How can we better manage soil and plant microbiomes to increase crop production?

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Introduction

Increasing food production on current agricultural land is paramount to ensure food security for an increasing world population. To achieve this goal, targeted management of the functionally diverse soil and plant-associated microbiomes in situ represents a promising and sustainable approach to increase crop productivity. Bioprime, a soil additive, is a patented ferment of molasses[1] containing a plethora of carbon compounds. Some of these directly stimulate plant growth[2] while others are plant and microbial signalling molecules and analogues[1]. We tested the effects of Bioprime on plant growth and yields for different crops and farming systems.

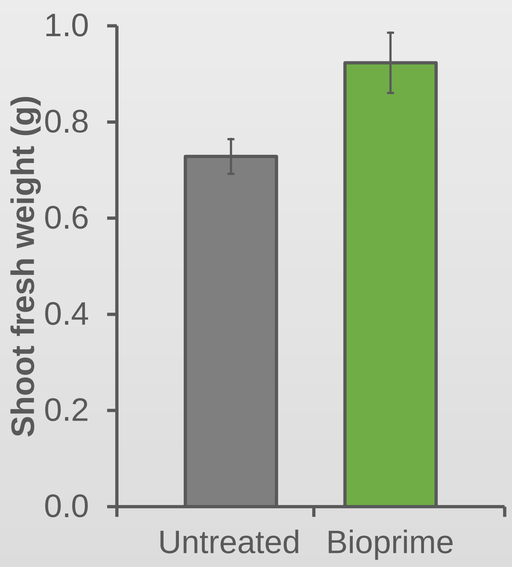
Methods

A pot trial using sandy soil was planted with Bioprime-treated and untreated wheat seeds and harvested after three weeks. Shoot biomass was determined and rhizosphere soil was sampled. The microbial community was analysed by sequencing the V4-V5 region of the 16S rRNA gene (Illumina MiSeq, AGRF). Obtained reads were processed using Qiime[3], Primer-E[4], and PICRUSt[5]. An on-farm potato trial with four treatments (control, compost [40t/ha], Bioprime [100 L/ha], Bioprime and compost) was harvested at the end of the 2018 growing season and marketable potato yields were determined. Bulk soil was analysed for nutrition and microbial community composition (ARISA[6]).

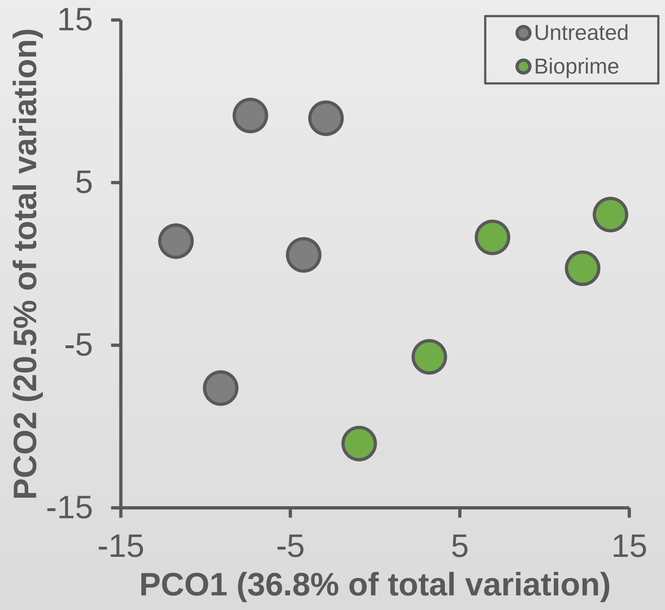
Results

Wheat pot trial

Bioprime increased wheat biomass (27%; $P = 0.004$).

