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Rhizosphere Bioengineering and Plant Growth Management under Climate Changing Era

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ABSTRACT

Past few decades, due to intensive agriculture cultivation, the soils are getting huge amount of chemical-based fertilizers/pesticides, which is directly/indirectly affecting the soil microbiota; especially rhizospheric microbiome. These soil microbes are playing significant role to help plants to uptake nutrient, make unavailable elements to available form, and responsible for decomposition to enhance soil fertility. Soils are not only suffering with agro-chemical inputs, but it also facing various abiotic-abiotic stresses, including heavy metals and emerging contaminates accumulation such as nanoparticles, microplastics, pharmaceuticals and personal care products. The organic matter is continuously decreasing, and soil are losing its fertility and productivity. Due to the population explosion under this climate change era, to achieve the "Zero Hunger" goal in sustainable way is a challenging issue. It is necessary to solve the fundamental tasks that are of frontier importance for soil science today. The recent research developments, and combination of various emerging technologies such as nanotechnology, carbon or biochar materials, genomic, synchrotron, neutron, microbiome and metabolome, and genome editing tools open new avenue to restore soil health via soil engineering; especially rhizospheric microbiome. Thus, our focus on research is to edit soil rhizospheric microbiome and study its responses, determine dynamics, nature and features of interactions in the soil-microbe-plants system. To analysis of the processes occurring in rhizosphere in presence of nanoparticles, nanofertilizers and nanocarbon materials using synchrotron-neutron methods and NBIC (Nano-, Bio-, Information, and Cognitive) technologies to improve the soil fertility, to restore degraded soils, artificial soil system. Analyzed the processes and mechanisms of interphase interactions between the surface of soil particles, plant roots and microbes with the participation of nanoparticles. The structure and functions of the rhizosphere, and the possibilities for optimize its condition is critical to design the artificial ecosystem. Thus, the advanced technologies that is capable to decode the biological and ecological processes, and interactions in rhizosphere system were used such as genomic, synchrotron, neutron tomography methods and computer modeling with microscopic methods. The neutron computed tomography helped to construct a 3D combined image of the rhizosphere structure at the micro-level, whereas, omics technologies characterized the microbiome and metabolome of the rhizosphere.

Keywords: soil health, biochar, plants, zero hunger, nanotechnology

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References:

1. Singh, A.; Sharma, R.; Singh, S.; Singh, R.K.; Alexiou, A.; Sousa, J.R.; et al. Addressing abiotic stresses and advancing SDGs by Biochar for sustainable agriculture and environmental restoration. *Egypt. J. Soil Sci.* **2025** *65*, 463–489. DOI:10.21608/ejss.2025.340493.1927

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