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SOIL MICROORGANISMS

1. Soil is a dynamic habitat for an enormous variety of life-forms.

Soils give a mechanical support to plants from which they extract nutrients. soil provides shelters for many animal types, from invertebrates such as worms and insects up to mammals like rabbits, moles, foxes and badgers. It also provides habitats colonised by

a staggering variety of microorganisms.

All these forms of life interact with one another and also interact with the soil to create continually changing conditions. This allows an on-going evolution of soil habitats.

2. Distribution of Microorganisms

Microorganisms constitute < 0.5% (w/w) of the soil mass yet they have a major impact on soil properties and processes. 60-80 % of the total soil metabolism is due to the microflora.

These are the smallest organisms (<0.1 mm in diameter) and are extremely abundant and diverse. They include algae, bacteria, cyanobacteria, fungi, yeasts, myxomycetes and actinomycetes that are able to decompose almost any existing natural material. Micro-organisms transform organic matter into plant nutrients that are assimilated by plants. Soil organisms represent a large fraction of global terrestrial biodiversity.

3. Soil organisms can be grouped on the basis of:

-Size: how big they are

-Species: who they are related to

-Function: how they make their living

One gram of topsoil may contain:

- as many as one billion bacteria
- up to 100 million actinomycetes
- one million fungi
- 100 nematodes

4. Importance of Soil Organisms

x Responsible for cycling of C, N and other nutrients

x Enhance soil structure

x Relocate and decompose organic materials

x Maintain soil quality and health

x Increase soil aeration and penetrability

x Involved in disease transmission and control.

5. Rhizosphere

The rhizosphere is the region of soil immediately adjacent to and affected by plant roots. It is a very dynamic environment where plants, soil, micro-organisms, nutrients and water meet and interact. The rhizosphere differs from the bulk soil because of the activities of plant roots and their effect on soil organisms.

6. The major Functions of soils:

Soil organisms are responsible for carrying out many vital functions in the soil. The major Functions of soils are:

- Anchor plant roots
- Supply water to plant roots
- Provide air for plant roots
- Furnish nutrients for plant growth
- Release water with low levels of nutrients

7. The soil environment

Soil microorganisms play key roles in ecosystem functioning.

They are known to be influenced by biotic and abiotic factors, such as plant cover or edaphic parameters.

Among the edaphic parameters, pH is the factor that most strongly influences soil bacterial communities.

Some studies have also shown that phosphorus and soil texture can shape soil bacterial communities.

8. Soil life are classified into 3 groups as:

x **Macrofauna**: Mice, moles, etc.; Earthworms and other worms; Ants, beetles, termites, spiders

x **Mesofauna**: Nemaodes, arthropods (mites, centipedes, and springtails), molluscs

x **Microfauna**: Protozoa

9. MACROFAUNA

Members of species classed as macrofauna are visible to the naked eye (generally> 2 mm in diameter).

Macrofauna includes vertebrates (snakes, lizards, mice, rabbits, moles, etc.) that primarily dig within the soil for food or shelter, and invertebrates (snails, earthworms and soil arthropods such as ants, termites, millipedes, centipedes, caterpillars, beetle larvae and adults, fly and wasp larvae, spiders, scorpions, crickets and cockroaches) that live in and feed in or upon the soil, the surface litter and their components. In both natural and agricultural systems, soil macrofauna are important regulators of decomposition, nutrient cycling, soil organic matter dynamics, and pathways of water movement as a consequence of their feeding and burrowing activities.

10. MESOFAUNA

Mesofauna (0.1-2 mm in diameter) includes mainly micro-arthropods, such as pseudo-scorpions, springtails, mites, and the worm-like enchytraeids. Mesofauna have limited burrowing ability and generally live within soil pores, feeding on organic materials, microflora, microfauna and other invertebrates.

Nematodes are tiny filiform roundworms that are common in soils everywhere.

11. MICROFAUNA

The microfauna (<0.1 mm in diameter) includes *mainly* protozoa.

