

Soil Microbes

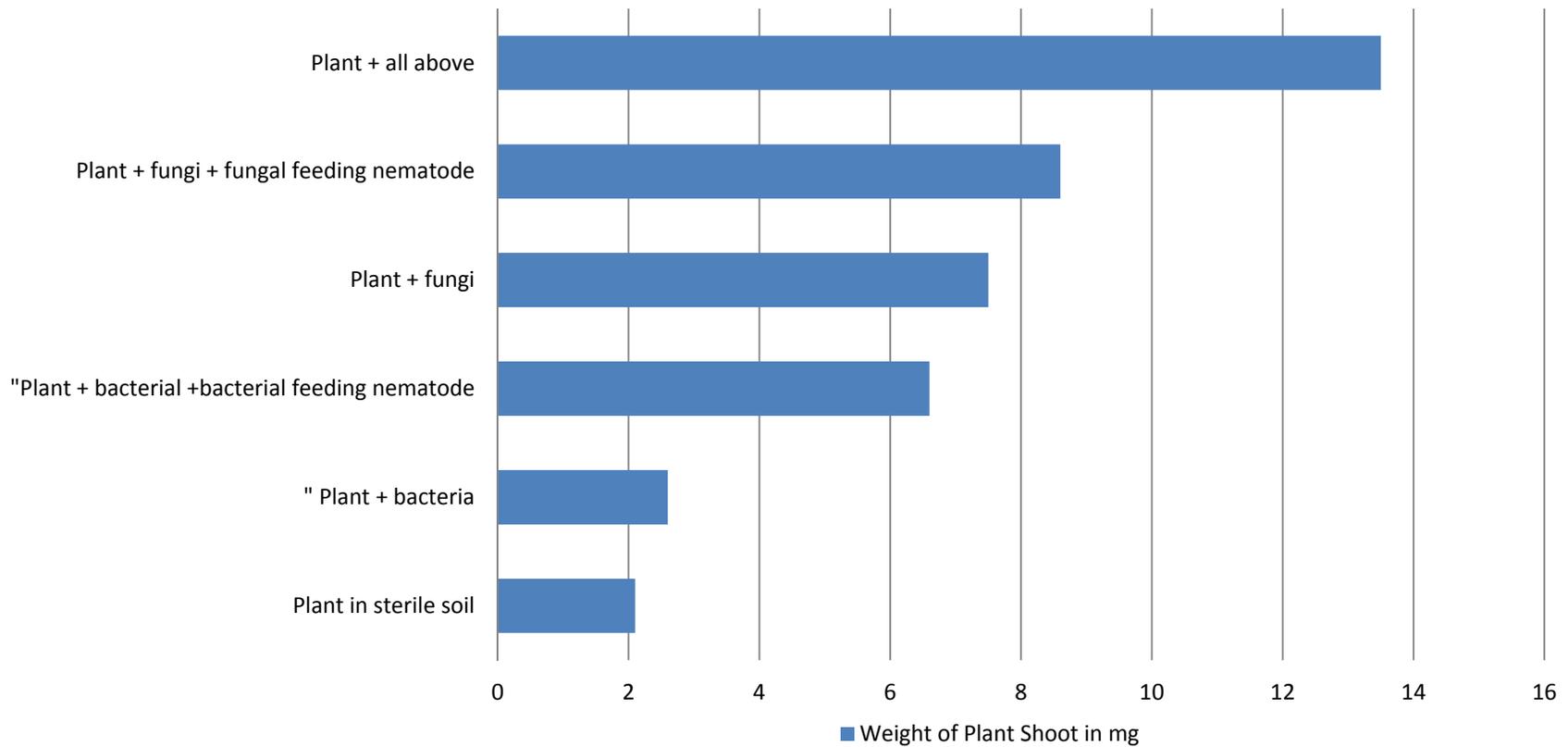
Judith Fitzpatrick, Ph.D.

The Superorganism



This chart taken from data of
Ingham, R.E. et al 1985 www.jstor.org/stable/1942528

Effect of microbes on weight of plant shoot in mg.



What Are Microbes Doing For Plants?

- Providing nutrition
 - Mycorrhiza – absorb water and nutrients
 - Nitrogen fixation and siderophores– rhizobacteria
 - Decomposition of dead material into plant usable
 - Store nutrients in their cells
- Preventing pathogens
 - Bacteriocins and antibiotics
 - Competition
- Molding the architecture of the soil
 - Aeration
 - Aggregates that enhance water retention

[Mycorrhizae](#) on root tips (Amanita)
Wikipedia



Nodules formed where Rhizobium bacteria infected soybean roots.

Credit: Stephen Temple, New Mexico State University. Please contact the Soil and Water Conservation Society at pubs@swcs.org for assistance with copyrighted (credited) images.



What does the plant do to encourage the microbiota?

