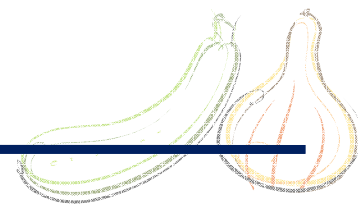
Macro or large
(>2 mm)

Meso or mid-size
(2–0.2 mm)

Micro or small
(<0.2mm)



Diversity of soil organisms



➔ Soil organisms can be grouped on the basis of:

✓ **Species and function**

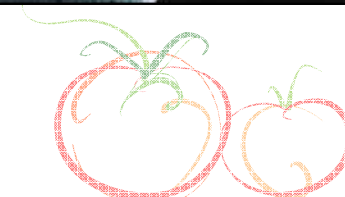
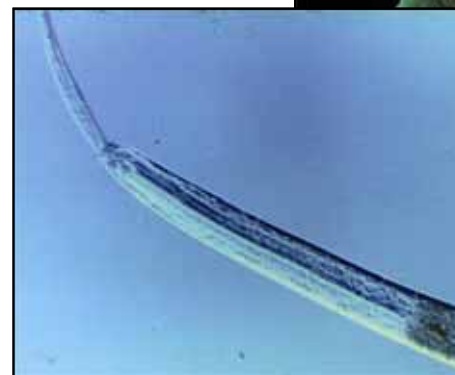
Vertebrates: gophers, mice, voles, snakes

Arthropods: spiders, ants, beetles, maggots

Annelids: earthworms

Mollusks: snails, slugs

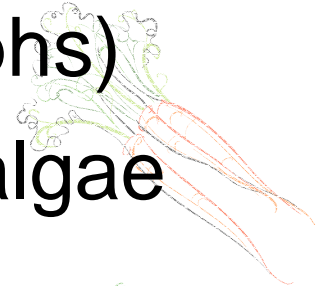
Nematodes



Species and function con't

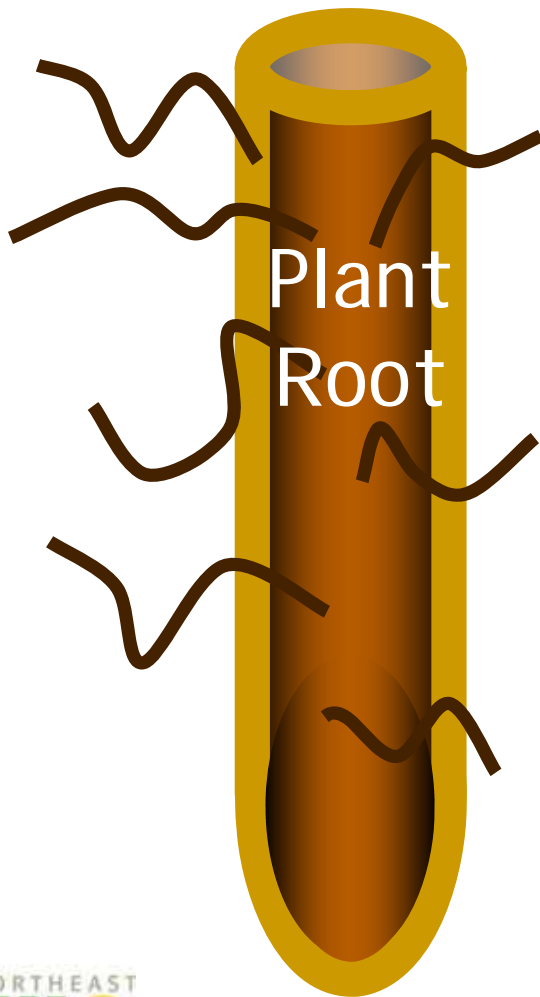
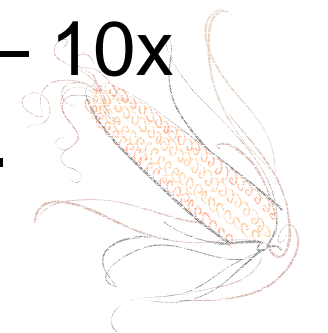


- ✓ **Plants:** the primary producers (autotrophs)
....includes plant roots and algae



The Rhizosphere

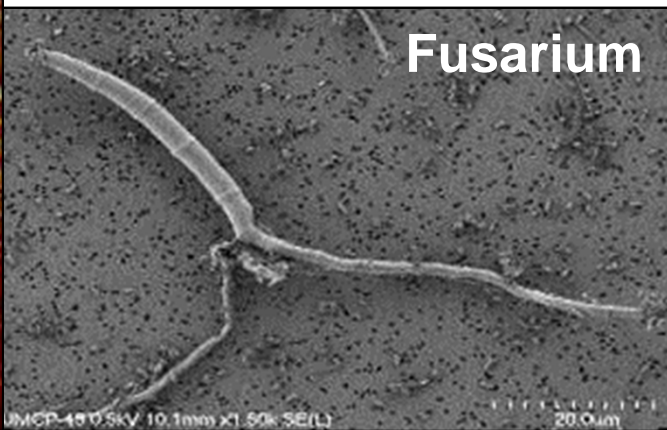
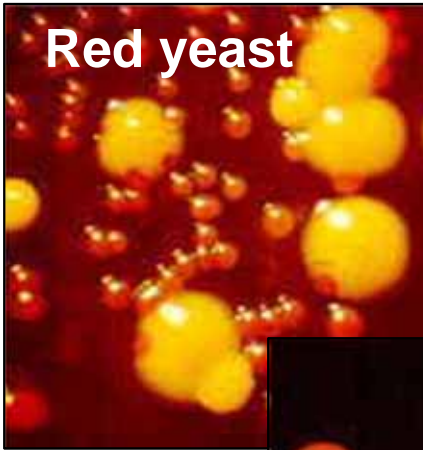
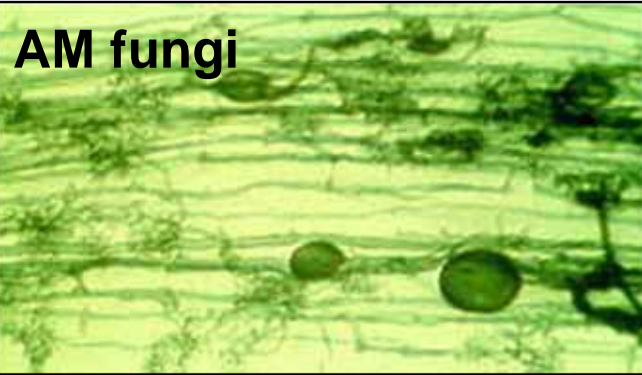
- ✓ The zone of soil that is significantly influenced by living roots
- ✓ Enriched in organic material due to root exudates and sloughed off root cells.
- ✓ Microbial activity may be 2 – 10x greater than in the bulk soil.



