ASSOCIATION OF MICROORGANISMS WITH PLANT

Plants and microorganisms interact with each other and the interaction can be beneficial and sometimes detrimental to either of the partners. Microorganisms are present in the different parts of the plant and in different plants, and influence of plant on microorganism varies depending on the part of plant and the plant. Therefore the association of microorganisms and different plant parts are discussed below.

Association with plant roots

Plant root system occupies the soil horizon most heavily endowed with soil organic matter and life, senescent and dead roots provide substrate materials for microbial growth. The sum total of phenomena occurring at or near the root /soil interface has great impact both on plant welfare and on soil organisms. The number of soil organism at successive distances from the root surface is inversely correlated with increasing distance. For bacteria, higher population occurs within the first 5 μm, fungal hyphae occur on the root surface and strands extend randomly for several millimeters. The sum total of root/microbial interaction is termed **rhizosphere**.

Rhizosphere

This is known generally as the soil region under the immediate influence of plant roots and in which there is proliferation of microorganisms. The recognition that the root surface itself is a critical site for interactions between microbes and plant led to its designation as **rhizosplane**. The epidermal and cortical tissue of roots has been shown to harbor organisms other than symbionts and pathogens. Colonized root tissue is sometimes referred to as **endorhizosphere, histophere** or **cortosphere**. The factor primarily responsible for microbial activity in the three zones is the available carbon contained in or emanating from plant roots.

The R/S ratio i.e ratio of organisms count in rhizosphere soil to count in root-free soil were determined for different plant species and for single species in different soils under differing climatic regimes and at different stages of phenology. Total microbial counts increased from 10-50 folds in the rhizoshpere.

Root exudates

Organic materials found on, in or near roots include a wide assortment of amino, aliphatic and aromatic acids and amides, sugars and amino sugars. In addition to soluble and diffusible substrates is an array of insoluble materials like cellulose, lignin, protein etc. Nearly all plant rhizosphere is expected to contain varying amounts of nearly all the simple sugars, organic acids, and amino acids. Some of the more complex aromatic acids occur only in certain rhizospheres.

Likewise, production of certain microbial attractants and repellants is limited to certain species, for example asparagus plant produse a diffusible glycoside that is toxic to some nematode. Various plants are also known to produce non diffusible compounds that are biostatic or biocidal to saprobes and root invading pathogen. Such phytoalexins include tomatin, allicin, pisatin and phaseolin produce by tomato, onion, pea, and bean plants respectively.

Pathways for the release of plant assimilates from roots include leakage or diffusion of molecules across cell membranes, roots secretion and extrusion and losses of cells and tissue fragments during root growth. Root caps and tips are sites of active exudation of mucilaginous materials, while the main root axis release mostly diffusible materials ans some mucigels.

Root mucigel consists of polysaccharides synthesized intracellularly and extruded through the cell membrane. It is highly hydrated with fibrillar structure and contains carboxyl groups that form bondings with clays. Mucigel is the dominant excretory product of root accounting for up to 80 % of the total carbon loss from roots.

Association with plant shoot

Plants support abundant leaf surface organisms, this association is termed **phyllosphere**. Intensity of colonization is influenced by climatic and plant factors, high humidity favours while insolation disfavor most heterotrophs both factors favour phototrophs. Plant stems and barks are often colonized by algae and liches. Broadleaf plants support more organisms on their leaf surfaces than grasses. G^- and yellow pigmented bacteria dominate the bacteria flora while yeasts dominate the fungal flora.

Nonpathogenic organisms occur within the tissues of fruits, stems and leaves. The coats of seeds prior to release from fruiting structures are sparsely colonized, during dispersal, additional organisms either casual or contaminants or members of the phyllosphere population become seed coat occupant. Some seed associated organisms produce auxins, vitamins and gibberellin-like substances that benefit emergent seedlings. Other organisms are known to produce substances that delay seed germination and others represent plant pathogens.

Association with plant litter

The initial invaders of the aboveground litter are primarily organisms already present in the phyllosphere. Senescent leaves before detachment suffer attack by both microflora and fauna, standing dead wood and branches often lose half their carbon through attack mesofauna and lignolytic fungi before becoming surface litter. As leaves and small twigs or stems fall to the ground the numbers of bacteria there on increases sharply. The bacterial populations of moist litter exceed that of the phyllosphere by two folds. The litter organism varies with depth and with stage of decay. The soil fauna are more active in forest litter than in litters from grassland or cultivated land. Fauna biomass is concentrated in the surface litter and decreases rapidly in the underlying soil.