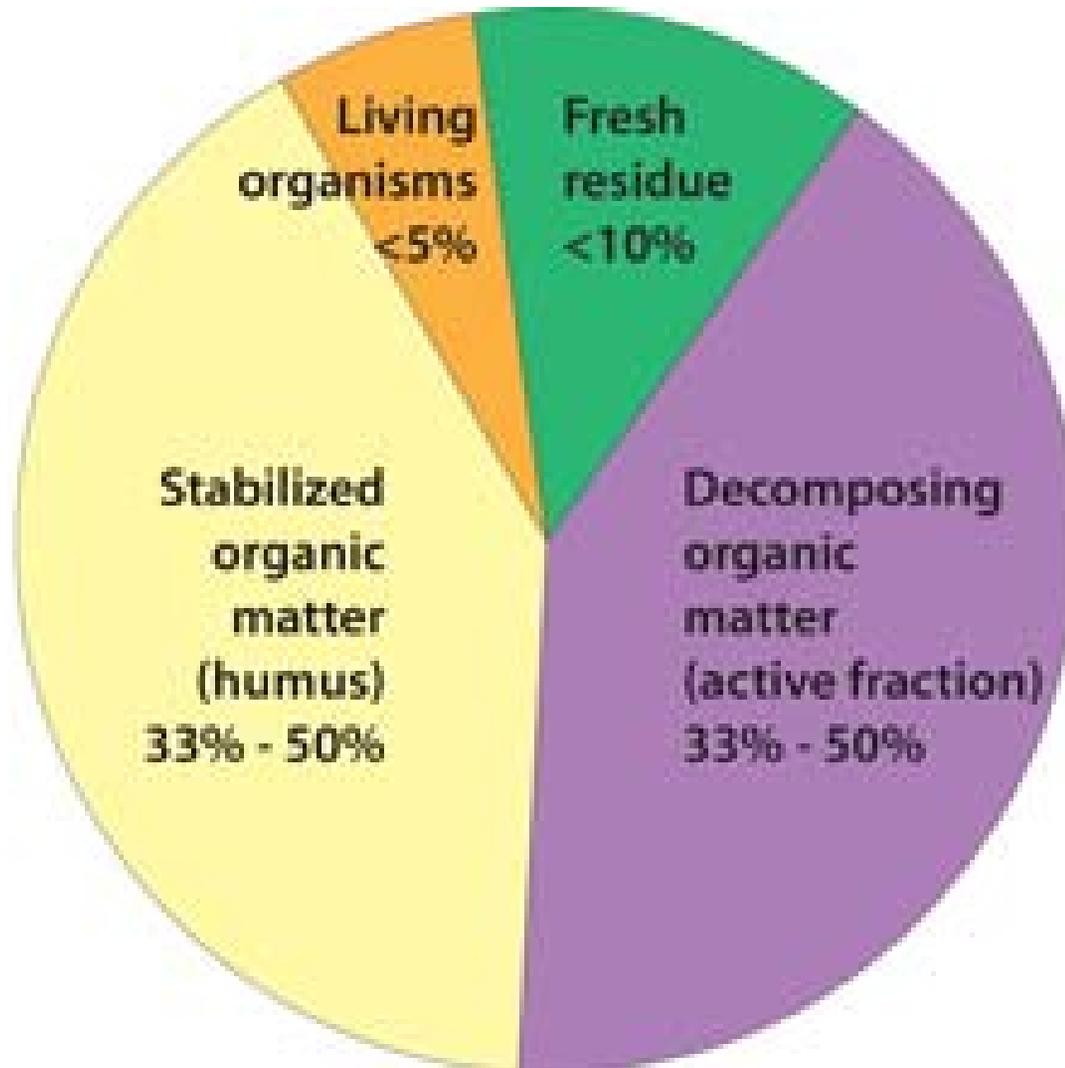
- Secretes small molecules such as sugars and amino acids, peptides
 - Far more life in the rhizosphere than away from it.
 - A large part of the plants energy stores are secreted into the soil.
- Protection: allows some bacteria to live in plant cells.

Bacteria colonized on Root hair.

The plant secretes small molecules to feed the bacteria it requires.