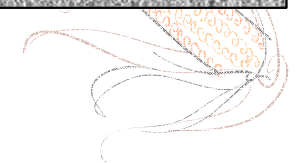
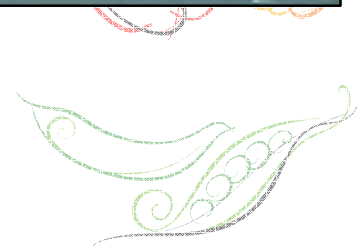
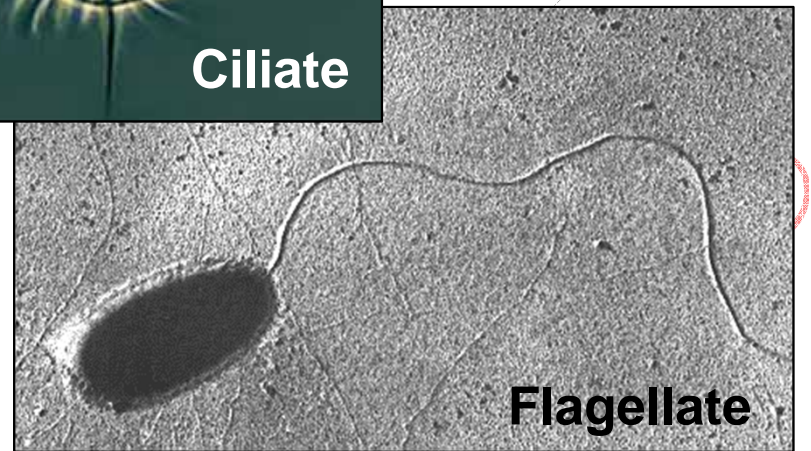
Species and function



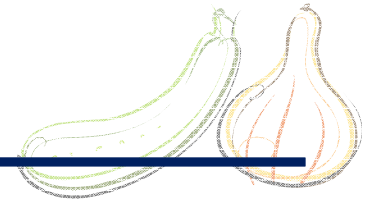
Fungi



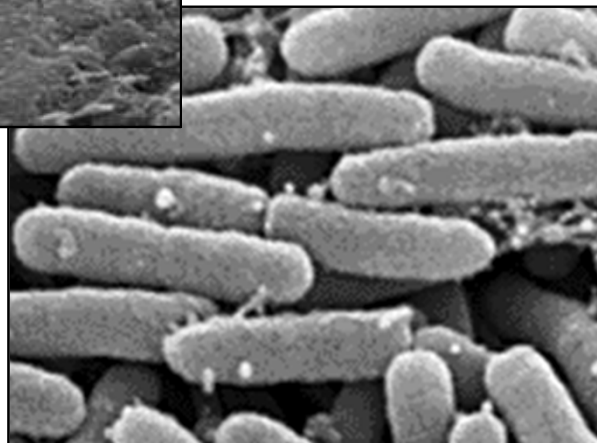
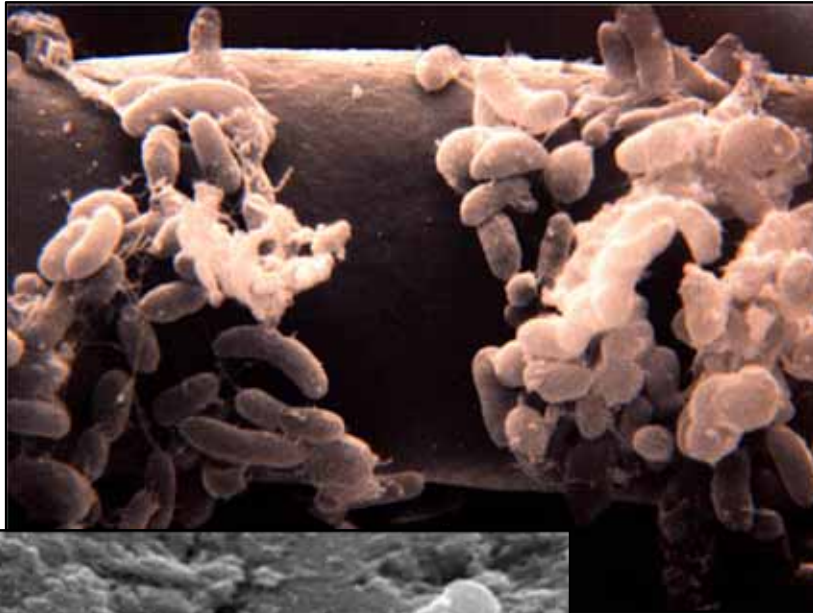
Protists



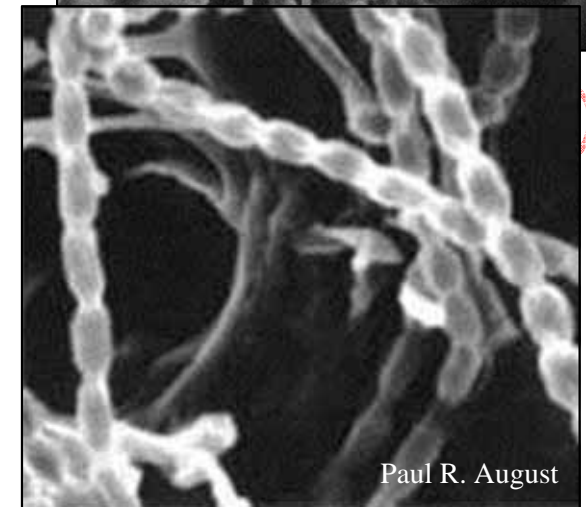
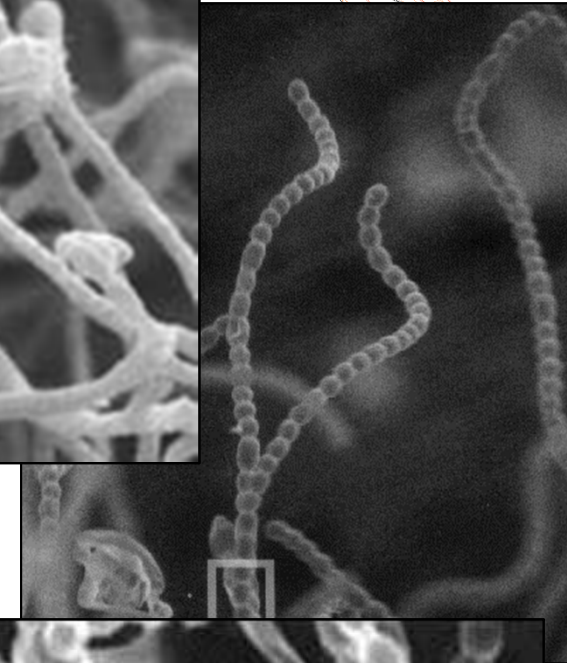
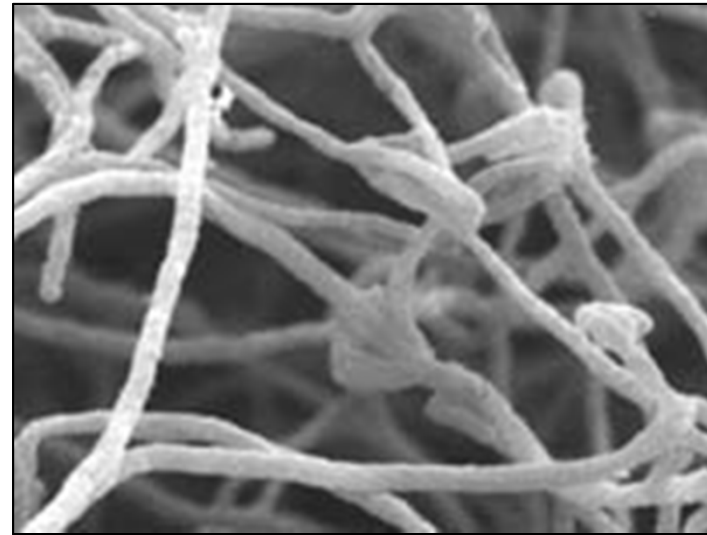
Species and function



