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ROOTS OF THE FUTURE
Suolo e pianta nel cambiamento globale: tecnologie, degrado, sostenibilità

LIBRO DEGLI ABSTRACT

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SESSIONE 4

Tecnologie emergenti per l'analisi e la gestione integrata del sistema suolo-pianta

PLANT GROWTH PROMOTION AND BIOCONTROL BY SOIL CYANOBACTERIA IN TOMATO: A SOIL–MICROBE–PLANT INTERACTION PERSPECTIVE

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Soil cyanobacteria are increasingly recognised as key drivers of soil health and climate-resilient agroecosystems due to their ability to enhance nutrient cycling, stabilise soil structure, and modulate plant–microbe interactions. In this study, we investigated the diversity, functional traits, and biotechnological potential of soil cyanobacterial communities in a Mediterranean olive (Olea europaea L.) orchard located in a semiarid region of southern Italy, managed for over twenty years under contrasting sustainable (S_{mng}) and conventional (C_{mng}) management systems.

Topsoil samples (0–5 cm) were analysed using an integrated approach combining culture-dependent isolation, 16S rRNA gene-based metagenomics, and rhizosphere metabolomic profiling. Sustainable management significantly increased cyanobacterial abundance (0.408×10^2 vs. 0.240×10^2 g^{-1} soil) and taxonomic diversity, with diazotrophic genera such as Anabaena and Nostoc dominating the communities. Functional annotation revealed enrichment in biosynthetic pathways associated with secondary metabolism, including alkaloids, phenylpropanoids, phytohormones, polyketides, and terpenes, suggesting an active role in plant signalling and stress adaptation.

Cyanobacterial communities from the S_{mng} soils exhibited plant growth-promoting effects, enhancing the development and physiological status of tomato plants (Solanum lycopersicum L., cv. moneymaker) grown under controlled conditions, and improved soil chemical and biological quality. Metagenomic and metabolomic analyses further indicated that these microorganisms contribute to the establishment of beneficial microbial networks and to the accumulation of defense-related and stress-responsive metabolites in the rhizosphere.

Consistently, germination assays revealed a clear link between microbial metabolites and early plant development. Selected S_{mng}-associated strains markedly enhanced germination, increasing it up to 98.5%. These results are linked to the presence of hormone-like compounds promoting radicle growth and seedling establishment.

Isolates from S_{mng}soils exhibited enhanced biocontrol potential, with methanolic extracts showing selective antimicrobial activity against phytopathogens, including inhibition zones up to 37.5 mm (Aspergillus niger) and 27.5 mm (Penicillium italicum), and moderate effects (6–19 mm) against Fusarium solani. This indicates a strong pathogen-suppressive capacity linked to diverse secondary metabolites, with S_{mng}-derived strains displaying broader and more consistent bioactivity than those from C_{mng} systems.

Overall, sustainably managed soils (S_{mng}) supported cyanobacterial communities with enhanced functional potential for nitrogen fixation, carbon sequestration, and production of bioactive compounds. These findings highlight the central role of soil cyanobacteria as modulators of plant–soil system resilience and support their exploitation as biotechnological tools for sustainable agriculture and ecosystem-based climate adaptation strategies.