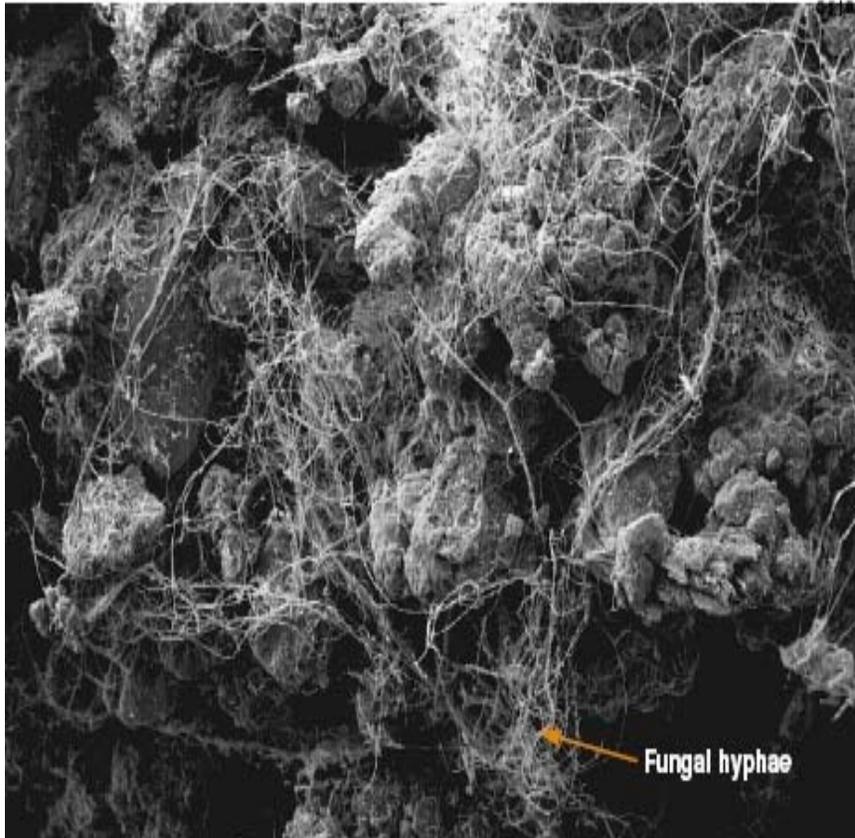


Food sources of Soil Microbes



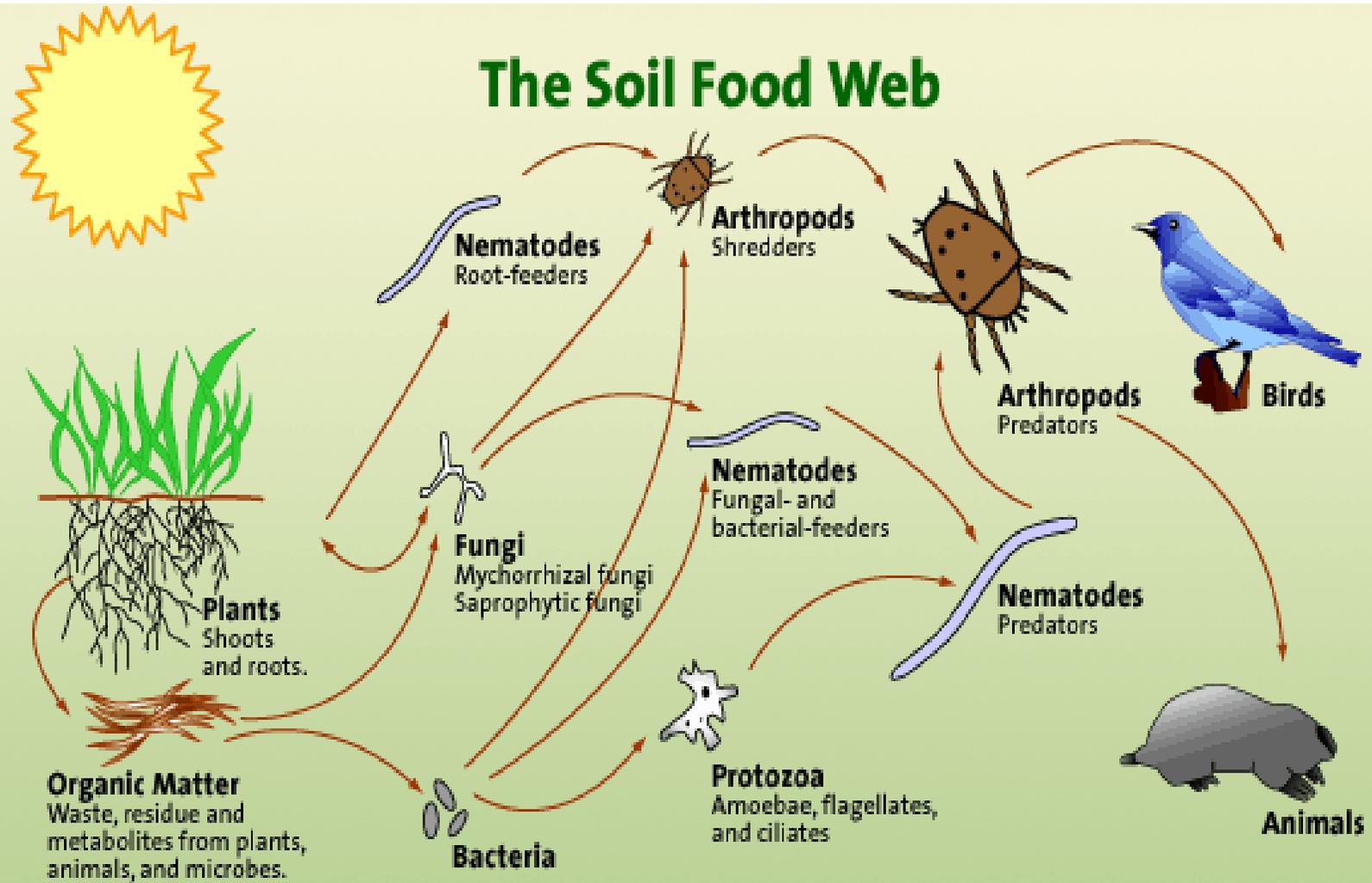
Soil Aggregates

<http://www.extension.umn.edu/distribution/cropsystems/M1272.html>



- **Improved structure, infiltration, and water-holding capacity.** Many soil organisms are involved in the formation and stability of soil aggregates..... Fungal hyphae and root hairs bind together and help stabilize larger aggregates. Improved aggregate stability, along with the burrows of earthworms and arthropods, increases porosity, water infiltration, and water-holding capacity.