Bacteria



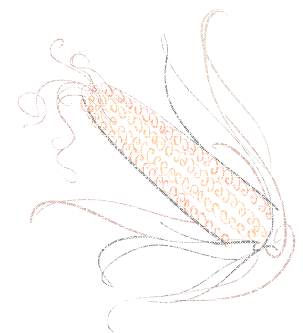
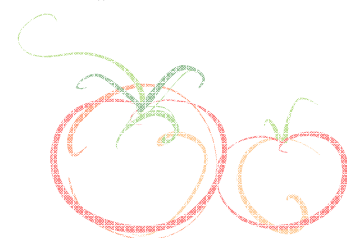
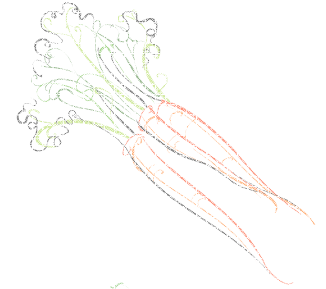
Actinomycetes



Paul R. August

How much diversity in an acre of farm soil?

Vertebrate	Several species
Earthworms	Several species
Mites	20 – 30 species
Insects	50 – 100 species
Nematodes	Dozens of species
Fungi	Hundreds of species
Bacteria	Thousands of species



Benefits of Diversity



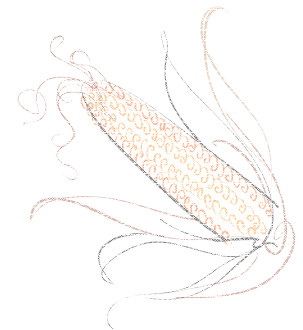
➔ Ecosystem Stability

Soil has several ways to accomplish the same function (system redundancy)



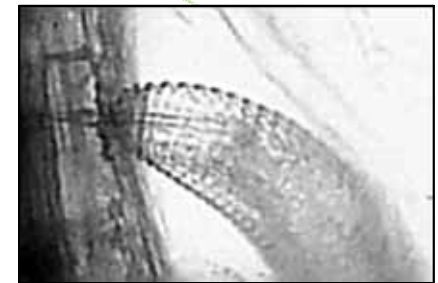
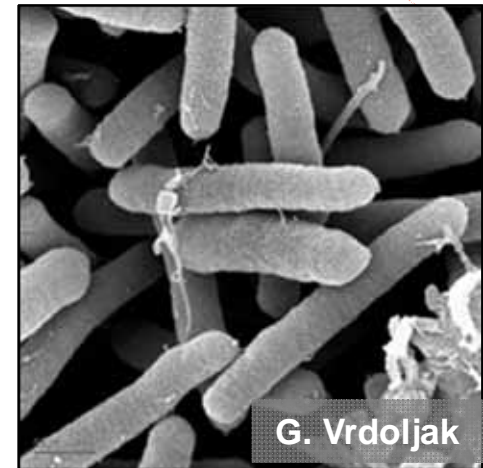
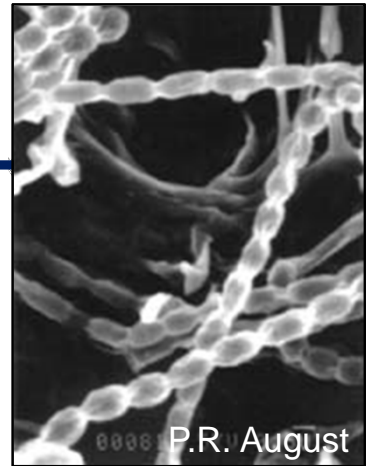
➔ Ecosystem Resilience

Soil has the ability to bounce back from a severe disturbance



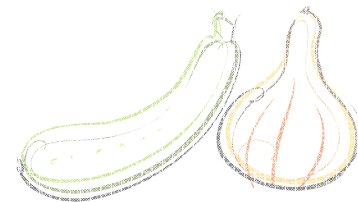
Functions of Soil Organisms

- ✓ **Decomposition of organic matter**
- ✓ Mineralization and recycling of nutrients
- ✓ Fixation of nitrogen
- ✓ Detoxification of pollutants
- ✓ Maintenance of soil structure
- ✓ Biological suppression of plant pests
- ✓ Parasitism and damage to plants



Healthy soils have a large highly diverse population of beneficial organisms but only small population of active plant pests.

Different stages of organic matter decomposition



Living



Dead



Very Dead



Simple sugars,
starches,
proteins



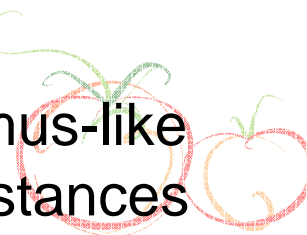
Cellulose,
lignin



Waxes and
phenols



Humus-like
substances

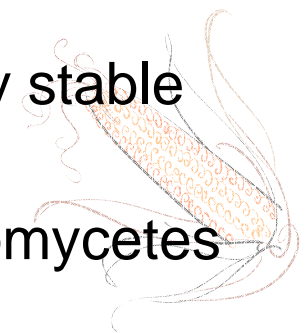


Quickly – fuels
microbes

Several years

Up to 10 years

Very stable



Bacteria



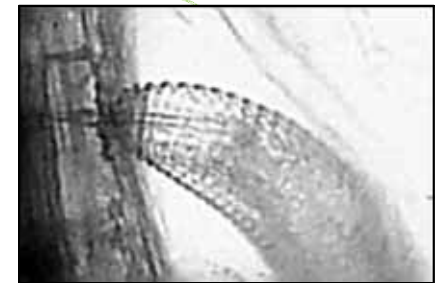
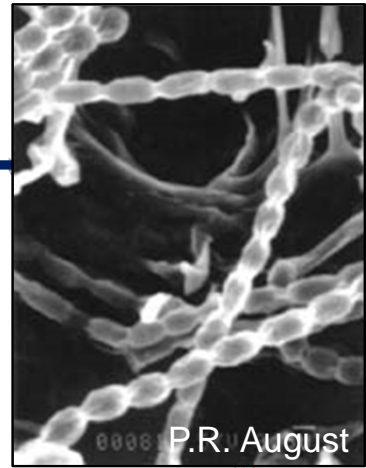
Fungi