These generally live in the soil water films and feed on microflora, plant roots, other microfauna.

There may be sometimes larger which feed on insects and other larger invertebrates.

They are important to release nutrients immobilized by soil microorganisms.

12. The Soil Flora (or Garden)

x Macroflora: Vascular plants, Mosses, etc.

x Microflora: Bacteria, Actinomycetes, Fungi, Algae.

13. Soil Bacteria

Bacteria are very small, one-celled organisms that can only be seen with a powerful light (1 000×) or electron microscope. They constitute the highest biomass of soil organisms. They are adjacent and more abundant near roots, one of their food resources. There are many types of bacteria but the focus here is on those that are important for agriculture, e.g. Rhizobium and actinomycetes.

Bacteria are important in agricultural soils because they contribute to the carbon cycle by fixation (photosynthesis) and decomposition. Some bacteria are important decomposers and others such as actinomycetes are particularly effective at breaking down tough substances such as cellulose (which makes up the cell walls of plants) and chitin (which makes up the cell walls of fungi).

14. Soil Actinomycetes

1. Transitional group between bacteria and fungi
2. Active in degrading more resistant organic compounds
3. Optimal growth at alkaline pH
4. 2 important products:- produce antibodies
5. Negative impact - potato scab (*Streptomyces scabies*)

15. Soil Fungi

These organisms are responsible for the important process of decomposition in terrestrial ecosystems as they degrade and assimilate cellulose, the component of plant cell walls. Fungi are constituted by microscopic cells that usually grow as long threads or strands called hyphae of only a few micrometres in diameter but with the ability to span a length from a few cells to many metres.

1. Dominate the soil biomass
2. Obligate aerobes
3. Can survive desiccation
4. Dominate in acid soils
5. Negative impacts:

- Apple replant disease (*Rhizoctonia, Pythium, Fusarium*, and *Phytophtora*)
- Powdery mildew is caused by a fungus

6. Beneficials:- *Penicillium.*

16. Biogenic structures

Biogenic structures are those structures created biologically by a living organism. Three main groups of biogenic structures are commonly found in agricultural systems: earthworm casts and burrows, termite mounds and ant heaps. The biogenic structures can be deposited in the soil surface and in the soil, and generally they have different physical and chemical properties from the surrounding soil.

The colour, size, shape and general aspect of the structures produced by large soil organisms can be described for each species that produces

17. The activity of living organisms in soil helps to control its quality, depth, structure and properties. The climate, slope, locale and bedrock also contribute to the nature of soil in different locations.

The interactions between these multiple factors are responsible for the variation of soil
types.
**18. Plants are the major producers of organic
material** to be found in soil, and plant matter accumulates as litter. Animal faeces and the decomposing bodies of dead animals complement this organic supply.

Artificially added fertilisers, herbicides and pesticides all affect the biological component and hence the organic content of soils. Horse dung and chicken manure are beloved of gardeners.

19. Microbes play a central role in re-cycling such material.

Besides recycling of naturally occurring organic compounds, soil microbes are responsible for the chemical degradation of pesticides.

20. EFFECTS OF ORGANIC MATTER ON SOIL PROPERTIES

x Organic matter affects both the chemical and physical properties of the soil and its overall health.

x Properties influenced by organic matter include:

x soil structure;

x moisture holding capacity;

- diversity and activity of soil organisms, both those that are beneficial and harmful to crop production; and nutrient availability.
- It also influences the effects of chemical amendments, fertilizers, pesticides and herbicides.
- Soil organic matter consists of a continuum of components ranging from labile compounds that mineralize rapidly during the first stage of decomposition to more recalcitrant residues

(difficult to degrade) that accumulate as they are deposited during advanced stages of decomposition as microbial by-products.

21. Soil Nutrient Cycling

The minerals and **nutrients** in the **soil** are recycled back into the production of crops.