The Soil Food Web



First trophic level:
Photosynthesizers

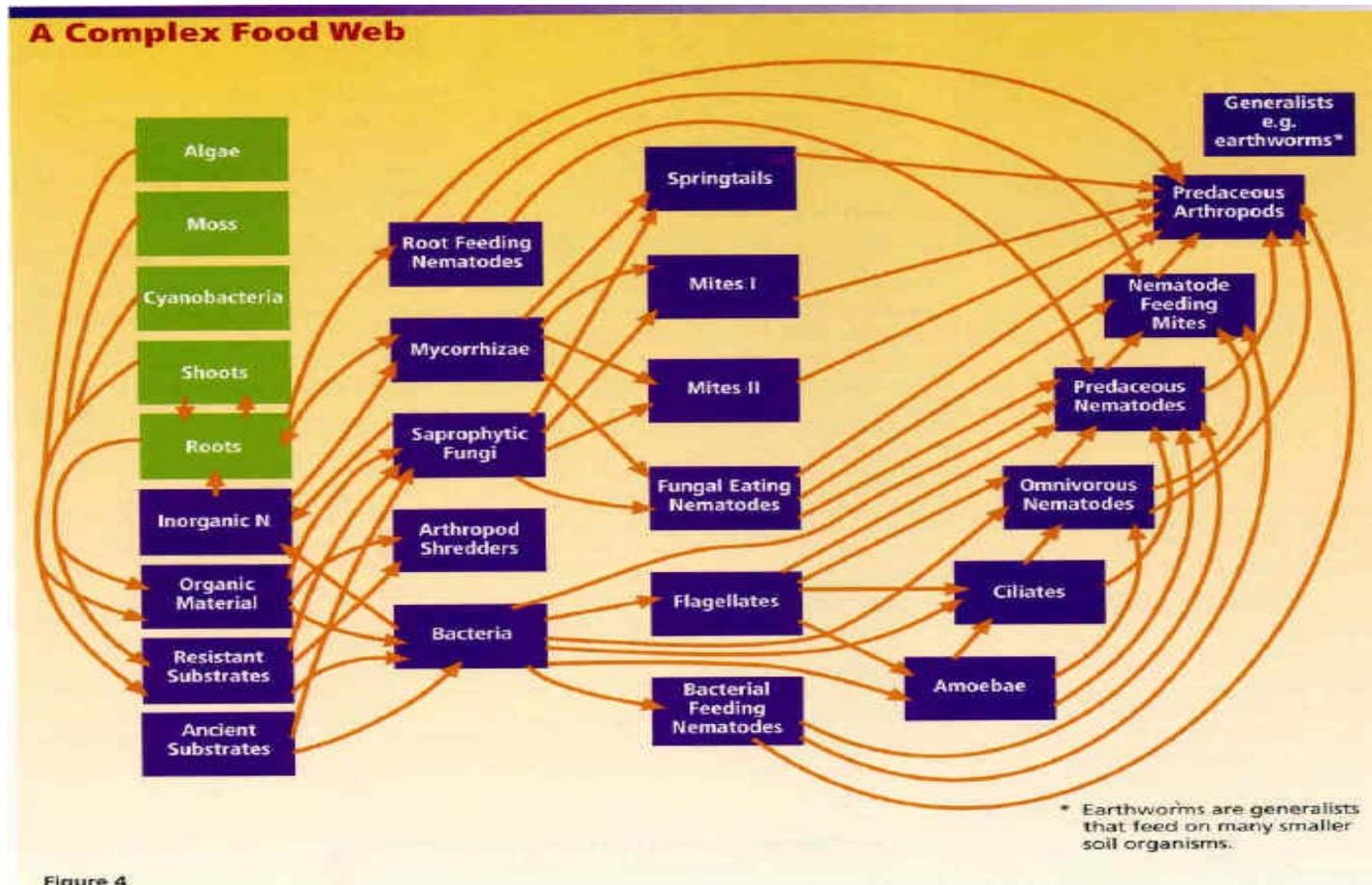
Second trophic level:
Decomposing Mutualists
Pathogens, Parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level predators

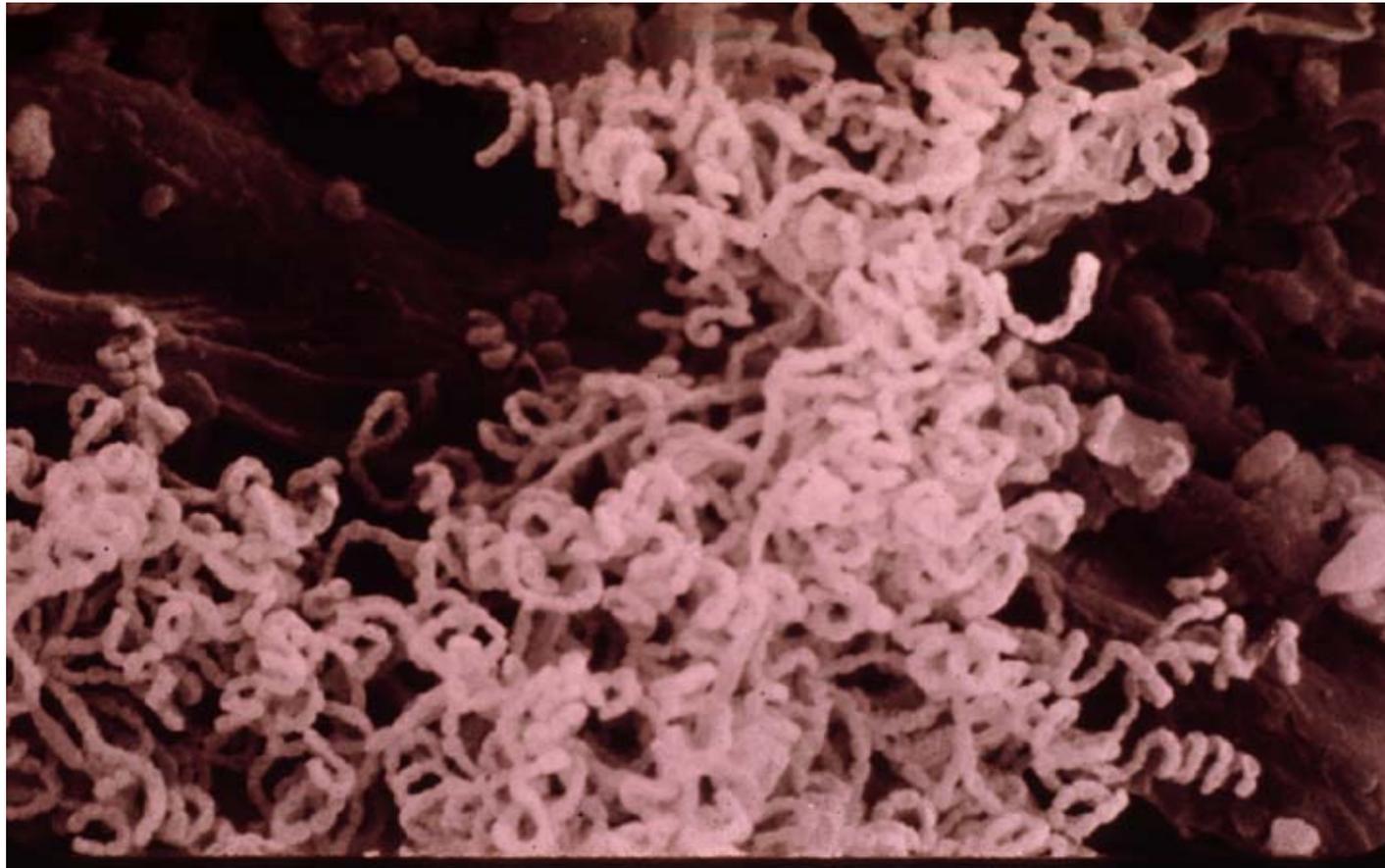
Fifth & higher trophic level:
Higher level predators

