Microorganisms, the indispensable helpers in the garden and in agriculture

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The level of awareness and knowledge among garden lovers and farmers with respect to the use of natural microbial products to promote soil fertility (soil aid) and plant health (plant aid stabilisation), is limited. This could be due to them not being able to see these "nano" helpers and/or a lack of scientific information, a limited flow of information, on the complicated processes taking place in the soil. This article is an attempt to introduce the reader to the great daily work done by the billions of invisible-and indispensable helpers.

Did you know that in a handful of good humus soil you'll find far more living beings than humans on the entire planet? In just one third ⅓oz of soil, you'll find several billion active bacteria, millions of funguses plus thousands of invisible insects. The average amount of biomass per acre is 6 tons. About one third of the biomass on earth is a result of the good work done by the invisible-and indispensable helpers also referred to as bacteria.

The microbial involvement in the cycle of elements

By studying the behaviour of microorganisms, it becomes obvious how critical they are for the survival of all living species on our planet: including humans, animals and plants.

1. Green plants produce organic substances by using the suns' energy; carbon dioxide (CO_2) from the air and from "dead" leaves, roots, and stems. The microbes produce inorganic plant nutrition, such as phosphate and nitrate (chemical sugars, strength, cellulose, lignin, protein, fat and many other substances). That's why they are referred to as **Producers**.

2. Animals are called **Consumers**, because, in order to build up their body mass, they primarily feed on biomass.

3. Both animals and plants eventually die so prior to the start of a new life cycle, it's necessary to close the old one. The organic substances must be converted into mineralised, inorganic compounds. That process is referred to as the "decomposition process" and is mainly achieved by funguses and bacterium. In the ecosystem, these are referred to as **Destructors**. Without Destructors, life is simply unthinkable.

By simply studying one material cycle e.g. the carbon cycle, the overriding importance of micro-organisms becomes evident. They are responsible for the mineralization of carbon conveyed by green plants as organic bonds and also for keeping a very delicate balance. The total photosynthetic production of green plants on earth is so huge, that if no additional sources of CO_2 existed, it would take about 20 years to exhaust the carbon dioxide stored in the entire atmosphere (app. 0.03 per cent). If the microbes didn't mineralize all organic matters produced by plants, these matters would simply end up coating every surface on our planet, even the oceans. The ongoing oxidation processes executed by the microbes are sufficient enough to keep the delicate balance of Carbon as CO_2 in the atmosphere far beyond the 20 years, perhaps for ever.

Microbes play a similar role in other cycles, such as nitrogen, sulphur, and phosphorous. The Nitrogen compound in soil, present as ammonium, is originated from dead plans and animals etc. which is not directly absorbable by plant roots. In an oxidation process, microbes are turning ammonium into Nitrate and Nitrite, thus Nitrogen is becoming absorbable for root systems, and in other words, the cycle is completed.

Microbes and plant nutrition

When acting as "Destructors", the microbes are producing compounds, essential for starting up new life-cycles. Due to their relentless work of transforming soil-stored organic substances e.g. roots, leaves, greens, manure, dead animals etc. into inorganic compounds e.g. Nitrogen compounds, Carbon dioxide, minerals, they are able to create plant-available nutrition, the invisible and indispensable helpers them selves, and this becomes the foundation for life on earth. Because they are mineralising all soil-stored organic substances, plants will not starve. Plants are, unlike animals and human beings, unable to obtain and therefore to utilise complex organic compounds like celluloses or proteins.

The actual breaking down process is being initiated by microbes. Because of a catalytic impact on their enzymes, they, at a certain level, cease to work. In a defined pattern, groups of other specialised microbes take over and continue on until the job is done, namely the conversion of organic substances into mineralised compounds. Changes in weather i.e. temperature, humidity, pH-value, concentrations of oxygen etc., do not effect the process due to the microbes ability to constantly adjust to these factors.

Every single organic substance has its own decomposition pace. The decomposition period of Carbohydrates i.e. sugar, starch, cellulose, hemicelluloses respectively polyosen, pectin proteins and Protein derivates are relatively short compared to the time it takes to convert substances like Lignin, most Greases, Harts, Vaxes, Rubber etc. When it comes to soil fertility, these natural substances, being a part of a group referred to as "Intermediate Compounds", are crucial; however, their conversion is time consuming.

"Both growth and yield are dependant on some intimate interactions between microbes and root systems. Research shows that the diversity of soil related microorganisms is the key to an effective utilization of carbon hydrates, thus for the building up of a fertile rich humus soil "(Paul Maeder, FiBL, Research institute for biological Agriculture, Switzerland).