A **nutrient cycle** (or ecological **recycling**) is the movement and exchange of organic and inorganic matter back into the production of living matter. The basic plant nutrient cycle highlights the central role of soil organic matter. Cycling of many plant nutrients, especially N, P, S, and B, closely follows parts of the Carbon Cycle. Plant residues and manure from animals fed forage, grain, and other plant-derived foods are returned to the soil.

This organic matter pool of carbon compounds becomes food for bacteria, fungi, and other decomposers. As organic matter is broken down to simpler compounds, plant nutrients are released in available forms for root uptake and the cycle begins again.

22. How are microbes involved in nutrient cycling?

All Life on Earth are based on carbon.

Water and simple organic compounds such as carbon dioxide become elaborated into complex, carbon-based organic structures.

These compounds include other elements besides carbon, oxygen and hydrogen.

Nitrogen is found in nucleic acids, amino acids and proteins. Phosphorous is a component of nucleic acids, lipids, energy storage compounds
and other organic phosphates. Sulphur is found principally in certain amino acids and proteins. All of these elements are continuously cycled through the ecosystem.

Many natural biological cycling processes require elements to be in different chemical states in different stages of the cycle. Phosphorous is an exception.

It is always taken up as inorganic phosphates. Once absorbed into living organisms, biochemical processes transform phosphorous
into more complex forms.

Besides the cycling of non-metal elements, microorganisms have a role in the biochemical transformation of metal ions. Many bacteria can reduce small quantities of ferric iron to its ferrous state. Without the cycling of elements,
the continuation of life on Earth would be impossible, since essential nutrients would rapidly be taken up by organisms and locked in a form that cannot be used by others.

The reactions involved in elemental cycling are
often chemical in nature, but biochemical reactions also play an important part in the cycling of elements.

23. How is carbon cycled?

Most people are familiar with the aerobic carbon cycle.

During photosynthesis, organic compounds are generated as a result of the fixation of carbon dioxide. Photosynthetic plants and microbes are the primary producers of organic carbon compounds and these provide nutrients for other organisms.

These organisms act as consumers of organic carbon and break down organic material in the processes of fermentation and respiration. Chemo organotrophic microbes break down organic carbon compounds to release carbon dioxide. Chemo lithotrophic bacteria can assimilate inorganic carbon into organic matter
in the dark. Certain bacteria are also capable of
anaerobic carbon cycling.

24. How is nitrogen cycled?

Nitrogen is the nutrient needed in largest amounts by plants and is the most commonly applied fertilizer.

Excess N can have negative effects on plant growth and crop quality as well as harming the

environment, especially water quality.

The availability of fixed nitrogen in a form that can be used by crop plants is of prime importance in determining the fertility of soil.

As a consequence, the biological nitrogen cycle is of fundamental importance, both to agriculture and to natural ecology.

Inorganic nitrogen compounds such as nitrates,
nitrites and ammonia are converted into organic nitrogen compounds such as proteins and nucleic acids in the process of nitrogen assimilation. Many bacteria reduce nitrates to nitrites and some bacteria further reduce nitrites to ammonia. Ammonium salts may then be incorporated into organic polymers in the process of assimilatory nitrate reduction.

Ammonia is primarily fixed into organic matter
by way of amino acids such as glutamate and glutamine. Other nitrogen compounds can be made from these
Bacteria are also involved in the inorganic cycling of nitrogen compounds. Nitrifying bacteria are responsible for the biological oxidation of ammonia.

25. Phosphorus Cycle

Phosphorus is a component of the complex nucleic acid structure of plants, which regulates
protein synthesis.

Phosphorus exists in many different forms in soil. These sources are grouped into four general forms: (1) plant available inorganic P, and three forms which are not plant available: (2) organic P, (3) adsorbed P, and (4) primary mineral P.

The general P transformation processes are: weathering and precipitation, mineralization and immobilization, and adsorption and desorption. Weathering, mineralization and desorption increase plant available P. Immobilization, precipitation and adsorption decrease plant available P.

Phosphorus lost from agricultural soils can increase the fertility status of natural waters (eutrophication), which can accelerate the growth of algae and other aquatic plants.