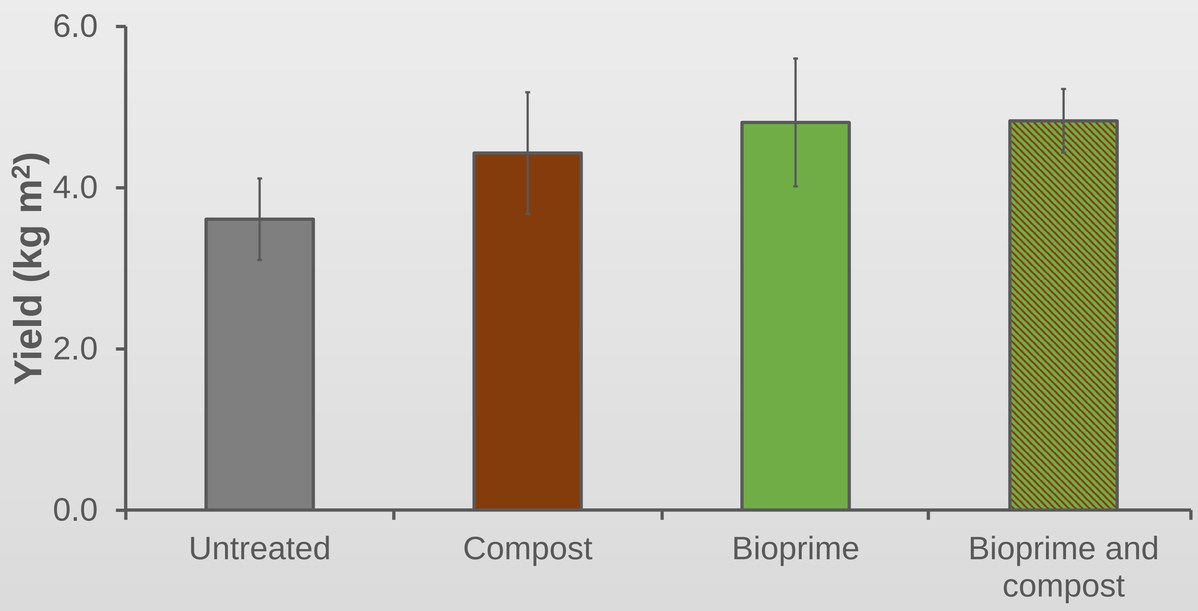


Bioprime altered the microbial community structure ($P = 0.011$).

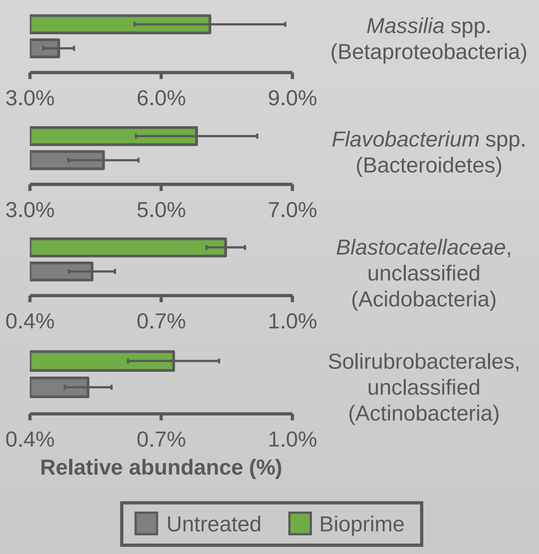


Potato farm trial

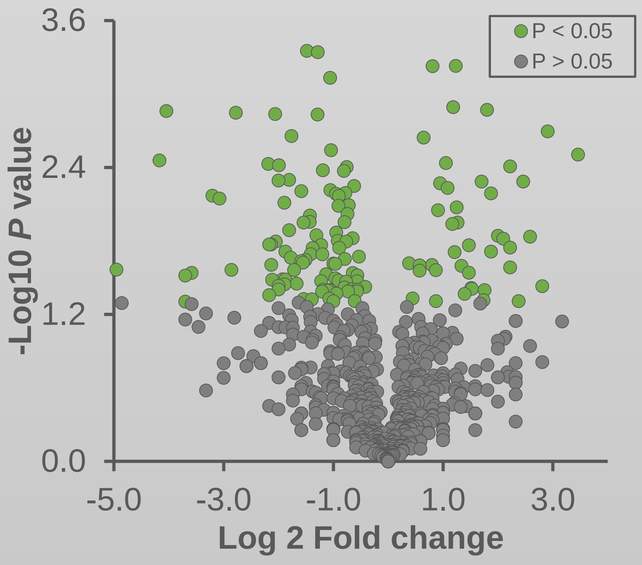
Marketable potato yield increased in all treatments (23% to 34%) but was only significant where Bioprime was added ($P < 0.039$).