Actinomycetes

Functions of Soil Organisms

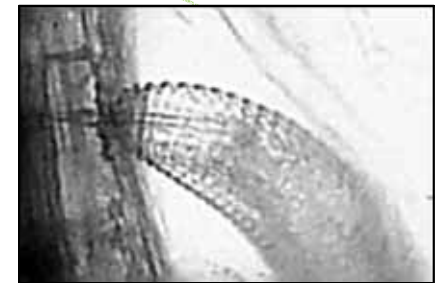
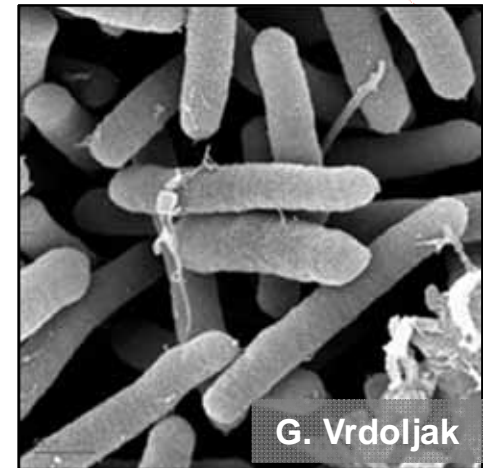
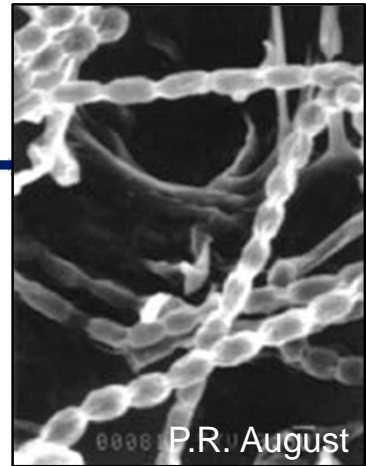
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Ray Weil, Univ. MD

**25 yrs of
conventional corn**

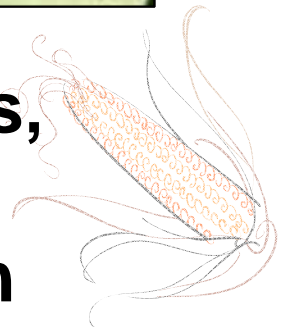
**20 yrs of bluegrass,
then 5 yrs
conventional corn**





**25 yrs of
conventional corn**

**20 yrs of bluegrass,
then 5 yrs
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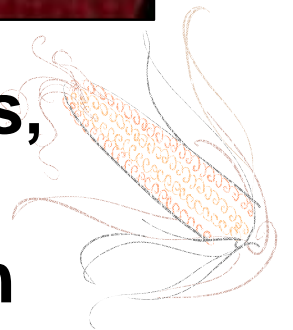


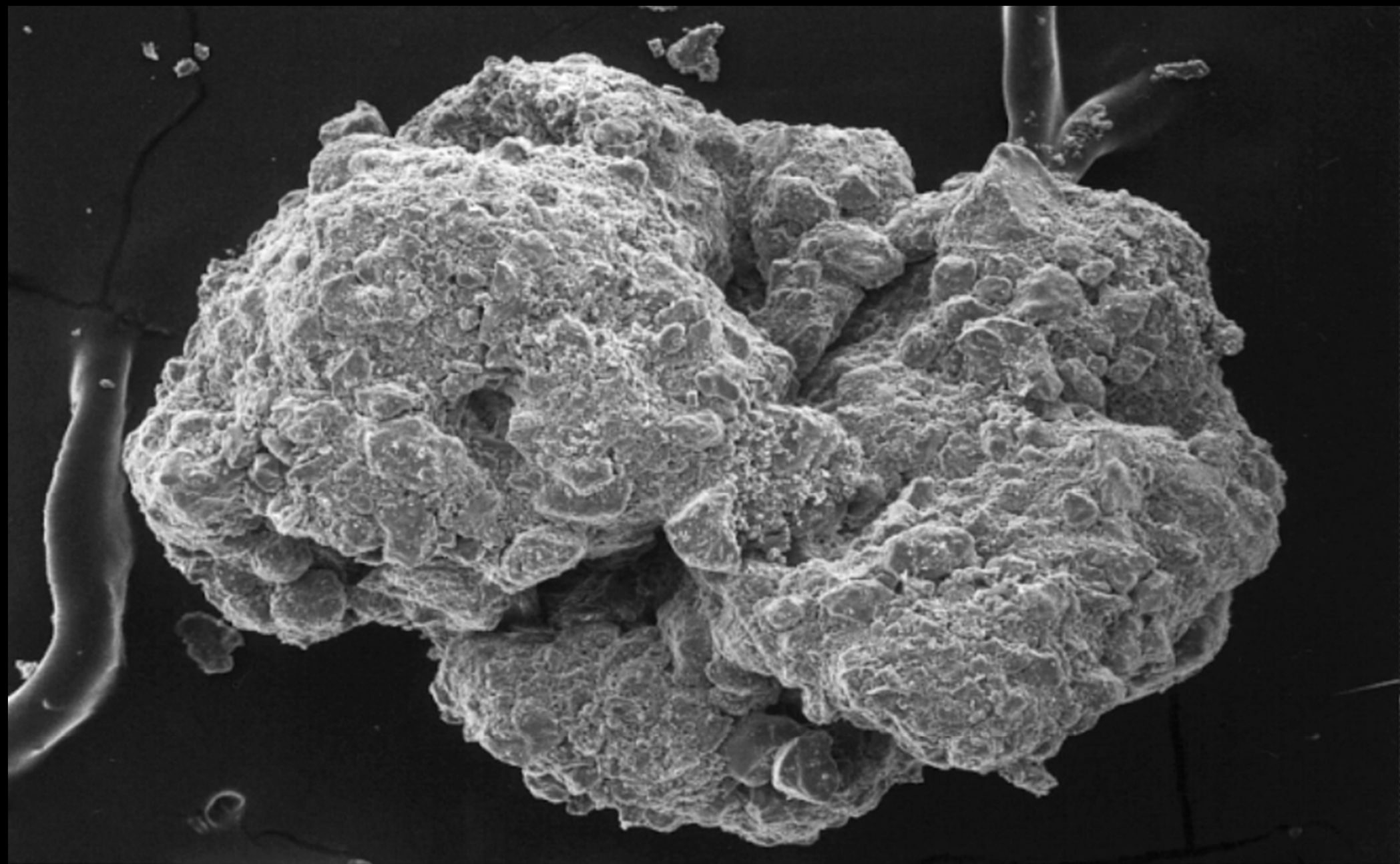


Ray Weil, Univ. MD

**25 yrs of
conventional corn**

**20 yrs of bluegrass,
then 5 yrs
conventional corn**





200µM

20KV

23

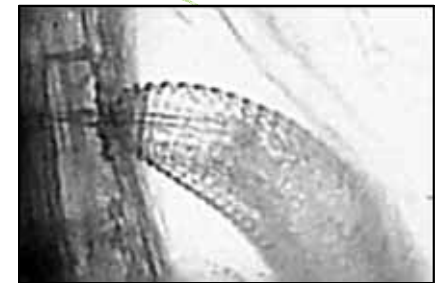
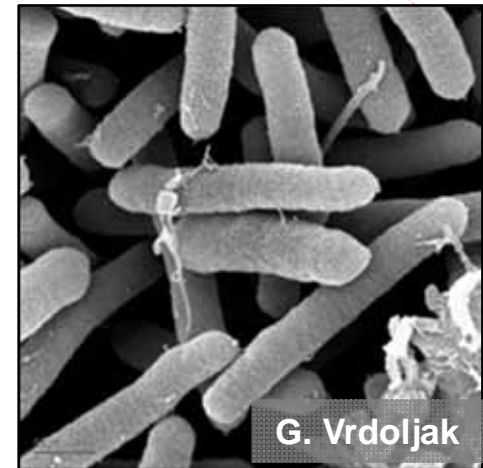
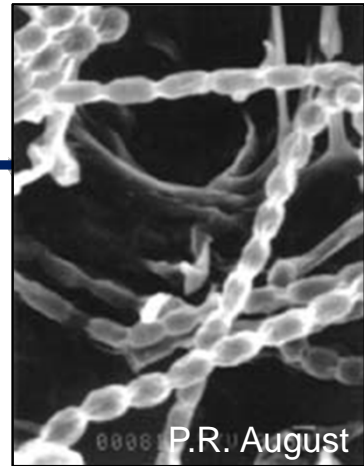
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Scanning electron micrograph by V.V.S.R. Gupta

