

MATCHING SOIL PERFORMANCE INDICATORS TO AUSTRALIAN FARMING SYSTEMS Project 2.1.006



KEY POINTS

- Soil indicators such as tests (e.g. pH) and observations (e.g. crop vigour) provide farmers with essential information for managing soil health and performance.
- Chemical tests and visual assessments are the most widely used soil indicators across all Australian farming enterprises. Biological tests remain poorly adopted due to cost, difficulty of interpretation and limited locally relevant guidance.
- Five indicators — pH, organic carbon, available phosphorus, exchangeable cations and electrical conductivity — are used extensively across Australian enterprises and appear consistently in international soil monitoring schemes.
- Farmers conduct soil testing regularly and see clear value in it. Tests and assessments are chosen for their relevance to the farming enterprise, ease of sampling and suitability to land use.
- The project tested a framework for using publicly available digital soil data to identify low and high performing soils.

THE CHALLENGE

Healthy, productive soils are fundamental to Australian agriculture. Understanding how soil is performing requires practical ways to measure and monitor it. Soil indicators such as observation (e.g. crop vigour) and measurements (e.g. pH, salinity) give clues to soil health and performance, and are widely used by land managers, agricultural industries, and policy makers as a practical shorthand for monitoring the things that matter most to a given production system.

Because soils vary considerably across landscapes, seasons, and farming systems, no single soil property can universally indicate soil performance across all settings. Additionally, indicators are complex, interrelated, and linked to plant growth, health and seasonal conditions. An earlier Soil CRC scoping study (project 2.1.001) confirmed that soil indicators need to be matched to their intended purpose and contextualised to their region. For example, water repellency is an important indicator for sandy soils, while exchangeable acidity is important in dryland cropping in high rainfall zones.

Providing farmers with relevant, targeted guidance on soil indicators requires understanding what they are already using and why. Yet little is known about how Australian farmers select and apply soil indicators on their farms, what drives their choices, or where the gaps in knowledge and practice lie. Without this foundation, efforts to improve soil indicator use risk missing the mark for the farmers and farming systems they are intended to support.

OUR RESEARCH

This two-year project set out to understand which soil indicators farmers currently use to assess soil status and which are most appropriate for different farming systems and regions.

Survey

A national survey of farmers, agronomists and other industry stakeholders collected information on which soil indicators they use and the factors that influence their indicator choices. Survey questions covered topics including demographics, soil type, frequency of soil testing, awareness of soil properties, and knowledge and preferences regarding soil indicators. The survey also examined the factors that inform and support decisions about soil indicator use, including the role of advisors, education, and farming system context.

Comparing survey data to soil data

The Soil CRC's Visualising Australasia's Soils (VAS) portal holds over 230,000 soil observations and measurements from research and development projects across Australia. A subset of approximately 52,200 records was extracted and cross-referenced with the soil indicators reported in the survey, to compare what farmers are using in practice with what is being recorded in the national data system. This analysis also compared Australian soil indicator use against frameworks from New Zealand, the European Union and the USA.

RESEARCH FINDINGS

Survey

Two hundred and forty-two surveys were completed. Most respondents were farmers, producers, and growers (59%), followed by agronomists, consultants, advisors, and extension officers (28%), with researchers and students making up the remaining 13%.

Farmers conduct soil testing regularly and see clear value in it. Tests and assessments are generally chosen for their relevance to the farming enterprise, ease of sampling and suitability to land use. For example, because sulphur and phosphorus are important for pasture production in intensive production systems, sheep farmers were found to test sulphur more frequently than cattle farmers grazing native pastures.

Farmers' choices of which indicators to use are largely driven by in-person interactions, including with advisors and agronomists, at field days and through farmer groups. Advisors are most influenced by their own education and training.

Chemical tests and visual appraisal of crops and soil are widely used across all agricultural enterprises. A paddock walk or drive-by was the most frequently used observation, employed by 99% of respondents. Visual assessment of plant growth or yield condition was similarly common (98%), with farmers using the performance of their crops or pasture as a practical, on-farm indicator of how the soil is performing. Among laboratory tests, available phosphorus and pH were used by 96% and 95% of respondents respectively.

Some indicators are relevant only in specific situations. Exchangeable acidity, for example, is primarily used in dryland cropping in high rainfall zones.

Biological tests are the least used across all enterprise types. Root health and rooting depth were the most commonly used biological indicators, while gene abundance and gene transcript analysis were the least used biological tests of those surveyed. Low uptake of biological tests more broadly reflects a combination of barriers, including difficulty in sampling and obtaining accurate results, a lack of locally relevant interpretations, limited awareness of their relevance to soil performance and management, and cost.

Farmers who are not soil testing cited cost and a lack of knowledge about how to conduct tests or apply the results as the main barriers.