Soil life, soil biota, or edaphon



Actinomycetes, such as this *Streptomyces*, give soil its "earthy" smell.

Credit: No. 14 from Soil Microbiology and Biochemistry Slide Set. 1976. J.P. Martin, et al., eds. SSSA, Madison, WI. Please contact the Soil and Water Conservation Society at pubs@swcs.org for assistance with copyrighted



Plant Growth Enhancing by Bacteria

- *By Ann Kennedy, USDA Agricultural Research Service, Pullman, WA*
- Certain strains of the soil bacteria *Pseudomonas fluorescens* have **anti-fungal activity** that inhibits some plant pathogens.
- *P. fluorescens* and other *Pseudomonas* and *Xanthomonas* species **can increase plant growth** in several ways. They may produce a compound that **inhibits the growth of pathogens** or reduces invasion of the plant by a pathogen. They may also produce compounds (**growth factors**) that directly increase plant growth.
- These plant growth-enhancing bacteria occur naturally in soils, but not always in high enough numbers to have a dramatic effect. In the future, farmers may be able to inoculate seeds with anti-fungal bacteria, such as *P. fluorescens*, to ensure that the bacteria reduce pathogens around the seed and root of the crop.

Fungi

- *Decomposers* – saprophytic fungi – convert dead organic material into fungal biomass, carbon dioxide (CO₂), and small molecules, such as organic acids. These fungi generally use complex substrates, such as the cellulose and lignin, in wood, and are essential in decomposing the carbon ring structures in some pollutants. Like bacteria, fungi are important for immobilizing, or retaining, nutrients in the soil. In addition, many of the secondary metabolites of fungi are organic acids, so they help increase the accumulation of humic-acid rich organic matter that is resistant to degradation and may stay in the soil for hundreds of years.
- *Mutualists* – the mycorrhizal fungi – colonize plant roots. In exchange for carbon from the plant, mycorrhizal fungi help solubilize phosphorus and bring soil nutrients (phosphorus, nitrogen, micronutrients, and perhaps water) to the plant. One major group of mycorrhizae, the *ectomycorrhizae*, grow on the surface layers of the roots and are commonly associated with trees. The second major group of mycorrhizae are the *endomycorrhizae* that grow within the root cells and are commonly associated with grasses, row crops, vegetables, and shrubs. Arbuscular mycorrhizal (AM) fungi are a type of endomycorrhizal fungi.
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- *pathogens or parasites*, cause reduced production or death when they colonize roots and other organisms. Root-pathogenic fungi, such as *Verticillium*, *Pythium*, and *Rhizoctonia*, cause major economic losses in agriculture each year. Many fungi help control diseases. For example, nematode-trapping fungi that parasitize disease-causing nematodes, and fungi that feed on insects may be useful as biocontrol agents.

Table 2. Nutrients taken in by plants that are infected and are not infected with AM when no phosphorus is added to corn

<http://www.extension.umn.edu/distribution/cropsystems/M1272.html>

Element	No Mycorrhizae	With Mycorrhizae
	-----Micrograms/plant-----	
Phosphorus	750	1340
Potassium	6,000	9,700
Calcium	1,200	1,600
Magnesium	430	630
Zinc	28	95
Copper	7	14
Manganese	72	101
Iron	80	147