INFLUENCE OF MANAGEMENT PRACTICES ON SOIL ORGANISMS

Any management practice that changes soil properties or plant cover affects the soil organisms. Practices that affect coil water, temperature, aeration, pH regimes, organic carbon and nitrogen levels will also affect the population and activities of organisms.

Effect of tillage on soil microorganism

Three tillage procedures commonly used are conventional tillage, reduced or minimum tillage and zero tillage. The first employs various mechanical/manual farm implements; reduced tillage involves weed control by machinery, while zero tillage control weed by the use of herbicides, the only soil disturbance is that associated with seed placement. In conventional tillage there is stimulation of microbial activity shown by higher count and increase rate of respiration. This result from disruption of soil aggregates and better exposure and aeration their degradable material. The inversion and fragmentation of surface residues results in a zone of intense microbial activity. By contrast reduced or zero tillage result in microbial activity at or near the soil surface. For the 0-0.75 cm depth counts for total aerobes, facultative anaerobes and fungi are higher in zero tillage than in plowed soil. For 7.5-15 cm depth counts of aerobes, fungi and nitrifying bacteria are significantly reduced in zero tillage.

SOIL FAUNA

Soil biota (living things in the soil, soil organisms) consists of two broad categories – flora and fauna. Soil organisms are a major factor in soil formation and their effects determine many differences between soils. Soil organisms are an integral part of agricultural ecosystems. The presence of a range of a diverse community of soil organisms is essential for the maintenance of productive soils. Soil organisms are responsible for a range of ecological functions and ecosystem services including:

- nutrient cycling and nitrogen fixation,
- control of pest and diseases,
- organic matter decomposition and carbon sequestration,
- maintenance of a good soil structure for plant growth and rainwater infiltration,
- detoxification of contaminants.

Various soil organisms affect certain soil processes in different ways. An excessive reduction in soil biodiversity, especially the loss of species with key functions, may result in severe effects including the long-term degradation of soil and the loss of agricultural productive capacity.

Through their feeding activities, soil fauna play important roles in ecosystem dynamics as they influence the decomposition subsystem and cycling of plant nutrients and other elements that are of environmental importance. Soil fauna as a major group of soil biota are classified based on their sizes, habitat, and feeding form apart from their taxonomic classification. Classification of soil fauna based on their feeding form is also termed functional classification

Soil fauna classification based on sizes

Soil fauna are classified on the basis of their sizes as microfauna, mesofauna and macrofauna. The classification could be based on the body width or body length.

Table 1: Soil fauna classification based on body width

Body width	Class	Examples
< 0.1 mm	Microfauna	Protozoa, nematodes, rotifer,
0.1 mm – 2.0mm	Mesofauna	Mites, Collembola, Protura, Symphyla
2.0 mm – 20.0 mm	Macrofauna	Earthworms, termites, millipedes

Table 2: Soil fauna classification based on body length

Body length	**Class**	**Examples**
< 0.2 mm	Microfauna	Protozoa,
0.2 mm – 10 mm	Mesofauna	Nematodes, Mites, Collembola, Protura, Symphyla
> 10 mm	Macrofauna	Earthworms, termites, millipedes

A taxonomic class of soil organisms may also be grouped based on the their sizes. For example, members of the phylum Arthropoda are classified based on their sizes as either microathropods, mesoarthropods or macroarthropods

Different size-groups of soil fauna may also be classified on the basis of their habitat or life form. The habitat and life form of soil fauna are closely related to their ecosystem function. Classification of soil fauna based on their feeding form is also termed functional classification

SOIL MACROFAUNA

Soil macrofauna consists of a large number of different organisms that live on the soil surface, in the soil spaces (pores) and in the soil area near roots. Their way of living, their feedings habits, their movements into the soil, their excretions and their death have direct and indirect impacts on the soil. The biological activities of soil macrofauna play significant roles in soil processes and soil fertility. The effects of soil macrofauna on soil can be divided into three classes: physical, chemical and biological effects. These effects are determined by the functional group involved in the process.

Classification of macrofauna based on habitat or life form

Endogeic: Endogeic species are those that live entirely in the soil and feed on organic matter and dead roots; they may also ingest large quantities of mineral material. The two main groups among soil macrofauna are earthworms and soil-feeding termites.

