Tropentag, September 16-18, 2026, hybrid conference

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Soil management shapes plant responsiveness to rhizosphere bacterial inoculation: Single strains versus consortium

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Abstract

Soil management drives plant–microbe interactions, affecting the outcome of microbial inoculation strategies. In this study, we evaluated the effects of oat (*Avena sativa*) seed inoculation with rhizosphere bacterial inoculants. A five-week greenhouse experiment was conducted using a randomised complete block design (6 repetitions), with three soils and five seed coating treatments. Soils were obtained from a long-term field experiment at INIA Las Brujas – Uruguay, with contrasting management histories (CTMF -conventional tillage and mineral fertilisation, RTOF - reduced tillage and organic fertilisation, and UND - undisturbed soil as control). Seed coating treatments were single bacterial isolates (*Agrobacterium fabrum* (3IV10), *Pseudomonas umsongensis* (4IV7), *Ensifer adhaerens* (5II23)), a consortium (CON) composed with the three isolates, and a non-inoculated control. We assessed plant growth and chlorophyll content, root growth, rhizocompetence (bacteria cfu) and rhizosphere microbial community composition using amplicon sequencing. Plant responses were strongly soil-dependent. UND behaved distinctly, with lower chlorophyll content but higher root biomass and greater responsiveness to inoculation compared to CTMF and RTOF. This soil, characterised by higher biological activity and favourable structure, appeared to enhance soil–plant–microbe interactions, suggesting a shift towards root development. Inoculant performance varied, with 3IV10 showing the most consistent positive effects on root volume and chlorophyll content. CON did not outperform single isolates despite higher cfu, indicating that colonisation alone does not necessarily translate into plant benefit. CTMF behaved as a more restrictive system, while RTOF showed intermediate and stable responses. Inoculants 3IV10, 5II23, and CON were most affected by soil management, showing strong soil-dependent responses, with effect sizes reaching up to ~60 % variation in root volume, ~50 % variation in shoot biomass, and ~16 % variation in chlorophyll content across soils. Overall, soil management was a key factor shaping plant responses to inoculation, and microbial establishment alone was not a reliable predictor for plant benefit.

Keywords: Consortium, microbial inoculation, plant–microbe interactions, soil management

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