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Rhizosphere Microbial Diversity: Impacts on Food Security and Ecosystem Integrity

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The rhizosphere (the soil root interface) plays a vital role in sustaining life in the terrestrial ecosystem. Microbes are key to soil formation and quality. An estimated 140–70 million tons of nitrogen are fixed by microbes worldwide annually (worth an equivalent of US $90 billion compared to nitrogen fertilizer use).Fungi are the main agents of decomposition in terrestrial environments and are responsible for the degradation of 70 percent of cell wall material and lignocelluloses. Micro-organisms control mineralization, organic matter production, geochemistry, and nitrogen availability in the rhizosphere. In mutualistic associations, micro-organisms provide the biological interface with the physical and chemical environment that many higher organisms depend upon for survival. However, the diversity of microbes and their function, both beneficial and antagonistic to sustainable agriculture, is poorly understood and has been largely ignored. There are an estimated 5–30 million species globally – some two million have been formally described, while the remainders are unknown or unnamed. Of the one billion bacteria found in one gram of soil, fewer than 5 percent have been discovered and named. For fungi alone, there are at least 1.5 million species with only 5 percent described.

The plant-microbe interactions result in intense biological processes in the rhizosphere. Interactions among crops and microbes influence the quality, productivity, and sustainability of food production systems. Microbes provide the potential to rely on biological processes rather than on external inputs for sustainable farming systems. The impacts of the rhizosphere on plant health and crop production is a critical issue in feeding the world population. 30% of farmers in developing countries are food-insecure. Beneficial microbes that confer ecological resilience include those that act to fix or cycle nutrients. The activity of these organisms, in turn, increases crop vigour and the sustainability of soils suitable for durable agricultural production.

Agriculture intensification, land use management, globalization, and the wide distribution of crop germplasm will continue to create new selection pressures on microbes, which, in turn, will create a matrix of negative pressures on food production systems. Climate change will provide an additional selection pressure on microbial species, strains, and populations by alterations in the rhizosphere environment. Several factors associated with climate change will affect microbes, including elevated temperature, extreme rain events, elevated carbon dioxide, and wind. The elevated atmospheric concentration of carbon dioxide is likely to result in changes in plant growth characteristics, affecting root systems, exudates, and litter production. Changes in vegetation cover will in turn affect the growth and distribution of free-living fungi, mychorrhizal relationships, soil bacterial diversity, and the occurrence of plant diseases. All of these changes are likely to be accompanied by dramatic fluctuations in local nitrogen cycling and in the efficiency of other biogeochemical cycles

Microbes can play a role in climate change mitigation. Soil organic matter is the major global storage reservoir for carbon (and not forests as is commonly thought). Microbial diversity is responsible for breaking this material down and making it available to plants while, at the same time, contributing to the rate of production and consumption of carbon dioxide, methane, and nitrogen. Soil biota thus plays a role in climate stabilization and regulation.

Food insecurity is likely to increase under climate change, unless early warning systems and development programs are used more effectively. Fundamental understanding of soil physical, chemical, and biological interfacial interactions in the rhizosphere at the molecular level is essential for developing innovative strategies for land resource management to sustain food security and ecosystem integrity. Managing world soils for food security and environmental quality is an extremely important mission of agricultural scientists. In this context, understanding and management of rhizosphere microbial genetic resources (MGR) deserves close attention in sustaining and enhancing soil productivity and crop production. Future research on this extremely challenging and important area of science should be stimulated to sustain and enhance ecosystem productivity.

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