Functions of Soil Organisms

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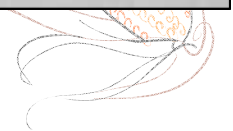
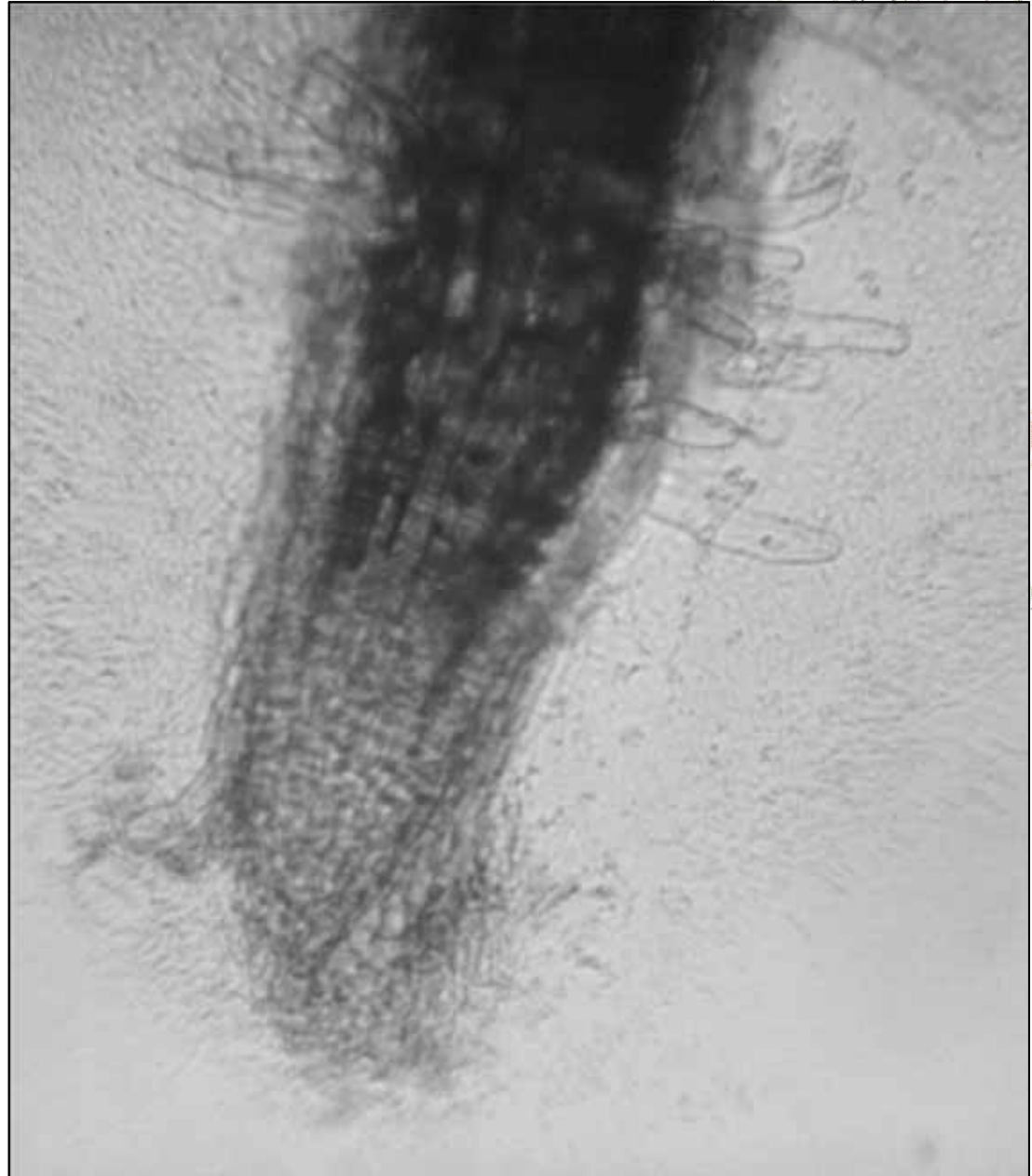
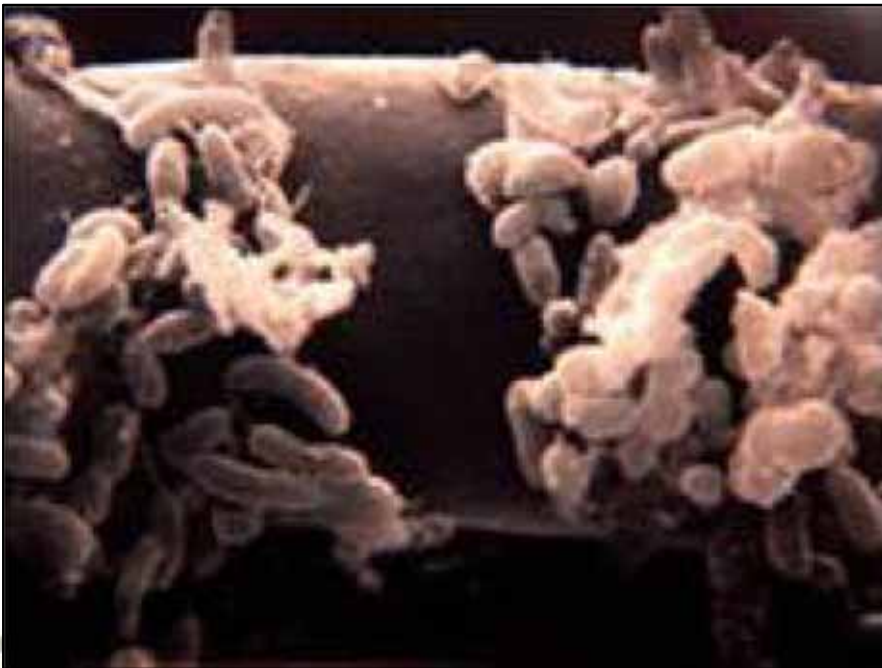


Healthy soils have a large highly diverse population of beneficial organisms but only small population of active plant pests.

