Effect of soil restoration practices on the soil microbiota in Uruguayan vegetable and grain production systems

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Intensive agriculture affects soils worldwide leading to increasing soil degradation and loss of ecosystem functions. We hypothesized that soil restoration practices select beneficial soil and rhizosphere microbiota, preserve soil health and hence, increase plant biomass in contrast to conventional intensive agricultural practices.

Therefore, we evaluated two Uruguayan long-term field experiments (LTEs), where soil physicochemical properties, plant performance and soil and rhizosphere microbiota were studied. LTE1 allows to assess the soil restoration potential of organic fertilization (compost, poultry manure, cover crop) combined with conventional tillage (CTOF) or reduced tillage (RTOF) in a vegetable farming system. CTOF and RTOF were compared with conventional tillage combined with mineral fertilization (CTMF), and an adjacent undisturbed site (UND) was used as reference of healthy soil. LTE2 allows to assess the soil restoration potential of pasture-crop rotations in a grain cropping system. Short pasture-crop rotation (SR, two years grain crop cultivation alternating with two year of sown pastures) and long pasture-crop rotation (LR, two years grain crop cultivation alternating with four year of sown pastures) were compared with continuous grain crop rotation (CC), and an adjacent natural grassland (NG) was used as reference of healthy soil.

In LTE1, the fertilization source strongly shaped the soil and table beet rhizosphere microbiota. RTOF exhibited higher table beets yields than CTMF, also a significantly proportion of large soil aggregates (> 2 mm), soil organic C, nutrient availability and microbial alpha-diversity than CTMF and became more similar to UND. We propose that RTOF has the potential to restore and improve soil health under intensive vegetable farming systems mediated by soil and rhizosphere microbiota.

In LTE2, pasture-crop rotations increased soil aggregates >2 mm, soil N and decreased bulk density in comparison to CC and showed values similar to NG. High-throughput amplicon sequencing (16S rRNA gene/ITS2) showed that soil microbial communities, and rhizosphere bacterial/archaeal communities were shaped by rotations. Moreover, in spring, the two N-fixing bacteria Devosia and Microbacterium were positively correlated with oat aerial biomass and N content, and had a higher relative abundance in SR in comparison to CC. The selection of a beneficial soil and rhizosphere microbiota and the improvement of soil physicochemical properties lead to an increase of oat aerial biomass and N content in crop-pasture rotations in comparison to CC. In summer, the rotation effect on the microbial rhizosphere communities' was lost. Nevertheless, Microbacterium isolates were obtain by bacterial dilution plating from SR rhizospheres, which showed several in-vitro plant-beneficial traits. The majority of bacteria isolates were identified as *Bacillus* and *Pseudomonas* and isolates obtained from SR/LR showed several in-vitro plant-beneficial traits. In summary, our results suggest that pasture-crop rotations have the potential to improve soil health under grain cropping systems mediated by soil and rhizosphere microbiota.