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EXPLOITING THE MULTIFUNCTIONAL POTENTIAL OF BELOWGROUND BIODIVERSITY IN ORGANIC FARMING: A CHANCE FOR IMPROVING HORTICULTURAL PRODUCTIONS.

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Abstract: A project (EXCALIBUR) has been started aiming to deepen the knowledge on soil biodiversity dynamics and its synergistic effects with prebiotic and probiotic approaches in horticulture. In this context, new multifunctional soil microbial inoculants (bio-inocula) and bio-effectors will be tested on three model crops of economic importance (tomato, apple, strawberry) under different experimental and open-field conditions across Europe. Excalibur plans to develop a comprehensive strategy of soil management improving the effectiveness of biocontrol and biofertilization practices in organic farming also through the development of a Decision Support System (DSS) and tools for monitoring inocula in the soil. Such activities are expected to encourage the adoption of best practices derived from the new strategy by the farmer's increasing also the awareness on the potential benefits of soil biodiversity maintenance for crops' performance.

Introduction: Most of the biodiversity in agricultural systems resides in the soil, where microbial communities play a central role in virtually every biogeochemical cycle, and interact with other soil organisms and plants shaping the crops performance (Vukicevich et al. 2016). However, soils are becoming more and more vulnerable due to several pressures: as a direct consequence, the decline in soil biodiversity has been identified as one of the major threats and issues to deal with in the coming years (McBratney et al. 2014).

Diverse groups of soil-borne microbes, such as root endophytic fungi, mycorrhiza, plant growth-promoting rhizobacteria, rhizobia and phosphate solubilising species exert positive effects on plant growth and survival through direct and plant-mediated mechanisms (Van der Heijden et al., 2008). Thus, the application of selected beneficial microbial consortia in agriculture represents an intriguing tool to promote plant-soil system's health and productivity. However, the major bottleneck to the commercial use of microbial inoculants is their inconsistent performance under field conditions (Malusá et al., 2016). Understanding and being able to predict the consequences on natural soil biodiversity due to introduction of bioinocula and function-specific microbes require dedicated studies on the composition and functioning of ecosystems (van der Putten et al. 2007). Therefore, considering the complexity of the soil system, we have designed a project ("Exploiting the multifunctional potential of belowground biodiversity in horticultural farming" - EXCALIBUR) that moves beyond the simplified view of individual plant–microbe or soil-plant interactions and consider the key factors that influence this complex ecosystem, considering the plant, the soil, and the soil organisms as a unique “meta-organism” able to mediate and influence the various mechanisms that contribute to plant health and productivity. To this end, the project aims to deepen the knowledge on soil biodiversity dynamics and its synergistic effects with prebiotic and probiotic approaches in horticulture, using a multi-actor approach.

Material and methods: New multifunctional soil microbial inoculants (bio-inocula) based on microorganisms showing either plant growth promoting or plant protection effects and bio-effectors (animal- or plant-based materials) are tested on three model crops of economic importance (tomato, apple, strawberry) under different experimental and open-field conditions across Europe (11 countries). The feed-feedback effect on native biodiversity is monitored using a plethora of methods (classic and molecular) that covers the majority of the soil organisms: archaea, bacteria, fungi, nematodes, meso and macrofauna. The analyses include: soil physical, chemical and biochemical parameters, microorganisms’ community analysis (classical microscopic and DNA-based methods), nematode and earthworm trophic groups analysis, analysis of mycorrhizal fungi. The effect on the crops is assessed by measuring their growth and yield parameters, as well as the influence on diseases or pests occurrence.

The data gathered at the beginning of the trials and during the crops’ growth are used to develop a statistical model to better quantify the impacts of bio-effectors and bio-inocula on crop production and soil biodiversity under organic farming management and biotic/abiotic stress conditions. The model will be the base for the development of a DSS meant to support adopting a biodiversity-driven soil management approach by farmers.

Moreover, adequate tools to monitor the persistence and the fate of the microbial inocula in the field are planned to be devised. These will support the assessment of the microbial inputs and fine tuning their application methods.

The data will be used to evaluate the effects of the new strategy on soil quality and ecosystem functions, verifying the dynamics of soil and plant-associated microbial biodiversity at multi-scales, as well as ecological sustainability through the analysis of a life-cycle assessment (LCA) throughout the value chains.

Results: The identification of beneficial microbial strains to be formulated into liquid or solid products resulted in the selection and characterization of about 15 bacterial and fungal strains in total. They are tested to assess the compatibility between strains having different functions (i.e. growth promotion and plant protection) and also to verify the feasibility of creating formulations with bio-effectors. A total of 33 trials (19 using inocula for plant protection and 14 for growth promotion) have been set up. The results from these trials are expected to allow finding the link between soil biodiversity and plant health and growth. As an output, Excalibur plans to develop a comprehensive strategy of soil management, considering thus the timing and mode of application of bioinocula, the effect of soil practices on the bioinocula activity as well as their effect on soil biodiversity dynamics in relation to the different agro-ecological factors, which shall improve the effectiveness of biocontrol and biofertilization practices in agriculture.

Discussion: Enhancing the efficacy and application of biocontrol and biofertilization practices in horticultural farming is the final goal of the project activities. Indeed, the difficulties in optimizing the use of bioproducts under different conditions as well as the not uniform results obtained under field conditions are hindering the diffusion of their use among farmers (Malusá et al. 2016). Soil biodiversity plays a role in this regard (Orgiazzi et al., 2016). It is believed that dissemination to encourage the adoption of best practices derived from the new proposed strategy is expected to maximise, particularly among organic farmers, the awareness on the potential benefits of soil biodiversity maintenance as underlined also by the United Nation 2030 Agenda for Sustainable Development (2015) and its Sustainable Development Goals as well as by the new EU Regulation 2018/848 on organic production and labelling of organic products.

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