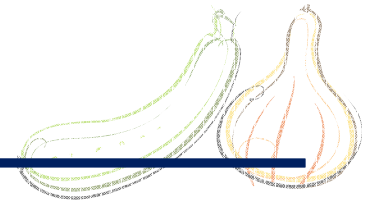
The Rhizosphere

“rhizo” = root

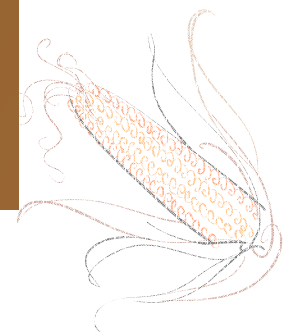
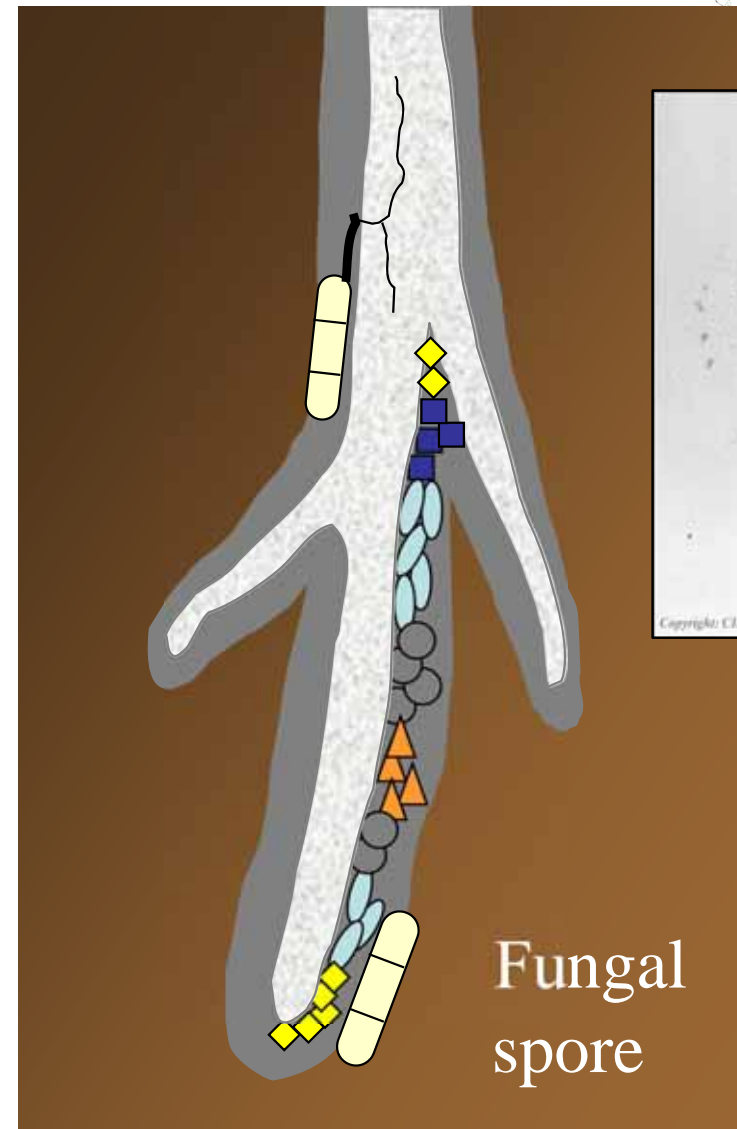
“sphere” = zone



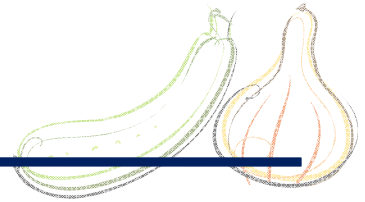
Plant pathogen suppression



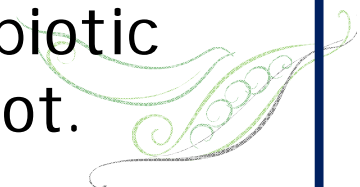
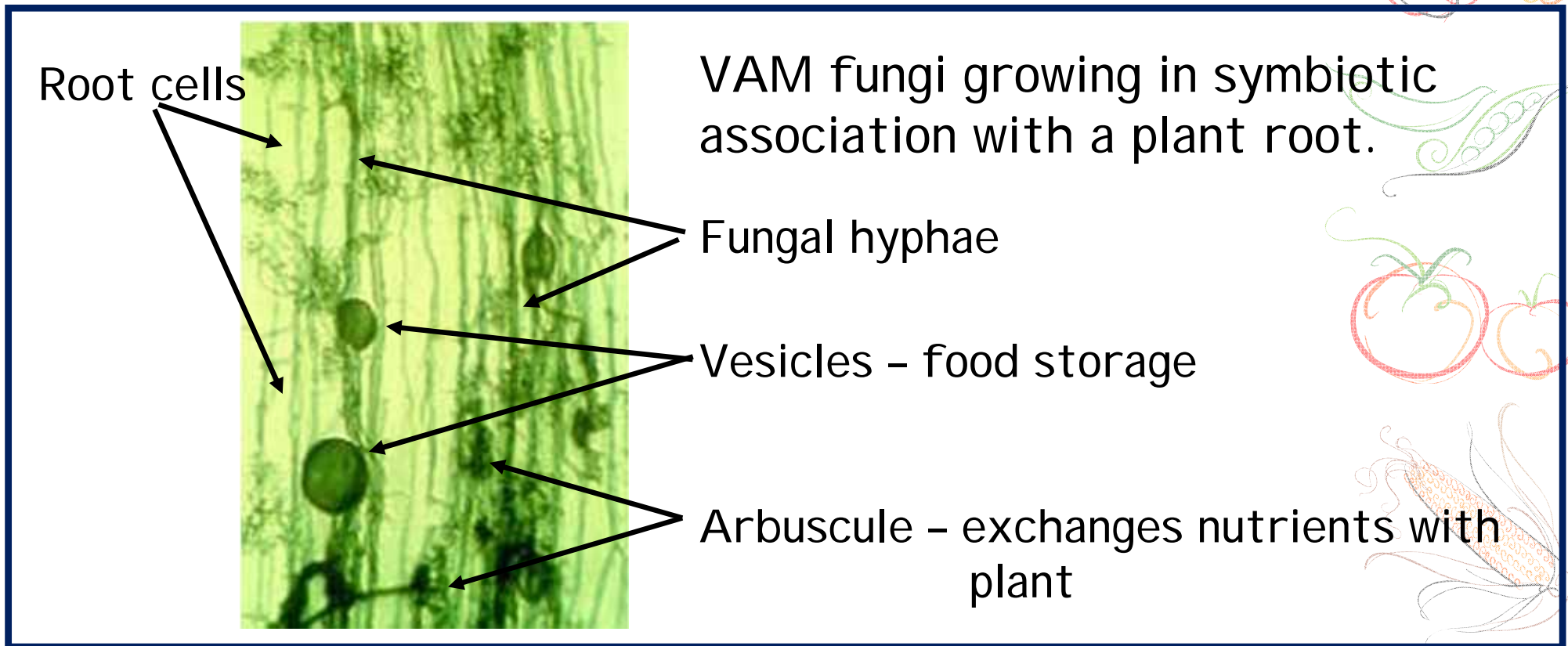
1. Competition
2. Antibiosis
3. Hyperparasitism
4. Induced SAR



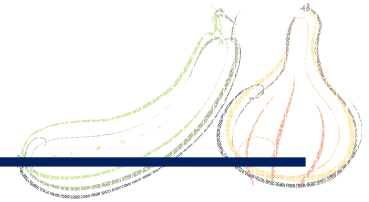
Mycorrhizae (“fungus root”)



- ✓ Fungi develop a symbiotic assoc. with plant roots
- ✓ Plant receives improved access to water & some nutrients esp. phosphorus
- ✓ Fungus received energy and nutrients from plants



Mycorrhizae benefit soil structure



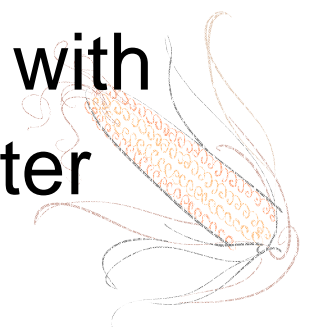
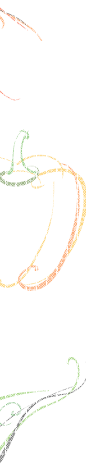
Mycorrhizae present