Soil Protozoa feed on bacteria

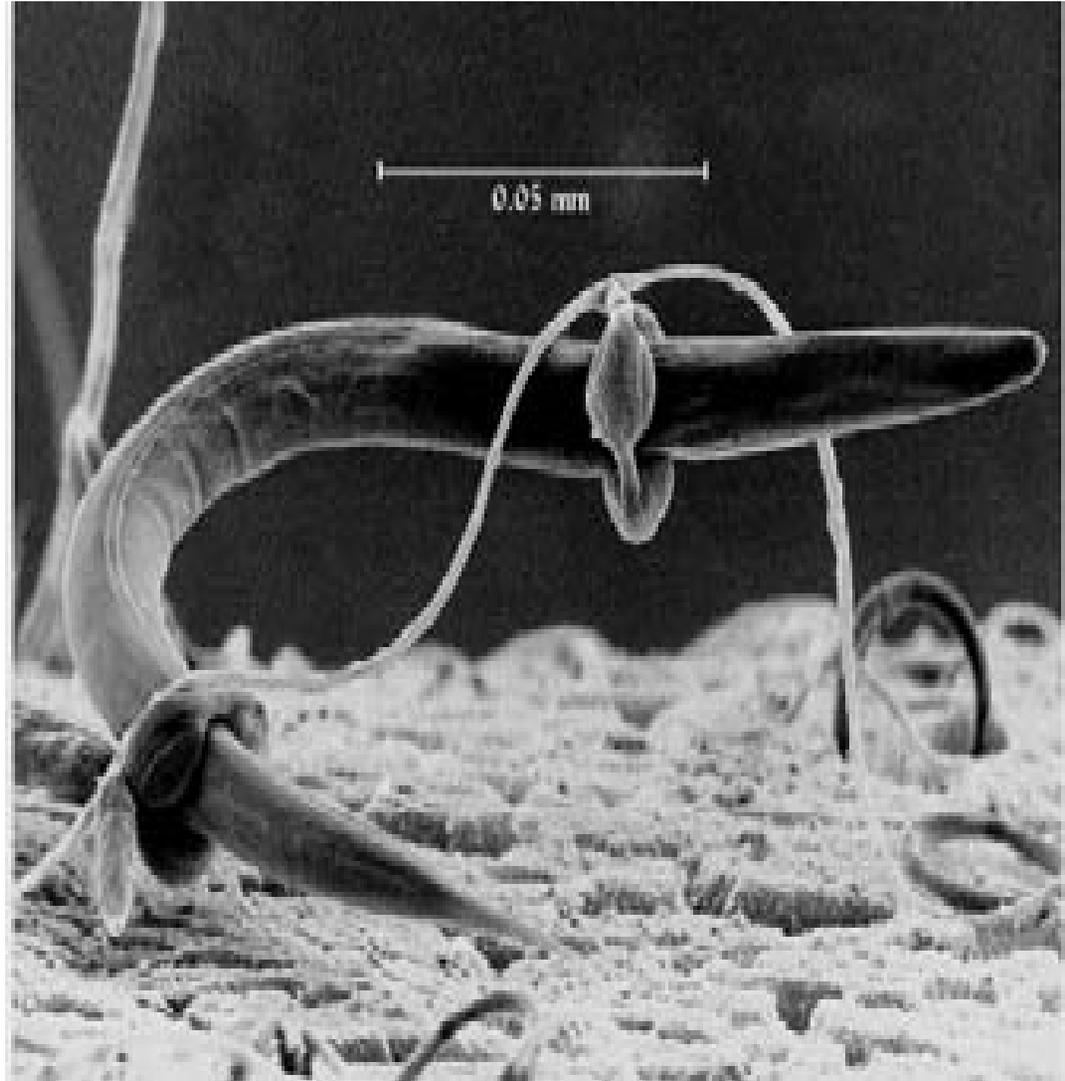
- Ciliates – paramecia eat bacteria and each other
- Amoeba – feeds on bacteria and paramecia
- Flagellates
- Release nitrogen from bacteria

Nemotodes – microscopic worms

Arthropods

- Bacterial eating nematodes
- Fungal Eating Nematodes
- Root feeding Nematodes

- Omnivores
- Pathogens



Earthworms

- Casts: earthworm creates a burrow by ingesting the soil.
 - Digests some material
 - Excretes all in form of castes that are rich in organic materials that are plant available.

What is Compost Extract/TEA

- Compost extract is what is produced when compost is mixed with water, usually at 10% compost and mixed for 5-24 hours, with or without aeration.
- Compost Tea is when added ingredients are added to the mixture, either before incubation or after.

Advantages of Compost Extract/TEA over Compost

- Applied to leaves has **pesticide activity**
- It is sprayed which is easier to apply and can be applied over course of growing season.
- It can usually be diluted.

Current Definition of good Compost

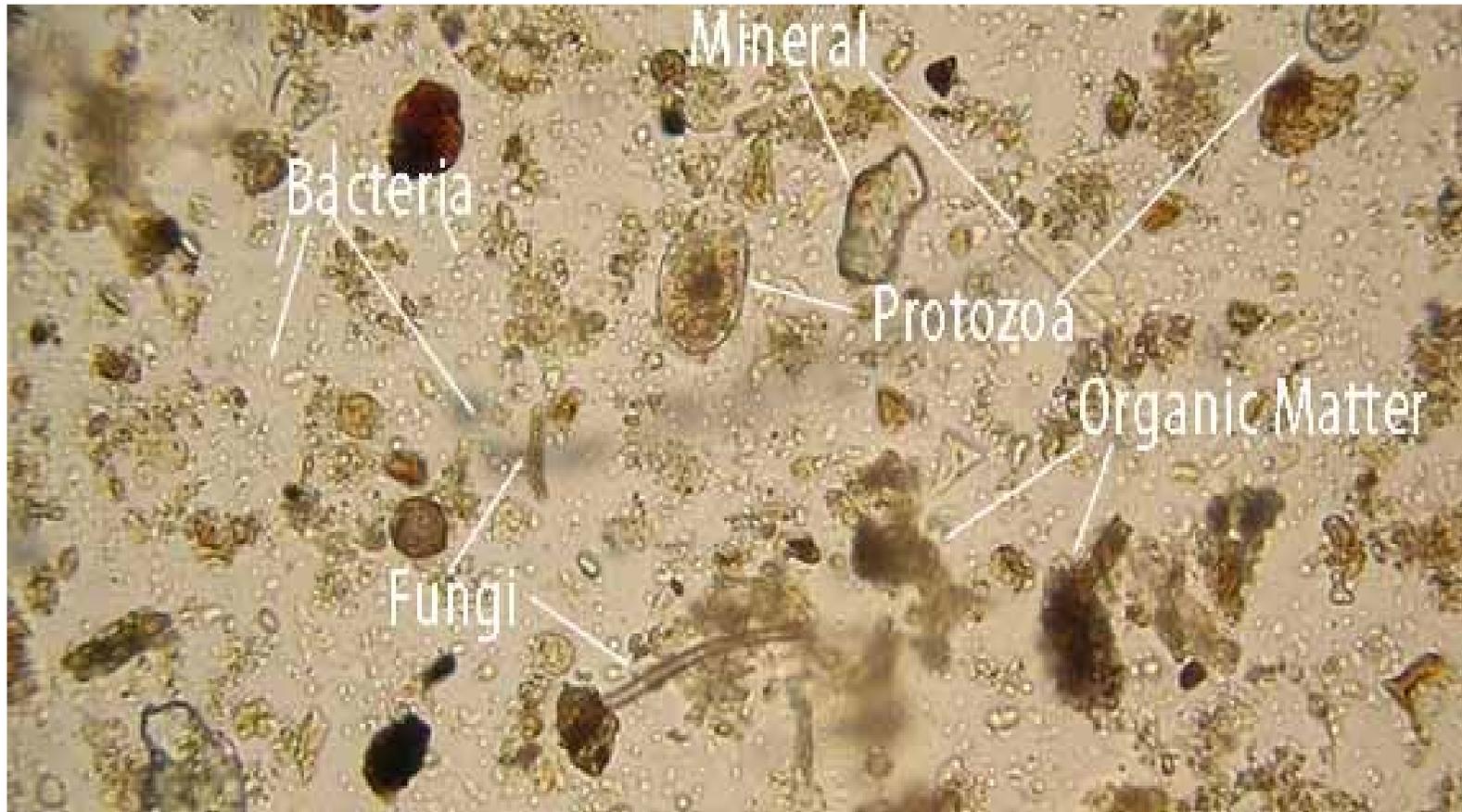
- High number of microbes
- High Diversity – bacteria, fungi, protozoa, nematodes
- How ascertained
 - \$300 lab test that takes 3 weeks.

