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Biological strategies and phosphorus management improving soil phosphorus dynamics and microbial functionality in sugarcane

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Sugarcane (*Saccharum* sp.) cultivation relies heavily on phosphate fertilisers, increasing costs and compromising long-term sustainability. In this context, microbial bioinoculants emerge as a promising strategy to optimise phosphorus (P) dynamics in soil–plant systems. This study evaluated the effects of inoculation with arbuscular mycorrhizal fungi (*Rhizophagus clarus* – RC) and plant growth-promoting rhizobacteria (B), applied individually or in consortium (RC+B), on soil P fractions, plant P uptake and rhizosphere microbial interactions. The experiment was conducted under greenhouse conditions using a Oxisol and the sugarcane variety RB867515, under three P levels (0, 30 and 90 mg kg^{-1}). Evaluations were performed at 30 and 90 days after inoculation (DAI), including soil P fractionation (Mehlich-3, Pi/Po-NaOH, HCl and residual), plant P content, and microbial community structure (16S rRNA and SSU-AMF). Statistical analyses included generalised linear models (GLM) and Spearman correlations ($|r| \geq 0.7$; $p \leq 0.05$). At early stages, the RC+B consortium increased available P and plant P uptake under moderate fertilisation, indicating enhanced nutrient mobilisation. At later stages, bacterial inoculation showed greater effectiveness under high P, maintaining higher availability. Over time, a shift towards more stable P fractions was observed, particularly under bacterial treatments, suggesting progressive transformation of soil P pools. Microbial associations varied with fertilisation level, with key bacterial groups positively correlated with plant P under moderate and high P. Notably, the fungal family Endogonaceae showed consistent negative correlations with plant P variables under high fertilisation, suggesting functional suppression of the mycorrhizal symbiosis under excess phosphorus. These results demonstrate that aligning phosphorus management with bioinoculation strategies improves P use efficiency and promotes more sustainable sugarcane production systems.

KEYWORDS: Phosphorus fractionation, nutrient cycling, microbial consortia, plant nutrition

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