- Soil structure is stabilized
- Structure is maintained with immersed in water



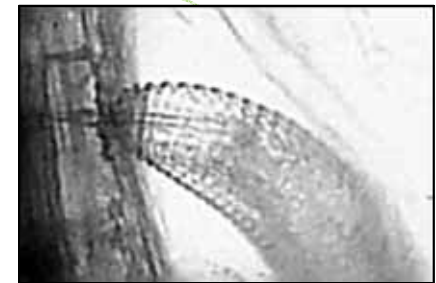
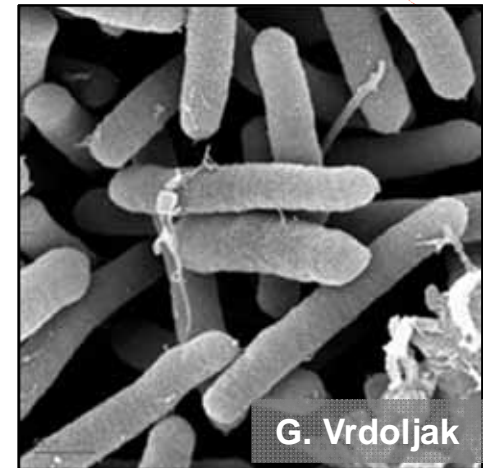
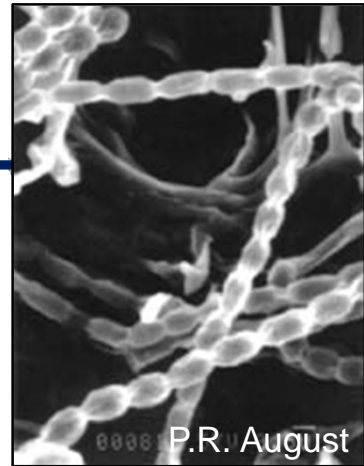
Mycorrhizae absent

- Soil structure is poor
- Structure is lost with immersed in water



Functions of Soil Organisms

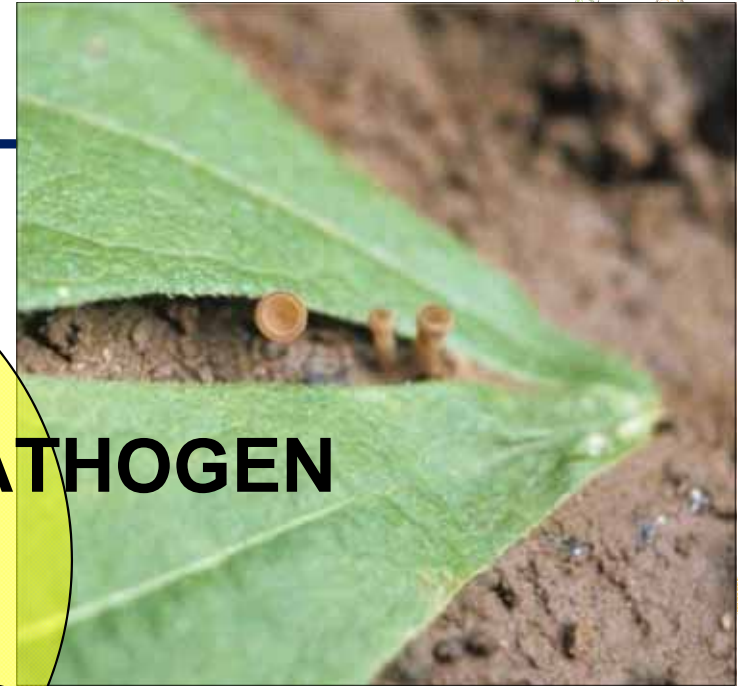
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The Disease Triangle

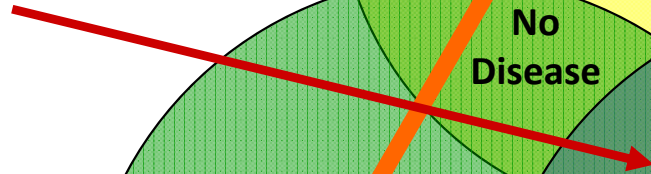
THE FOUNDATION OF
DISEASE MANAGEMENT



PATHOGEN

No
Disease

Disease



No
Disease

No
Disease



No
Disease

No
Disease

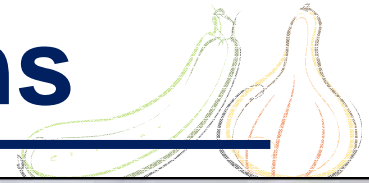
No
Disease

SUSCEPTIBLE HOST

ENVIRONMENT



Plant disease symptoms vs signs



➔ **Symptoms** – plant reactions or alternations of a plant's appearance due to a disease or disorder



➔ **Signs** – actual pathogen, parts or by-products seen on a diseased host plant



01/11

Where do the pathogens come from?



➔ Some come in on infected transplants and infested seed or other planting material

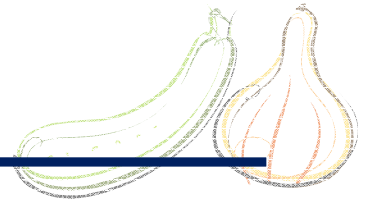
➔ Infested soil brought in on equipment, tools, storage containers, and people

➔ Contaminated irrigation water

e.g. *Phytophthora capsici*



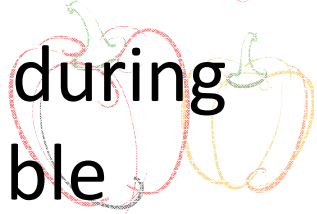
How do plant diseases spread?



➔ **Primary inoculum** is the source causing the 1st infection of growing season which usually overwinters in the field



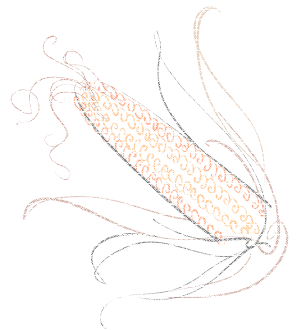
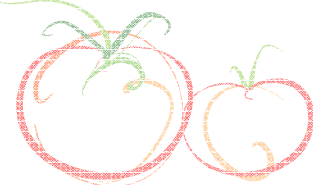
➔ **Secondary inoculum** (i.e. spores) are produced during the growing season when conditions are favorable (polycyclic = multiple generations)



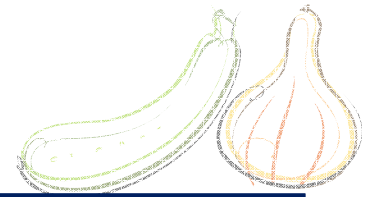
➔ **Wind, rain and soil splashing, insect vectors** are all factors which lead to the spread of disease



➔ **Mechanical transfer** through infested tools/equipment, people, etc...



How do the pathogens survive?



