July 2026

Soil Science Challenge Grants Program

Adelaide University

Drivers of change for soil microbiomes: project summary

Project period: June 2022 to December 2025

Introduction

This project examined how soil microbial communities have responded to 2 decades of changing agronomic management practices across the grain-growing regions of southern Australia. The project encompassed 3 major stages:

1) Stage 1 involved the analysis of an extensive deoxyribonucleic acid (DNA) archive of 1,023 soil samples. More than 42,000 quantitative polymerase chain reactions (qPCR) targeting 42 functional groups and pathogens were performed alongside full-length 16S bacterial sequencing of all 1,023 samples and fungal internal transcribed spacer (ITS) sequencing of 553 samples.

2) Stage 2 involved examining the effects of tillage, herbicides, nematode-microbe interactions and stubble management on microbiome composition. More than 300 samples were collected for determining the soil microbiome, which were supported by non-destructive phenotyping of plant growth using automated imaging systems.

3) Stage 3 involved field trials in Western Australia, South Australia and Victoria, comparing 'past' versus 'current' agronomic farming management systems and their effects on the soil microbiome and crop performance. In total, over 1,500 soil samples underwent DNA analysis, more than 50,000 qPCR reactions were completed, and around 1,700 samples were sequenced for bacterial and/or fungal diversity.

Findings

The findings revealed a striking resilience of soil biological communities. Despite 20 years of evolving agronomic management, the overall structure and diversity of soil microbial communities remained remarkably stable. Temporal factors like rainfall and temperature exerted greater influence on microbiome communities than gradual management shifts, with 'year of sampling' explaining roughly 25% to 31% of variation in fungal communities. Similar stability was evident in nematode assemblages, with Nematode Indicator Joint Analysis based indices (enrichment and structure) showing no directional changes across regions over 2 decades.

While long-term resilience dominated in the historical data, controlled studies in the greenhouse and field confirmed that management practices can still drive meaningful short-term microbial shifts. Soil sterilisation reduced network complexity, while the reintroduction of microbes or nematodes restored connectivity. Herbicide treatments significantly altered community composition and simulated tillage caused measurable bacterial shifts compared to no-tillage.

Publications

This project has published the following papers with additional papers currently in preparation or in review. This section will be updated once additional papers are published.

Shi, A, Cavagnaro, TR, Sumby, KM, McDonald, G, Denton, MD, Roy, SJ & Schilling, RK 2024, Impact of agronomic management on the soil microbiome: a southern Australian dryland broadacre perspective, in Sparks, DL (ed.), *Advances in Agronomy*, vol. 186, Elsevier (Academic Press), pp. 113–171 DOI: 10.1016/bs.agron.2024.02.008

Sumby, KM, Stephen, JR, Austin, JJ, Schilling, RK & Cavagnaro, TR 2024, A novel method to assess the integrity of frozen archival DNA samples: alpha diversity ratios of short- and long-read 16S rRNA gene sequences, *Methods in Ecology and Evolution*, vol. 15, no. 10, pp. 1804–1813, DOI: 10.1111/2041-210X.14411

More information

Learn more about the Soil Science Challenge Grants Program.

Contact the project lead, Professor Stuart Roy.

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Acknowledgement of Country

We acknowledge the continuous connection of First Nations Traditional Owners and Custodians to the lands, seas and waters of Australia. We recognise their care for and cultivation of Country. We pay respect to Elders past and present, and recognise their knowledge and contribution to the productivity, innovation and sustainability of Australia's agriculture, fisheries and forestry industries.