Sonja Kuster 08/07/2023
Unit Code: T/602/3921
UNIT GUIDE 2023-24

The Interaction of Soil Environments and Woody Plants

LO 4 Understand the role of the beneficial organisms found in the soil.

4.1. Describe two benefits that soil organisms can bring to soil composition

Soil microorganisms play a crucial role in various aspects of the natural world, including animals, plants, agriculture, and the global food web. They are particularly important in the carbon and nitrogen cycles. However, the changing environmental conditions caused by global warming, such as temperature, humidity, and pH, can have significant effects on these microorganisms. These changes may impact the community structure, physiological development, and ecological function of soil microorganisms in both the short and long term.
There are four main types of soil microorganisms: archaea, bacteria, fungi, and protozoa. These microorganisms' control most of the enzymatic processes in the soil, and their biomass serves as a source of nutrients and energy.
In addition to their enzymatic functions, soil microorganisms also perform vital ecosystem functions, such as decomposition and nutrient cycling. They also form symbiotic relationships with plants. Among the microbial community in the soil, fungi and bacteria are the two major functional subgroups. However, in soil ecological concepts that describe interactions between soil animals and soil microbes in food webs, these subgroups are often treated separately.

A diverse range of larger soil fauna, including springtails, mites, nematodes, earthworms, ants, and underground insects, contribute to the ecosystem. These soil animals play a dual role as consumers and decomposers by consuming organic debris and decomposing it in their digestive tracts. Some feed on roots, while others prey on fellow animals. Among the various types of worms, earthworms are the most easily recognizable. They consume organic waste and plant matter, producing worm castings that nourish other species in the soil. Additionally, their burrowing activities create channels that enhance soil aeration. Nematodes, also known as roundworms, are tiny aquatic creatures that inhabit soil particles. They exhibit a wide range of feeding habits, with some consuming dead materials and others preying on living roots and organisms. Certain nematodes can cause significant damage to roots, distorting or even destroying them. Apart from worms, arthropods with exoskeletons and jointed legs, such as mites, millipedes, centipedes, springtails, and grubs, form a substantial portion of the soil insect population. Plant roots release organic compounds from decaying materials into the soil, providing nourishment for bacteria and creating a region of activity known as the rhizosphere. While some organisms in this zone can be detrimental to plants or produce toxins, many of them play beneficial roles. Bacteria and fungi can cause plants to wilt or rot, as exemplified by the potato blight infection that triggered the Great Potato Famine in Ireland in 1845.

Certain types of fungi form a symbiotic relationship with plant roots, which is referred to as mycorrhizae. This interaction is beneficial for both the root and the plant, as it enhances the uptake of water and nutrients, improves resistance to drought, and reduces the risk of disease infection. Additionally, plants face difficulties in absorbing nitrogen, despite its abundance in the air. However, there are specific bacteria known as nitrogen-fixing bacteria that can convert atmospheric nitrogen gas into a form that can be utilised by plants, forming a symbiotic relationship with them.


This image shows a magnified interaction between a fungus and a root.

Microorganisms play a vital role in enhancing the organic composition of the soil, enhancing its structure, and promoting plant growth. They achieve this by assimilating organic matter from deceased plants and animals into the soil. Additionally, they break down rock particles and convert nutrients into soluble forms through the secretion of acids. The hyphae of these microorganisms act as extensions of roots, which help in aerating the soil. This expansion of the root system increases the surface area, making it easier for plants to access nutrients and moisture in the soil. Moreover, certain bacteria produce natural plant stimulants, thereby reducing the requirement for nitrogen. Furthermore, their secretion contributes to the formation of aggregates in the soil, thereby strengthening its structure.

In conclusion, the breakdown of animal and plant tissues into humus by microorganisms is essential in the soil enrichment process. Humus-rich soil with a crumb structure and increased pore space enhances water retention capacity and nutrient availability for plants. Furthermore, the disturbance caused by larger species like moles digging burrows can also improve soil aeration and water retention, facilitating deeper root penetration for plants.

Moles play a significant role in enhancing soil aeration, which is vital for the health of the soil and the growth of plants. Soil aeration—the presence of air in the soil—is essential for the proper development and survival of plant roots. By creating intricate tunnels in the soil, moles facilitate the entry of air and water deep into the ground, thereby improving soil aeration. This process brings several benefits to the soil.

The first advantage is that improved soil aeration promotes the decomposition of organic matter in the soil, releasing essential nutrients that are crucial for plant growth. Additionally, enhanced soil aeration increases the soil's ability to support a diverse range of microorganisms, which are vital for maintaining soil fertility.

The second benefit is enhanced soil drainage, which reduces the risk of waterlogging and plant root rot while also contributing to improved soil aeration. This is particularly important, as waterlogging is more likely to occur in soils with poor drainage.

Lastly, enhanced soil aeration helps to alleviate soil compaction, which can hinder the expansion of plant roots and their ability to absorb nutrients. The tunnels created by moles allow for deeper root penetration into the soil, loosening it and reducing compaction.

Overall, moles play a crucial role in improving soil aeration, which has numerous positive effects on soil health and plant growth.