By reading accessible research papers and using common knowledge, also referred to as "good soil management", it is possible to build up a diverse micro flora in soil, and secure an effective conversion of organic matters into plant nutrition. By integrating organic matters into the crop rotation, a diverse micro flora is automatically built up. This process is capable of reducing the spread of phyto-pathogen bacteria, which also contributes to creating healthy soil.

Reciprocal effect between plants and microbes

Microbes, in addition to colonizing our own skin, animal coats etc., even colonize the parts of the plant growing above the soil surface (stems, leafs etc). The microbes are living in an integrated ecological community and are bonded just like the natural flora on human skin and on mucous membranes.

The processes taking place underground are worth paying attention to. Until recently scientists assumed that the function of the root system was simply to absorb water and nutritional matters from the soil. Today we know that the root system is not limited to absorbing water and nutritional matters, but also secretes a variety of substances like sugar, enzymes and organic acids. These substances support the extraction of plant nutrition from the soil and serve as nutrition for both bacteria and fungi.

The part of the soil that is influenced by root secretions and associated microbes is referred to, as the "Rhizosphere". The amount of bacteria living in the Rhizosphere is significantly higher than in "bulk" soil. In "bulk" soil the numbers of microbes are much less and are not distributed uniformly; they are congregated around organic matters and referred to as a "nutritional source" (Curl, 1986)

"Why do plants feed microbes?"

The question has been pondered by many scientists in the past. Scientists have now thoroughly explored and investigated various inter-related microbial net works; one of them is the symbioses between the nitrogen fixing Rhizobium bacteria and Leguminous.

Plant leaves are not equipped to obtain and utilize the air borne but less reactive Nitrogen (N_2). Among the bacteria in the Rhizobium many are capable of converting elementary Nitrogen into nitrate and nitrite; compounds fully absorbable by the root system. Nitrogen and Phosphorous are growth related compounds and an insufficient supply will result in poor growth.

Rhizobien bacteria infect young root hairs by "digging" an infection canal-like system that enables the bacteria to move towards the center of the root hair. Both root hair and bacteria together create a tissue bruise or swelling in which the bacteria repopulate. The plant supplies the bacteria with nutrition's such as sugar, providing the best environment for a successful repopulation. For sure this is a perfect symbioses; a perfect win- win situation.

Since the beginning of the 90's, the Danish company Danisco has been working on isolating beneficial Rhizosphere bacteria from a sugar beet. Danisco succeeded in isolating some strains and securing their durability. They were also able to link the strains to a carrier substrate, and to integrate the mix into a sugar beet seed.

Because the Rhizosphere is not just a home for beneficial microbes but also a home for disease coursing germs and pathogens, this poses a potential risk to plants. Healthy soil holds a network of beneficial bacteria that keeps the pathogens and germs in place and prevents them from spreading.

A better understanding of the plant Genome and of the Rhizosphere bacteria promoted new research on “the extent of signal exchange and signal processing inside the Rhizosphere”.

Recent research shows that the bacteria present in the Rhizosphere have communicative capabilities. The language is of a chemical nature and depends on the density of a bacterium’s population. Molecules selected as “signal” molecules (N-Acyl-Homoserinlactone) are able to regulate certain germs and/or activate the production of defensive bacteria that suppress unwanted guests (biological control). It is obvious that by using “signal” molecules bacteria within the Rhizosphere are able to communicate with the help of their “chemical” language.

In the meantime, researchers have seen a reaction on a tomato plant caused by a “signal” molecule from the bacteria strain -Serratia liquefacies. Therefore, we may assume that in addition to an active exchange of information between plants and Rhizosphere bacteria, there is also an exchange among bacteria themselves. Even single cell organisms communicate, just like their more sophisticated counterparts i.e. Inspects and animals. When Amoebas feed on microbes living on one part of the root system, distant parts like leaves and roots respond. Here is another example: when a larva is feeding on a plant leaf, the composition of microbes on the root changes.

It would be wrong to underestimate the impact of soil microbes on the entire eco system beyond the soil surface.

We know for sure that soil related microbes have a positive influence on the nutrient supply to plants and on each single living organism in the Rhizosphere. A fertile soil promotes plant growth and is able to suppress and overcome attacks from pathogens and germs. Even with new and sophisticated methods, scientific efforts to understand and describe these effects in detail are in their infancy. Improved knowledge in this field will lead to a change in our soil cultivation approach; enhance soil fertility and lower, perhaps totally eliminating, our use of artificial herbs and pesticides.

Today farmers and garden lovers are able to replace chemical agro products like artificial herbs and pesticides with natural based micro-biological products; products which are working for- and not against nature.