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Ecological roles of soil microalgae and cyanobacteria in a Mediterranean olive orchard under differentiated management practices

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Soil microalgae and cyanobacteria (SM&C) play a crucial role in sustainable agricultural practices due to their diverse ecological functions. These microorganisms are actively involved in biogeochemical cycling, enhance soil biomass, contribute essential nutrients for plant development, and create favorable microenvironments by releasing bioactive compounds. They also establish synergistic relationships with other soil microbes. This study aimed to investigate the composition and functional potential of SM&C communities in a Mediterranean olive orchard located in a semi-arid region (Ferrandina, Basilicata, Italy), managed for over 22 years under two different systems: sustainable (S_{mng}) and conventional (C_{mng}). Microalgae and cyanobacteria were cultured using two selective liquid media—one with nitrogen to support general growth, and one nitrogen-free to isolate nitrogen-fixing cyanobacteria. Results showed that sustainably managed soils harbored significantly higher populations of microalgae (2.210×10^4 g^{-1} soil in S_{mng} vs. 0.872×10^4 g^{-1} soil in C_{mng}) and cyanobacteria (0.408×10^2 g^{-1} soil in S_{mng} vs. 0.240×10^2 g^{-1} soil in C_{mng}). Dominant taxa were identified through light microscopy and metagenomic analysis targeting 16S, 18S, and ITS rDNA regions. In C_{mng}, green algal genera such as *Trebouxia*, *Euglena*, and *Chaetophora*, along with the diatom *Cymbella*, were predominant. Conversely, in S_{mng}, a higher prevalence of the cyanobacterial genus *Anabaena*, green algae *Oedogonium* and *Scenedesmus*, and the diatoms *Navicula* and *Pinnularia* was observed. Soil management also influenced the metabolic output of SM&C, with S_{mng} soils showing upregulation of biosynthetic pathways associated with secondary metabolites, phytohormones, fatty acids, and lipids, which are known to enhance plant growth. Overall, the findings highlight the potential of SM&C not only for ecological functioning but also as valuable allies in maintaining soil health and improving crop productivity.
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