➔ Fungi survive as saprobes in last years infected **host plant or other organic debris** (invaders)



➔ **Free-living organisms** directly in the soil (inhabitators)



➔ Produce **resistant structures** on the host crop that are released during tillage and decomposition



Sclerotia in a tomato stem

Host range and pathogen survival

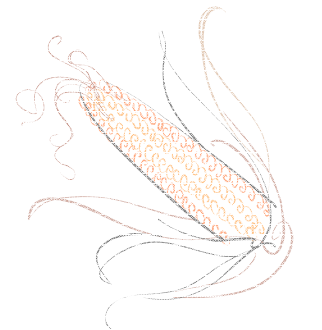
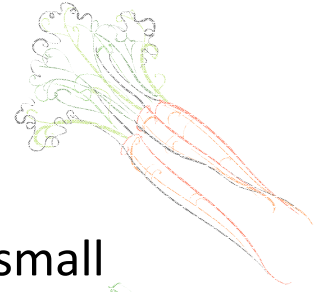
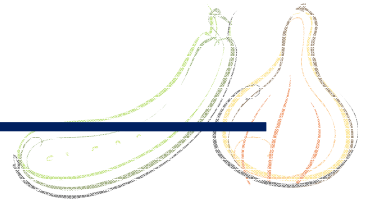
➔ All pathogens have a **host range**...

that can be either **very large** or very small

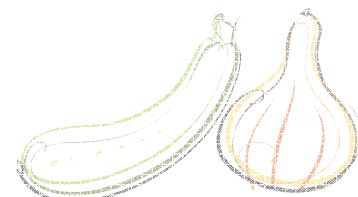
Examples:

Sclerotinia sclerotiorum (white mold) has a host range of more than 405 plant species

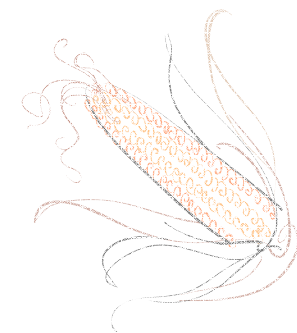
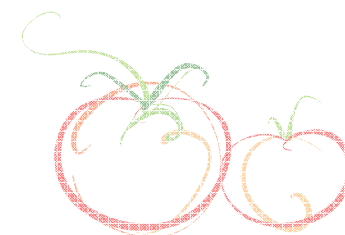
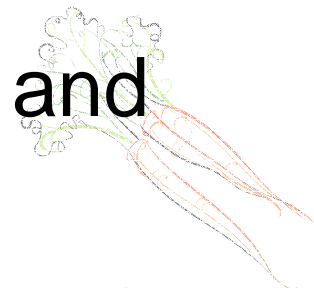
Fusarium solani f. sp. *cucurbitae* will only infect cucurbit crops



Pathogen distribution in the soil



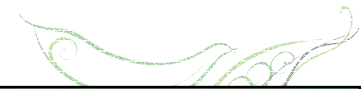
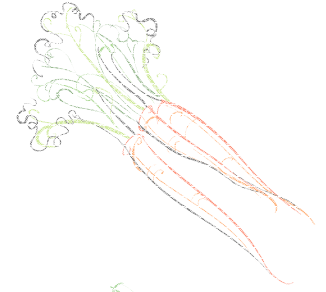
- ➔ Highly dependent on production practices and cropping history
- ➔ Horizontally, distribution is typically **aggregated**
- ➔ Vertically, inoculum typically resides in the **root zone** of the soil profile



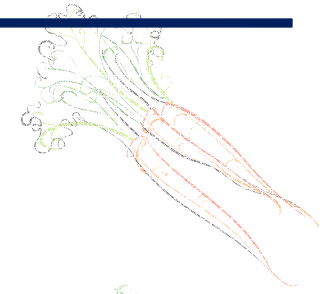
Factors that influence pathogen infection



- ➔ Soil moisture and temperature
- ➔ Soil pH
- ➔ Soil nutrient levels
- ➔ Soil type, texture, and quality



Effects of soil management practices on soil organisms including pathogens



Forest



Grassland



Crop Monoculture

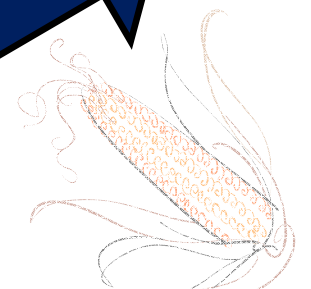


Crop rotation



Diversity decreases

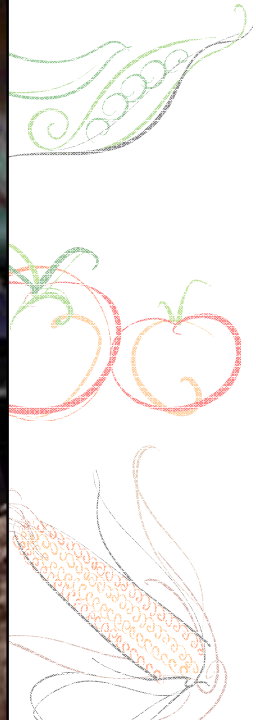
Diversity increases



Effects of soil management practices on soil organisms



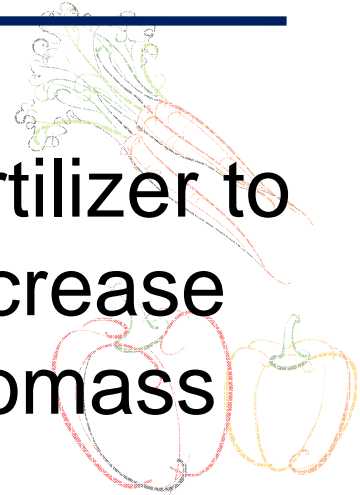
Increased intensity of tillage tends to decrease microbial diversity and microbial biomass



Effects of soil management practices on soil organisms



Application of lime or fertilizer to infertile soils tends to increase microbial activity and biomass



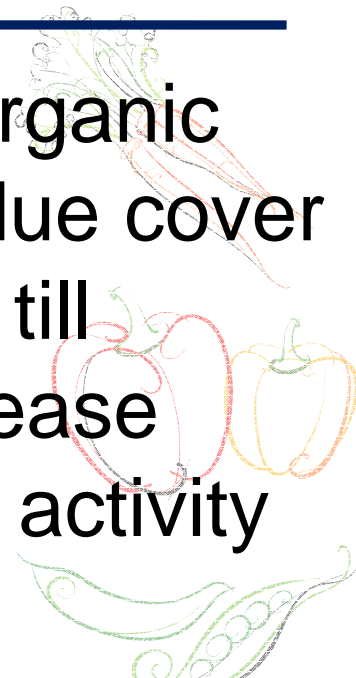
Addition of organic materials such as manure tends to increase microbial biomass and activity



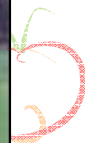
Effects of soil management practices on soil organisms



Maintaining high soil organic matter levels and residue cover on the soil surface (no till systems) tends to increase microbial diversity and activity

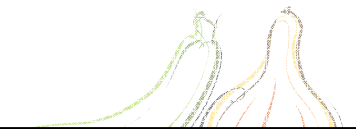


Pesticide applications have variable effects on microbial populations



The black box is open!

- ✓ A healthy soil ecosystem is extremely diverse and complex
- ✓ A diverse soil ecosystem is stable and resilient
- ✓ Soil organisms have developed many complex interdependencies that benefit agricultural soil functions.
- ✓ Soil management activities can significantly affect the life in your soil.





Questions on the biology and ecology of soilborne organisms?

Beth K. Gugino

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