Problems that need a quick test

- How much to dilute a batch of compost
- Whether to buy a load of compost or soil
- How to improve my compost extract with additives
- How to improve my compost making method

Soil sample under microscope

mauby.com



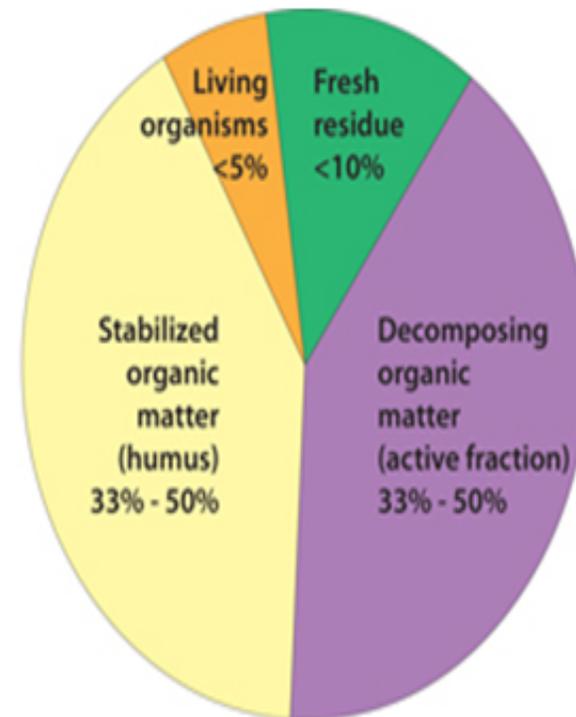
Problems

1. Separate organic material from microbes
2. Color, humic acid is dark brown
3. Separate microbes from soil particles to which they are glued
4. Turbidity must be able to be read without a spectrophotometer. This is a field test
5. All materials must be commercially available – don't invent anything you don't need to.
6. How to quality Control:
- 7.

Separate microbes from soil

- Filtration
 - Cost
 - Clogging
 - Steps
 - Loss of organisms on filter
- We had to settle for measuring only Bacteria

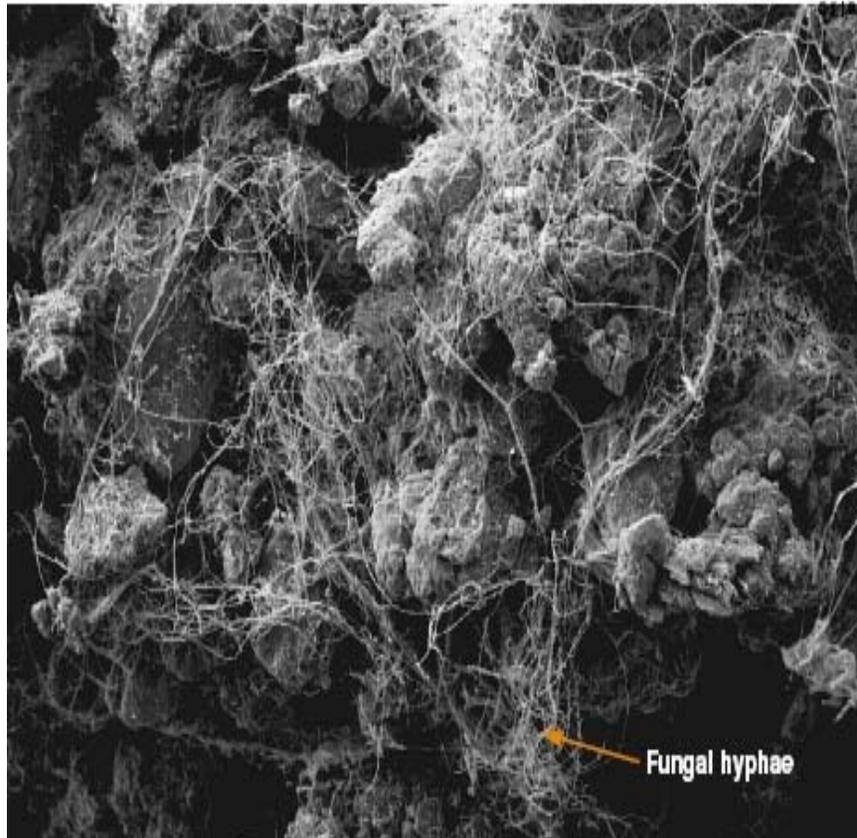
Food sources of Soil Microbes



Color, humic acid is dark brown

1. Decolorizing agent
2. That doesn't kill microbes during time of test
3. Safety
4. Disposability
5. Stability
6. Vendor

