Biofertilizers

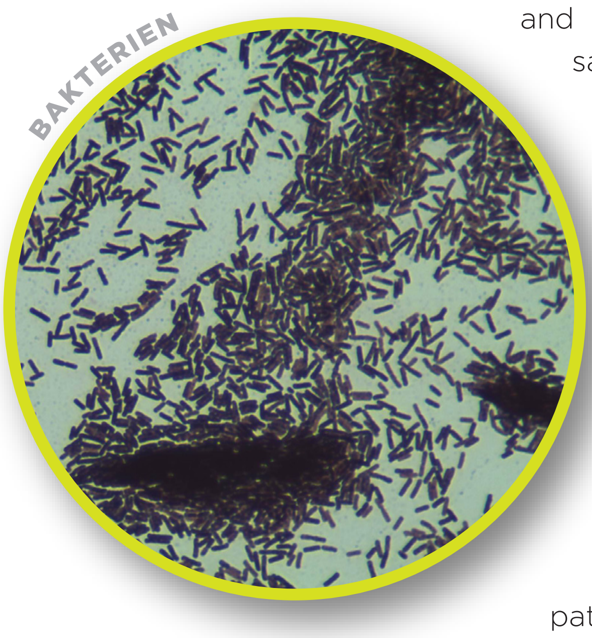
One of the objectives of agriculture is to achieve high yields per unit of land area to meet the growing demand for food, considering technical viability, economic profitability and pollution-free.

Biofertilizers are a relatively new technology, aimed at maintaining the sustainability of the system through the rational exploitation of natural resources and the application of appropriate measures to preserve the environment. They are products formulated with one or more microorganisms, which when inoculated can live associated or in symbiosis with plants, which helps nutrition and crop protection. The used groups of microorganisms usually constitute the edaphic microbiota; however, these can be affected by poor soil management and overuse of agrochemicals.

Biofertilizers are composed mainly of beneficial bacteria and fungi, which perform a wide variety of functions, meeting the needs of each type of crop. The development and use of **biofertilizers** is considered as an important alternative for the partial or total replacement of chemical fertilizers.

The benefits provided by **biofertilizers** in agriculture can be realized as phytostimulants, enhancing the germination of seeds and rooting by the production of growth regulators, vitamins and other substances. They increase the supply of nutrients by their action on biogeochemical cycles, such as nitrogen fixation (N_2), the solubilization of mineral elements or the mineralization of organic compounds, contributing to improve the structure of the soil by its effect on the formation of stable aggregates. They also act as bioremediators, which eliminate xenobiotic products such as pesticides, herbicides and fungicides, promoting soil health and allowing optimal root growth. In addition to being ecophysiological improvers, they increase resistance to both biotic and abiotic stress.

According to its agronomic approach, **biofertilizers** contain bacteria that have beneficial effects for the plant. They are known as Plant Growth Promoter Rhizobacteria (PGPR) as is the genus *Bacillus*; among which we find *Bacillus megaterium, B. subtilis, B. polymyxa,* all Grampositive, highlighting their ability to produce endospores (oval or cylindrical) as a support mechanism to various types of stress, which gives them resistance and helps to enhance their isolation in various habitats and even in environments under extreme conditions. Being saprophytes, most species are related to a great diversity of soils and substrates. Other genera of bacteria that may be present in these products are gram negative as: *Azobacter chroococcum, Azospirillum brasiliense* and *Pseudomonas flourescens*, these bacteria have affinity to the exudate of the roots of plants, in turn, these microorganisms have effect on soil fertility and crop productivity due to nitrogen fixation and solubilization of minerals such as phosphates, where *Azobacter chroococcum* acts. PGPR bacteria have adaptive capacity to the different phenological stages of plant cultures and the ability to be associative, endophytic and / or to establish symbiotic associations. Its metabolic diversity promotes plant growth and pathogen control.



Another type of microorganisms present in **biofertilizers** are fungi of the genus *Trichoderma*. The species of this genus are associated with the rhizosphere or can be related in an endophytic way, so they can promote the growth and development of crops, producing phytohormones such as auxins and gibberellins; in addition to producing organic acids (glyconic, smoke and citric) that lower the pH of the soil and promote the solubilization of phosphates, magnesium, iron and manganese; elements that are vital for plant metabolism. Within this genus we find species such as *Trichoderma harzianum, T. viride, T. reesei*.

Ectomycorrhizal and endomicorrhycic fungi that include the formulation of **biofertilizers**, establish symbiotic associations with the roots of vascular plants. The difference is that, in ectomycorrhizae the mycelium invades the root without entering the interior of the cells, unlike the endomyocorrhizas where the fungus penetrates into the interior of the root cells. The species present in the endomyocorrhizae are *Glomus intraradices, G. mosseae, G. brasilianum, G. clarum, G. deserticola, G. etunicatum, Gigaspora margarita*, where the hyphae of the fungus penetrate the cells of the root epithelium of the plant, forming a large mantle around the rootlets and interact between their cortical cells forming a mantle that helps the plant in the absorption of water and minerals, activity in which the fungus is also benefited from nutrients. The ectomycorrhizal fungi used as an active ingredient in **biofertilizers** are *Pisolithus tinctorius, Rhizopogon amylopogon, R. bilosuli, R. fulvigleba, R. luteolus, Lacaria bicolor, L. laccata, Scleroderma citrini, S. cepa*. Its function is the exchange of nutrients, when interacting with the roots the fungus receives carbon from the host plant, at the same time that the plant receives phosphorus and nitrogen through the hyphae of the fungus. This association improves the efficiency in the absorption of nutrients from the roots, increasing plant productivity.