EGU2020-3345, updated on 07 Dec 2020
https://doi.org/10.5194/egusphere-egu2020-3345
EGU General Assembly 2020

Smart use of microbial-rich vermicomposting to enhance tripartite plant-microbe-soil interactions

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Vermicomposting is a natural process that utilizes earthworms and associated microbiome to transform organic wastes into vermicompost by-products that are rich in beneficial microorganisms and nutrients such as carbon, phosphorus, nitrogen, magnesium, and calcium. Liquid vermicompost extract (LVE), a derivative of the vermicomposting process, has recently gained interest among scientists and organic farmers due to their potential ability to enhance tripartite plant-microbe-soil interactions that would lead to improved plant and root growth, soil health and overall crop yield productivity. To investigate the short-term effect of LVE on soil mycorrhizal inoculum potential (MIP) and plant-mycobiome interactions, a field trial was carried out at CiRAA E. Avanzi, San Piero a Grado, Pisa, Italy.

The effect of LVE and its associated microbial and chemical components on soil MIP and AMF root colonization was evaluated on five summer crops, i.e. chickpea (*Cicer arietinum* L.), berseem clover (*Trifolium alexandrinum* L.), lentil (*Lens culinaris* L.), soybean (*Glycine max* L. Merrill), and sunflower (*Helianthus annuus* L.). The test plants were grown with or without the application of LVE in a split-plot trial with five replicates. Freshly made LVE from vermicomposting of wheat straws mixed with horse manure was screened for microbial properties using the Illumina Miseq sequencing platform. Seed inoculation with LVE was done before planting while field inoculation was done at the stem-elongation stage. Un-inoculated seeds and plots were used as controls. Soil MIP was assessed before planting and after harvesting, while AMF root colonization was evaluated at the mid-flowering stage of each crop.

The bacterial 16S and fungal ITS sequence analyses showed a high bacteria and fungal abundance and taxonomic alpha diversity present in the LVE. The most dominant taxa included Mucor, Citrobacter, Pseudomonas, Arcobacter, Azomonas and Clostridium. These microbes are commonly found in agricultural soil and are linked to the hydrolysis of complex organic matter, nutrient recycling, production of growth-promoting factors and siderophores, while others are known to produce peptide antimycotics and antibiotics that protect plants against pathogenic soil microorganisms.

The soil MIP significantly ($p < 0.0001$) differed between the two soil sampling times (before

planting and after harvesting). It was evident that both seed and field inoculation with LVE significantly enhanced the soil MIP and this could benefit the next crop under rotation. AMF root colonization varied significantly across the crop species ($p < 0.0001$) and LVE treatment ($p = 0.006$). Highly nodulated lentils and berseem clover roots recorded significantly higher AMF root colonization than all the other crops. LVE inoculation had an overall positive effect on AMF root colonization with an average increase of 6.2% compared to the un-inoculated crops. These short-term results indicate that there could be a positive effect of the LVE inoculation on the soil MIP and AMF root colonization of our test crops, which could be attributed to the beneficial additive effects of the LVE that enhanced the tripartite plant-microbe-soil interactions.

Keywords: Vermicomposting, Liquid vermicompost extract, Soil MIP, AMF root colonization, Legumes