Soil pH is a commonly used soil indicator.

A [short video summary](#) of the project's key findings and the [project case study](#) can be found on the Soil CRC's [project webpage](https://soilcrc.com.au/projects/matching-soil-performance-indicators-to-farming-systems/) (<https://soilcrc.com.au/projects/matching-soil-performance-indicators-to-farming-systems/>).

Comparing survey data to soil data

Five indicators stood out as both heavily represented in VAS and widely used by survey respondents: pH, organic carbon, available phosphorus, exchangeable cations and electrical conductivity. Together these account for more than 58% of observations and measurements in VAS, and are used by more than 80% of survey respondents.

Indicators used infrequently by farmers and poorly represented in VAS include bulk density, potentially mineralisable nitrogen, phosphorus environmental risk index (PERI) and biological indicators such as soil respiration, fungi to bacteria ratio, microbial biomass and mycorrhizal fungi.

While the project aimed to identify tailored suites of indicators for specific enterprises and landscapes, this was not fully achievable from the VAS data alone. The data in VAS has been collected for many different purposes, including experimental trials, monitoring programs, and fertility assessments, and there was not always cross-over with the indicators farmers reported using. Where data did align, translating it into practical guidance would also require locally relevant threshold values for each indicator across different soil types and farming systems, information that does not yet exist in a systematic form. Building that kind of targeted guidance will require more consistent data collection, better coverage of biological indicators, and closer integration of VAS data with on-farm practice over time.

SIGNIFICANCE OF THE FINDINGS

This is the first research of its kind in Australia in over 15 years to gather direct insights from farmers on their use of soil indicators. Until now, decisions about which soil indicators to prioritise, and how to support farmers in using them, have been made without a clear, evidence-based picture of what farmers are doing on the ground.

The survey findings fill that gap, providing evidence from the perspective of farmers and industry stakeholders, that can support more informed decisions about soil indicators within particular landscapes. This foundation enables effort to be directed toward the indicators that are most relevant to farmers and advisors in practice, rather than those that are simply available or convenient.

While no single soil indicator is equally applicable across all farming systems and climatic zones, five indicators (pH, organic carbon, available phosphorus, exchangeable cations and electrical conductivity) are used extensively across enterprises and appear consistently in soil monitoring schemes from New Zealand, the USA and the European Union. These provide a robust, evidence-based foundation from which tailored, locally relevant guidance for different farming systems and landscapes can be developed. The VAS analysis demonstrates that large volumes of existing soil data can be drawn on to support assessment of soil health and performance.

RESEARCH PUBLICATIONS

- Senanayake, I., Yeo, I-Y., Robinson, N., Dahlhaus, P., Hancock, G. (2024). Identification of high-performing soil groups in grazing lands using a multivariate analysis method. *Soil Security*, 16(1). <https://doi.org/10.1016/j.soisec.2024.100163>
- Chadha, A., Robinson, N., Ollerenshaw, A., Larkins, J. (2026). Assessing soil indicator practices: Determinants and variations among Australian farmers. *Soil Use and Management*, 42(1), e70196. <https://doi.org/10.1111/sum.70196>
- Chadha, A., Robinson, N., Ollerenshaw, A. (2024). Matching soil performance indicators to Australian farming systems. IUSS conference 2024, Florence, Italy.
- Robinson, N., Ollerenshaw, A., Chadha, A., Senanayake, I., Yeo, I-Y., Dahlhaus, P., Hancock, G. (2024). Matching soil performance indicators to farming systems. Project 2.1.006 Final Report. Cooperative Research Centre for High Performance Soils, Callaghan, NSW.

NEXT STEPS

A follow-on project, 'Soil performance indicators and their interdependencies' (project 2.1.009), is building on the findings from this project. Working directly with farmers, advisors, and other practitioners, the project is developing locally relevant interpretations of soil indicators for specific combinations of soil type, climate and land use. The aim is to produce guidance that is actionable and tailored to the needs of different farming enterprises and agroecological settings.

Future investigations will also focus on the relationships and interdependencies between key indicators, improving critical target values for soil performance indicators, including biological health. Over time, this work will refine and extend the guidance available to Australian farmers and advisors on using soil indicators to support better soil management decisions.

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This fact sheet and related publications are available on the Soil CRC Knowledge Hub (soilcrc.com.au/resources).

The CRC for High Performance Soils (Soil CRC) brings together scientists, industry and farmers to find practical solutions for Australia's underperforming soils. Our aim is to enable farmers to increase their productivity and profitability by providing them with knowledge and tools to improve the performance of their soils. The Soil CRC is the largest collaborative soil research effort in Australia's history, with funding until 2027. We have attracted more than \$167 million in cash and in-kind resources over 10 years from our 39 participants and the Australian Government.