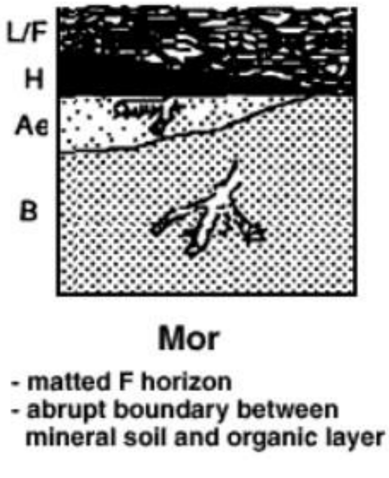
Mole activity in my backyard this morning, 22/06/23

Sources

https://hgic.clemson.edu/why-does-soil-health-matter-starting-with-soil-organisms/#:~:text=All%20soil%20organisms%20help%20decompose,shred%20and%20feed%20on%20SOM.%20https://www.sciencedirect.com/topics/earth-and-planetary-sciences/micro-organism
https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/soil-microorganism#:~:text=Soil%20microorganisms%20encompass%20archaea%2C%20bacteria,Jenkinson%20and%20Ladd%2C%201981).
https://www.soils4teachers.org/biology-life-soil/#:~:text=Living%20organisms%20present%20in%20soil,organisms%20such%20as%20burrowing%20rodents.%20
https://molescontrol.com/moles-soil-health-plant-nutrition/

4.2. Describe two benefits that soil organisms can bring to the woody plant

Soil organisms play a crucial role in woodlands by facilitating the formation of humus through the decomposition of leaves and other plant material. Humus, which is a non-living organic component of soil, is produced when microorganisms break down plants and animals.
Mor is typically found in coniferous forests or mixed-wood forests and is often associated with acidic conditions. It originates from the decomposition of organic matter that rests on the soil surface. Fungi, earthworms, and small arthropods are common organisms that contribute to the formation of Mor. Mor generally has a low mineral content and exhibits relatively low biological activity, which hinders the decomposition of organic matter. The transformation and accumulation of plant residue in the soil occur at a slow pace.



Mor humus is a specific type of organic material that is commonly found in coniferous forest soils and moorland soils. This type of humus is formed in environments with low biological activity in the soil. The decomposition of organic matter occurs at a slow pace, resulting in the formation of distinct layers that help maintain the structure of plant material. Acidophilic fungi and less active invertebrates play a role in breaking down plant residues. As a result, a thick layer of litter is formed under these conditions. The C/N ratio of Mor humus is consistently higher than 20, sometimes even ranging from 30 to 40, while the pH level remains acidic.

Typical Mor, Osh horizon, material compact packing and breaking into aggregates with sharp division surfaces that fit together again without gaps, © Ecke von Zezschwitz †

The substance known as humus is primarily composed of carbon, with a small percentage of nitrogen (approximately 6%), sulphur, and phosphorus. It is worth noting that humus typically has a dark colour, although there may be some shade variation, and its appearance is greatly influenced by the climate. In the field of agriculture, humus is a term used to describe well-aged compost. Soil microbes play a crucial role in breaking down the larger organic matter into smaller components. These components can then be absorbed by soil microbes and distributed to other organisms. Humus encompasses a wide range of decomposition, including peat moss, graded compost, leaf compost, wood chips, decaying sawdust, and garden waste, among others. In terms of water absorption, humus has a higher potential compared to clay. Its complex structure consists of two key components: nitrogen compounds and a phenolic nature. Additionally, humus exhibits weak cohesion and flexibility.

The decomposition of complex materials in decaying plants and animals by soil organisms is a critical function that allows surviving plants to repurpose them. The carbon cycle begins with plants, as they require water and carbon dioxide from the environment to produce tissues such as leaves, stems, and fruits. Animals consume plant tissues and convert them into animal tissues. When an animal dies and its decomposing tissues are consumed by soil organisms, carbon dioxide is released, completing the cycle. Proteins are the building blocks of organic tissues, and nitrogen is an essential component of every protein. The fertility of soils depends on the availability of nitrogen in forms that plants can use, making the role of soil organisms in promoting the nitrogen cycle crucial. When an animal or plant dies, soil organisms break down the complex proteins, polypeptides, and nucleic acids in their bodies, releasing ammonium, ions, nitrates, and nitrites that plants utilize to create their own tissues. While bacteria and blue-green algae can fix nitrogen from the atmosphere, the symbiotic relationship between Rhizobium bacteria and leguminous plants, trees, and shrubs is more significant for plant development. Rhizobia fix nitrogen in the root nodules of host plants in exchange for secretions that support their growth and reproduction, providing the plant with accessible nitrogen. Soil organisms also play a role in the Sulphur cycle by breaking down naturally occurring Sulphur compounds in the soil, making this essential element available to plants. These microbes produce hydrogen sulphide, which is responsible for the characteristic rotten-egg smell in swamps and marshes.

Fungi, as soil organisms, facilitate the exchange of nutrients and carbon among trees. Mycorrhizal fungi enable older trees to support seedlings and stressed trees. Symbiotic relationships, known as mutually beneficial alliances, are established between plant roots and mycorrhizal fungi. In return for supplying essential nutrients to plants, fungi receive sugars and carbon dioxide produced by the plants through photosynthesis. Professor Suzanne Simard's studies have shown that fungi also communicate with neighboring trees to alert them about potential predator threats.

Sources
https://www.sciencefocus.com/news/hidden-fungi-absorb-over-a-third-of-earths-fossil-fuel-emissions-new-study-discovers/

https://www.nature.com/articles/s41598-019-43026-8

http://karnet.up.wroc.pl/~weber/humic.htm#start