Soil biology testing

In a single teaspoon of soil there can be more organisms than the total number of human beings on this planet. The variety is staggering and includes millions of different species. To analyse such complexity is a tall order.

Compounding the difficulty is that soil organisms, and especially soil microbes, change rapidly in response to seasons, rainfall, crops, soil management and even the time of day. This means when you have a test done, some results may be high or low but this can just be a natural reflection of the conditions at the time.

There are three main types of soil biology testing: population analysis, biological activity, and indirect indicators.

Population analysis

Population tests count the numbers and types of organisms in a soil. Such tests are a snapshot of the current state of biology in a soil. However, because soil populations can change so quickly, a population that exists before a crop is planted may bear little relation to the soil population near harvest time. Results from a population analysis have to be considered in light of seasonal circumstances and the current stage of farming operations.

Soil organisms are strongly affected by management practices such as cultivation, mulching, irrigation, aeration and ground cover management. If current practices reduce organism numbers, additions of new microbes or organisms are unlikely to thrive and persist. A reduced population indicates the need for changed management practices rather than the addition of new microbes, unless a soil test identifies a particular disease organism.

A number of population tests are currently being used or developed and the following are only a selection.

Nematode analysis

This involves microscopic counting of different nematode types. Nematode populations incude fungal, bacterial and root feeders, parasites and predators. The ratios of these population groups correspond with the level of soil disturbance, nutrient cycling and microbial diversity.

FAME: fatty acid methyl ester analysis

FAME compares bacterial and fungal ratios. High bacteria to fungi ratios have been linked to nitrate and ammonia accumulation.

Food web analysis

This analysis determines the numbers and types of protozoans, bacteria, nematode types, fungi, and actinomycetes. The methods include direct counts using a microscope and numbers of microbes grown in artificial media. The value of recommendations from this analysis has yet to be proven.

Earthworm counts

Earthworm numbers are highly variable between soil types but this simple indicator is sensitive to organic matter supply, low soil pH and high copper levels.

Detritus diversity

This analysis counts the number of different organisms seen in surface mulch and is a crude measure of insecticide contamination or mulch quality. Ant numbers and types can be indicative of soil disturbance events.

Soil biodiversity

The total number of different species in a soil sample can be measured now with genetic techniques. DNA is used instead of counting all the different organisms. The pattern of organism types present indicates which soil processes have occurred. Cultivated or disturbed soils will typically have less fungi, earthworms and surface organisms. Rapid invertebrate diversity methods are now used commercially.

Biological activity tests

Biological activity tests measure what soil organisms are doing. Microbial activity is highly responsive to many factors, including temperature, soil moisture, organic matter supply, soil pH, salinity, cultivation, heavy metal toxicity, and chemical contamination. The variety of factors make it difficult to use this information to assess soil problems. Activity measurements are useful to compare different sites, management techniques and soil amendments. If a test gives an unsatisfactory result it is a general

indicator to improve soil management practices, especially those that build soil organic matter.

There are many ways to measure microbial activity.

Soil respiration rate

Soil respiration rate is estimated from the amount of carbon dioxide produced from a soil sample.

Enzyme assays

Specific enzyme assays include phosphatase and urease, enzymes involved in phosphorous and nitrogen transformations. The FDA (fluorescein diacetate) assay is relatively simple and is widely used to estimate general microbial activity.

Nitrification rate

Nitrification and denitrification rates in soils can be measured to indicate how much atmospheric nitrogen is fixed in soil by bacteria. A range of assays (including acetylene reduction method) measure this reaction.

Calico test

A simple qualitative assay for general activity is the cotton strip test. It involves inserting a strip of unbleached calico into the ground and examining it three weeks later for decay. The greater the decay, the greater the biological activity.

Indirect indicators

Indirect indicators only generally indicate healthy soil biology.

Carbon levels

Soil organic carbon (SOC)

SOC is a simple measure of a complex mixture of materials that encourage soil organisms. Low levels of organic carbon are an indicator of practices or soil types that may develop problems such as poor chemical fertility, structure decline or dryland acidity. A figure of 2% SOC is a minimum target but it can take many years to improve this figure. Soil organic matter is usually calculated as 1.72 x SOC.

Particulate organic carbon (POC)

Ideally, POC should be about 20% of SOC. Low POC levels are often a sign of erosion or over-cultivation.

Dissolved organic carbon (DOC)

DOC tries to measure the biologically available carbon and excludes the inert carbon (eg charcoal) found in some soils.

Microbial biomass organic carbon (MBOC)

MBOC uses a relatively simple microwave treatment to obtain a measure of the carbon bound in microbes. MBOC should normally be between 1-4% of SOC. Low MBOC levels can indicate chemical contamination.

Ground cover percentage

This is a useful indirect indicator of healthy soil biology. A soil lacking a cover of mulch or living plants almost certainly has depressed soil biology. Soil management that reduces or limits ground cover will also suppress soil biology. A spontaneous lack of ground cover can be an indication of salt scalds, acid scalds, surface compaction or crusting. Areas of particular weeds or ground cover plants can be useful indicators of shallow topsoil, compaction, water logging, acid sulfate soils, and salinity.

Soil biology monitoring

Soil biology test results are hard to interpret but they can be useful if the influence of rainfall, temperature and organic matter supply are taken into account. Results will vary widely according to soil type, topography and vegetation. Avoid mixing samples across these ranges.

If you get a test result indicating suppressed activity at a time when you would expect it to be active then the first thing to do is to look for an underlying problem such as salinity, acidity or compaction. If there is no clear underlying problem then you may need to consider changes in soil management such as minimum tillage, strategic grazing, green manure crops or different crop rotations. Additions in the form of soil inoculants are only effective in certain circumstances. (See ‘Fumigation, inoculants, and disease suppression’.)

Where a test result is only partly unsatisfactory there is as yet insufficient data for clear recommendations. A trend in test results observed over several seasons can be a valuable indicator for soil management.

More information

Soil biology basics is an information series describing basic concepts in soil biology. For more detailed information we recommend the Australian book *Soil biological fertility:A key to sustainable land use in agriculture* (2003), edited by Lyn Abbott & Daniel Murphy.

NSWDPI has online soil biology information at http://www.agric.nsw.gov.au/reader/soil-biology.

The University of WA has online soil biology information at http://ice.agric.uwa.edu.au/soils/soilhealth.

Written by Greg Reid and Justine Cox