Epigeic: Epigeic soil fauna live and feed on the soil surface. They play role in litter breakdown and nutrient release. They are mainly arthropods, for example: ants, beetles, cockroaches, centipedes, millipedes, woodlice, grasshoppers, together with gastropods (snails/slugs) and small or medium-sized entirely pigmented earthworms (dark red, green or brown colour, fast movers).

Anecic species: These remove litter from the soil surface through their feeding, redistributing it to other horizons or locations, accompanied by effects on soil structure and hydraulic properties.

Physical Role of Soil Macrofauna

The main activities of soil macrofauna may be grouped into the following

- Soil mixing (macro- and micro-levels)
- Gallery construction,
- Fragmentation,
- Aggregate formation.

Soil mixing at macro-level (macromixing)

This is the movement of notable quantity of soil: bringing back to the surface mineral matters from deeper horizons and burying the organic matter from the surface horizons, from litter and from excrements. Examples of macrofauna involved include ants, termites, earthworms and ground beetles.

Macromixing of soil by earthworms is major activity of importance to soils. It can be measured by the quantity of casts found on the soil surface. Earthworms can produce 40–250 tonnes of casts per hectare per year. Earthworms casts are richer in nutrient content than the surrounding top soil. Some beetles such as the large (*Heliocopris dilloni*) are very efficient at incorporating and removing excrements that are on the soil surface.

Soil mixing at micro-level (micromixing)

This involves mainly the incorporation of organic matter into the soil through the activities of soil surface dwelling macrofuana. For example Diptera larva. With the aid of water percolation, their effect could extend to the depth of 60 cm through leaching. Micromixing is important in influencing soil structure.

Gallery construction

Galleries are tunnel-shaped passages in form of network in the soil. They are formed through burrowing activities of especially earthworms and termites. Gallery formation is very important for

- soil aeration and water flux
- improved soil macro-porosity
- the water-holding capacity of soil
- reduce soil compaction,
- improved water infiltration
- offering new paths for root penetration and leached clays.
- penetration paths for other surface invertebrates with more limited burrowing capacities, e.g. very small earthworms, slugs, insect larvae, and mesofauna.

Litter fragmentation

The fragmentation of dead wood (lignin material), carcass and litter has a major effect on organic matter decomposition in soil. It creates large surface area for the activity of bacteria, fungi and microfauna populations. Fragmentation is performed by phytosaprophagous animals (i.e. animals feeding on decayed plant material and dead animals). Litter fragmentation enhanced decomposition leading to formation of humus

Aggregate formation

Humus formed as a result of the activities of soil fauna act as biding agent for soil mineral particles thus aiding the clumping together of soil particles forming a crumbly healthy structure.

Also, earthworms, termites, millipedes, centipedes and woodlice ingest soil particles with their food and contribute to aggregate formation by mixing organic and mineral matter in their gut.

Chemical effects of soil macrofauna

The chemical effects of soil macrofauna on soil include:

- modification of food quality through its passage in the gut,
- mineralization of organic matter and the release of nutrients.
- activation of microflora in the mineralization of N, P and S.

Macrofauna regulates the activity of soil microorganisms through their interactions. Because of their inability to move in soil to search for food, microorganisms are only active when in contact with assimilable substrates (root exudates, earthworm mucus and other materials) that initiates their metabolic capabilities. Microorganisms have a high capacity to digest almost all organic substrates, while macrofauna have the potential for mechanical activities that help bring the microorganisms in contact with the substrates. Hence their interactions are important to soil function.

Biological effects of soil macrofauna

The biological effects of soil macrofauna include

- Maintenance of ecosystem balance through their feeding habits – particularly predation and competition
- Soil environmental sanitation through the activities of **necrophagous** (which feed on dead and/or decaying animals) and **coprophagous** organisms (feeding on dung or excrement)

such as Diptera larvae, Coleoptera and Lepidoptera larvae and adults. They clean the soil surface and incorporate organic matter into soil.

- Dissemination of bacteria and spores through excrement dispersion in soils or by on-body transport.

The importance of the functions performed in soils by macrofauna and the physical, chemical and biological changes induced in a soil environment as a consequence of its activity make it a vital part of all ecosystems, including agro-ecosystems. Soil macrofauna is involved in:

degrading organic matter and mineralizing nutrients;

- controlling pathogen populations;
- improving and maintaining soil structure;
- mixing organic matter through the soil.