Separate microbes from soil particles to which they are glued.



1. Detergent like materials
 1. Don't lyse microbes
 2. Stable
 3. How to deliver
2. Mechanical method, shaking or sonication
 1. How long
 2. What damage

Turbidity must be able to be read without a spectrophotometer

- Secchi Tube
 - Requires 500 ml of fluid
- MicroBiometertm
 - 10 ml
 - Correlated with spec
 - 5% cv



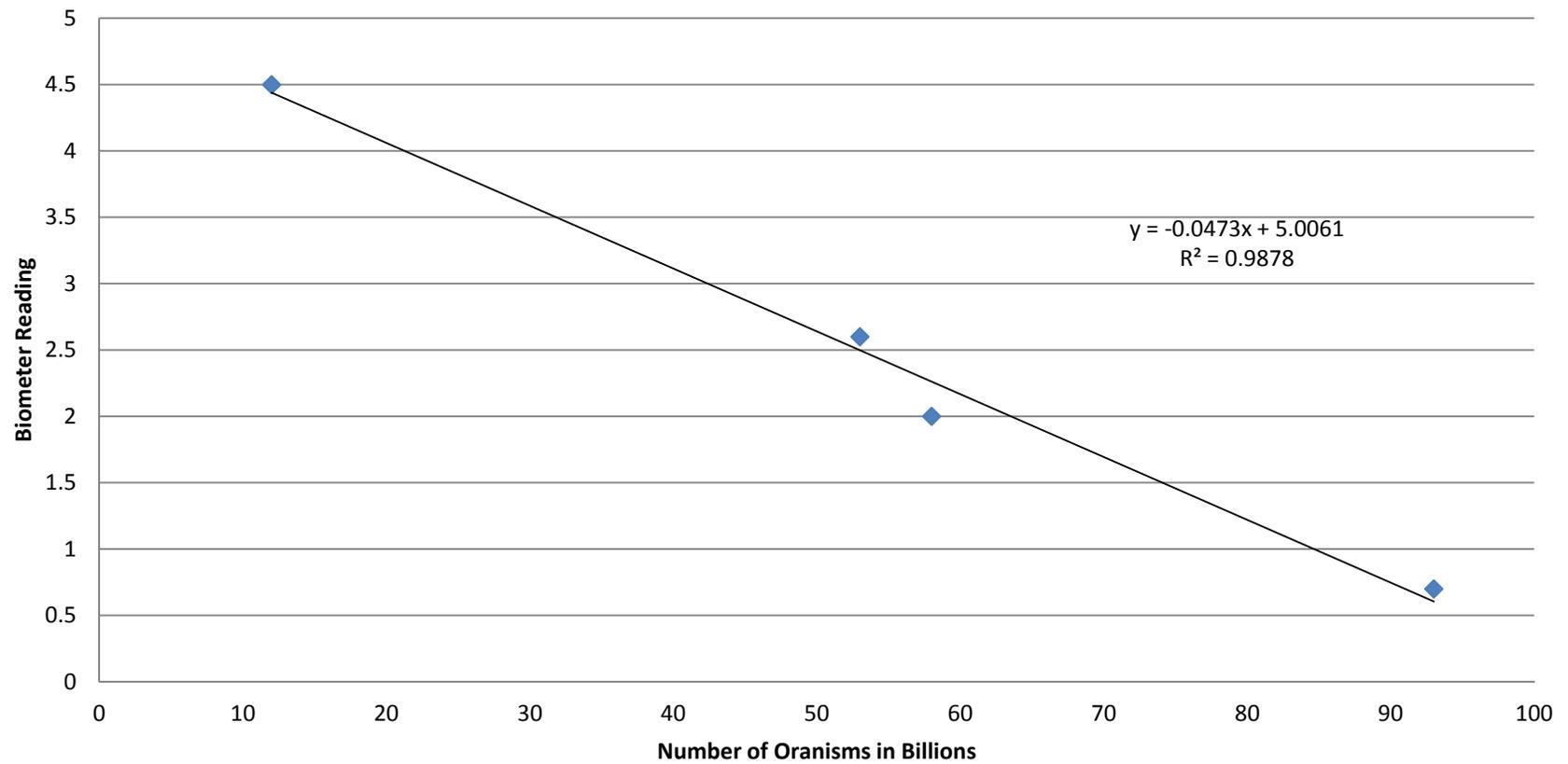
How to quality Control ?

If you say you measure 1 Billion/gm how do you prove it?

- Culture
 - Identifies 1-14% of bacteria, same for fungi
 - Dormancy, Cultures must go for up to 45 days
- Count
 - Hemocytometer
 - Does not distinguish between dormant and active
 - We do not see fungi-- disrupted during extraction

Linearity

Linearity of MicroBiometer



MicroBiometertm

Problems still to be addressed.

- Test for soil
- Test for bad compost