THE GOOD ARTICLES

GOOD
AGROECOLOGY FOR WEEDS

01

BENEFICIAL MICROORGANISMS TO BOOST AGROECOLOGICAL TRANSITION

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In the next decades, a major challenge for European agriculture will be the sustainable production of food crops that can be achieved through the implementation of agroecological practices, the reduction of chemical fertilizers and pesticides, and the protection of biological soil fertility.

In this perspective, soil microorganisms play a fundamental role, as they are the basis of the completion of biogeochemical cycles, modulating soil biochemical, biological, and nutritional processes. Among such beneficial microorganisms, a key group is represented by the complex microbial communities living in the rhizosphere and establishing symbiotic relationships with plant roots, the arbuscular mycorrhizal fungi (AMF). AMF (phylum Glomeromycota) live in the roots of about 80% of land plants, including the major food crops, from cereals to legumes, fruit trees, vegetables and industrial plants. They are obligate biotrophs, obtaining carbon from the host plant in exchange for soil plant nutrients (such as P, N, S, K, Ca, Cu, and Zn), that are absorbed and transferred to the host plant by large extraradical hyphal networks spreading from colonised roots into the soil, where many nutrient transporter genes are expressed. The importance of such hyphal networks for plant nutrition is shown by some data of their structure: their length ranges from 2.7 to 20.5 m/g of soil, with a mean growth rate of 0.74–1.1 m per day. AMF are closely associated with large and diverse bacterial communities that complement and enhance their properties, showing important plant growth–promoting traits, such as phosphate solubilisation, phytate mineralisation, nitrogen fixation, and the production of siderophores, plant hormones and antibiotics.

The numerous plant-beneficial properties of AMF and their associated bacteria may be exploited to improve the efficient use of natural resources and enhance the performance of cover crops. Actually, cover crops represent an increasingly used management practice in sustainable agriculture and agroecology, as the most promising tool to enhance biodiversity, reduce soil erosion and boost biological soil fertility, while reducing fertilizer input by suppressing the development of aggressive agricultural weeds. The competitive ability of cover crops against weeds may be enhanced by AMF inoculation through two mechanisms. The first one entails mycotrophic cover crop species, such as *Avena*, *Hordeum*, *Lolium*, *Trifolium*, *Medicago*, *Secale*, *Sorghum*, *Vicia*, *Vigna*, which are rapidly and highly colonized by AMF, thereby benefiting from the increased availability of soil nutrients absorbed and transferred by the extraradical mycorrhizal network. The second one entails non-mycotrophic (non-host) weeds, such as most species belonging to the families Brassicaceae and Chenopodiaceae, which are unable to establish the mycorrhizal symbiosis and whose growth is negatively affected by AMF inoculation, mainly due to their reduced access to nutrients and also to parasitic interactions involving plant defence responses and root cell death. Actually, two of the most aggressive weeds, *Chenopodium album* and *Echinochloa crus-galli*, when inoculated with AMF, showed

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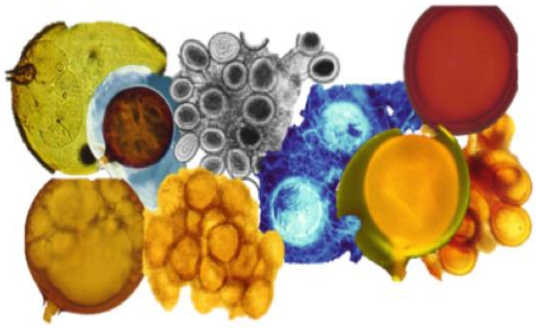
shoot dry weight decreases of 59% and 46% compared with control plants, while the main crop, sunflower, had P levels increases of 48%.

A further advantage of mycorrhizal inoculation of cover crops consists in the long-term survival of the extraradical mycelium, whose lifespan and functionality are uncoupled from host plant lifespan, being able to establish mycorrhizal symbioses with the successive crops for more than five months since the harvest of the preceding crop. In addition, mycorrhizal cover crops represents a strategic tool for AMF-inoculation of adjacent fruit trees, as the extensive networks of extraradical hyphae spreading into the surrounding soil can establish belowground connections among the root systems of plants belonging to different species, genera and families, thereby establishing the symbiosis with the roots of adjacent perennial plants, which can, in this way, benefit from the soil resources flowing in the network.

Our Horizon Europe research project GOOD (AGrOecOlogy for weeDs), will assess the efficacy of the combination of cover crops with the use of beneficial AMF as agroecological tools for weed management. Autochthonous AMF from seven EU countries will be reproduced in pot cultures together with highly mycotrophic host plants, given their status of obligate biotrophic symbionts. Then the reproduced AMF will be sent back to the relevant Living Labs, for inoculating the seeds of cover crops, in order to increase their performance and promote their competitive ability against weeds. The main crops to be tested with the experimental seed inoculation of cover crops are represented by herbaceous species, like wheat, rice, maize, soybean, and by perennial fruit plants like apple, citrus, grapevine and olive. At the end of the experimental studies, the GOOD project will devise innovative, systemic and sustainable solutions for weed management in Europe, in order to promote long-term and large-scale agroecological transition towards innovative low-input, safe and resilient agroecosystems.



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