Engineering *In Situ* Soil and Plant Microbiomes To Improve Agricultural Productivity

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The world's population is predicted to reach 9 billion people by 2050 thus increasing crop production on current agricultural land to meet the rising demand for food is paramount. Farmers routinely manage both plant and soil nutrition to increase crop yields. However, active management of *in situ* soil and plant microbiomes to improve productivity is uncommon. Here, we present a patented technology aiming to reliably engineer soil and plant microbiomes to increase crop production. Bioprime is a ferment of molasses that can be applied as seed coating, or as foliar and soil spray. Bioprime contains a diverse range of bioactive carbon compounds known to either stimulate plant growth directly (e.g. plant hormones 2,3-Butanediol and acetoin) or indirectly via the plant microbiome (e.g. microbial signalling molecules and labile carbon). Results from two trials highlight the robustness of Bioprime to improve crop growth and yields in vastly different production systems. An on-farm potato trial consisted of four treatments: Bioprime-only (100 L/ha), compost (40 t/ha five years prior to this trial), Bioprime plus compost, and an unamended control. From each treatment five spatial replicates were sampled. The two treatments containing Bioprime resulted in a significant increase in marketable potato yields compared to the untreated control (+33.8% for Bioprime plus compost; and +33.2% for Bioprime-only $P \leq 0.039$). Historic compost application on its own also increased yield (+22.7%), but this was not significant ($P = 0.214$) despite higher soil fertility e.g. higher concentrations of carbon (+30%), nitrate (+100%), and phosphate (+11%). Both compost and Bioprime amendment changed the soil microbiome as determined by automated ribosomal intergenic spacer analysis for bacteria and archaea, and to a lesser degree Dikarya (fungi). In a pot trial, sandy soil was planted with Bioprime-treated and untreated wheat seeds (*var*. Mace). After four weeks, plant shoot weight increased by 26.7% ($P = 0.004$) in the Bioprime treatment compared with the untreated control concomitant with significant changes to the rhizosphere microbiome ($P = 0.011$; 16S rRNA gene sequencing). Bioprime application increased the relative abundance of typical rhizobacterial taxa belonging to different phyla (e.g. Betaproteobacteria, Bacteroidetes, and Actinobacteria). Furthermore, *in silico* predicted gene functions related to microbial signalling chemistry, disease suppression, and nutrient acquisition were upregulated in the Bioprime-treated wheat rhizosphere soil. In conclusion, Bioprime represents a novel, low-cost technology to improve agricultural productivity by engineering soil and plant microbiomes *in situ* thereby contributing to global food security.