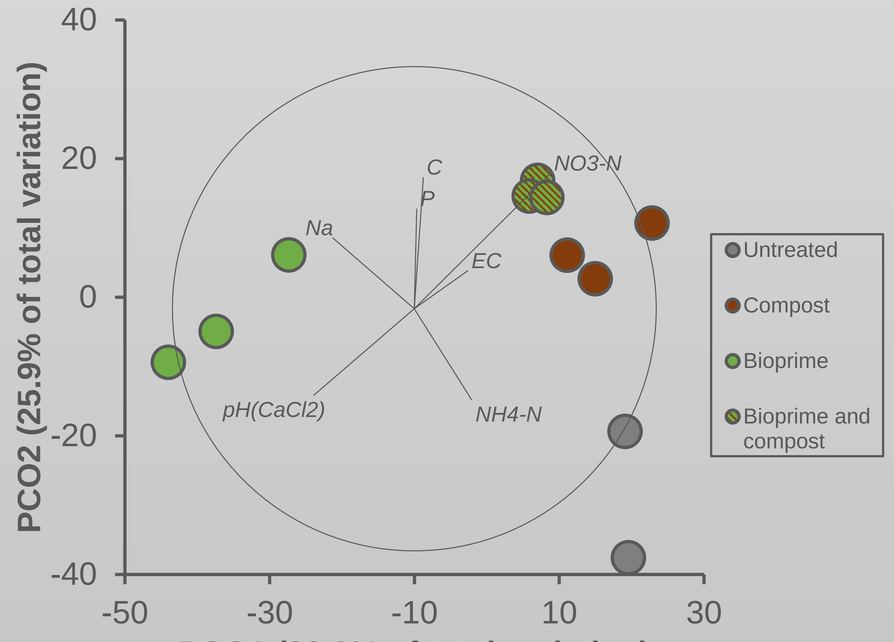
Bioprime stimulated rhizobacteria from different phyla.



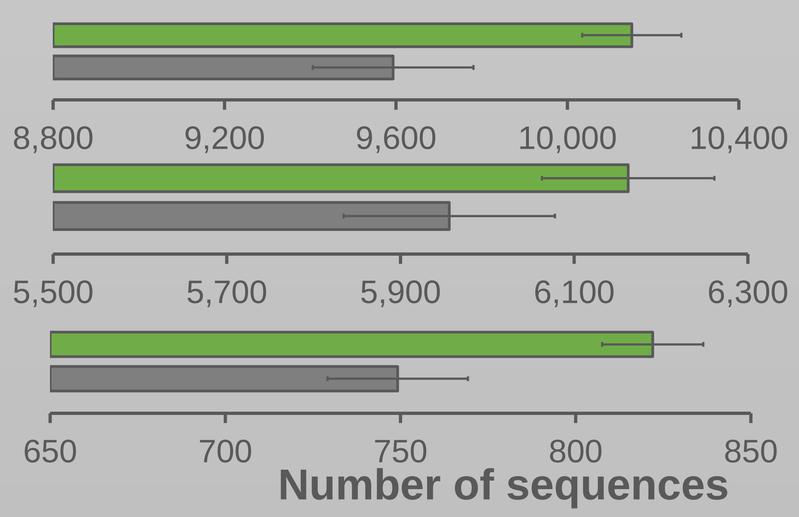
Bioprime stimulated and suppressed different genera.



Only the Bioprime treatment altered the microbial community structure significantly ($P = 0.05$).



Bioprime increased predicted gene functions involved in microbial signalling chemistry, disease suppression and nutrient acquisition.



Biosynthesis and biodegradation of secondary metabolites ($P = 0.010$)

Biosynthesis siderophore group nonribosomal peptides ($P = 0.009$)

4-phytase (K01093, $P = 0.044$)

Untreated Bioprime

Conclusions

Bioprime promotes plant growth and increases yield in different crops and farming systems.

Bioprime reliably changes the structure of soil and rhizosphere microbiomes stimulating rhizobacterial taxa belonging to different phyla.

Bioprime increases predicted gene functions that have plant-growth promoting properties.

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References: [1]Keating (2014) Patent number: WO2014082130A1; [2] Ryu et al (2003) PNAS 100: 4924-4932; [3]Caporaso et al. (2010) Nature Methods: 10.1038/nmeth.f.303; [4]Clarke & Warwick (2001) PRIMER-E: Plymouth; [5]Langille et al. (2013) Nature Biotechnology: 1-10; [6]Ranjard et al. (2001) AEM 67: 4479-4487