
Photo: S. Folder

HEALTHY SOILS

Soil health refers to the condition of the soil and its potential to sustain biological functioning, maintain environmental quality, and promote plant and animal health.

A healthy soil is one that is productive and easy to manage under the intended land use. It has physical, chemical and biological properties that promote the health of plants, animals and humans while also maintaining environmental quality.

- Land and Water Australia

Soils are described according to the following attributes;

PHYSICAL (soil type, texture, structure, compaction, erosion, water holding capacity & permeability)

CHEMICAL (salinity, pH, fertility and nutrients)

BIOLOGICAL (soil organic matter, beneficial organisms such as microbes and living organisms and pathogens)

CHARACTERISTICS OF A HEALTHY SOIL

Characteristic	Description
Physical	
Good soil tilth	Soil tilth refers to the overall physical character of the soil in the context of its suitability for production.
Sufficient rooting depth	Sufficient depth refers to the extent of the soil profile to which roots are able to grow and function. A soil with a shallow depth as a result of a compaction layer or past erosion is more susceptible to extreme fluctuations in the weather, thus predisposing the crop to drought or flooding stress.
Good soil drainage	Even after a heavy rain, a healthy soil will drain more rapidly as a result of good soil structure and an adequate distribution of different size pore spaces, but also retain adequate water for plant uptake.
Resistant to degradation	A healthy soil is more resistant to adverse events including erosion by wind and rain, excess rainfall, extreme drought, vehicle compaction etc.
Resilience when unfavourable conditions occur	A healthy soil will rebound more quickly after a negative event such as harvesting under wet soil conditions or if land constraints restrict or modify planned rotations.
Chemical	
Sufficient but not excess supply of nutrients	An adequate and accessible supply of nutrients is necessary for optimal plant growth and for maintaining balanced cycling of nutrients within the system. Excess nutrients can lead to leaching and potential ground water pollution, high nutrient runoff and greenhouse gas losses, as well as toxicity to plants and microbial communities.
Free of chemicals and toxins that may harm the crop	Healthy soils are either devoid of harmful chemicals and toxins or can detoxify and/or bind such chemicals making them unavailable for plant uptake.
Biological	
Small population of plant pathogens and insect pests	Plant pathogens and pests can cause diseases and damage to a crop. In a healthy soil, the population of these organisms is low and/or inactive. This could result from direct competition from other soil organisms for nutrients or niche habitats, hyper parasitism, etc. Also, healthy plants are better able to defend themselves against a variety of pests.
Large population of beneficial organisms	Microbes are important to the functioning of the soil. They help nutrient cycling, decomposition of organic matter, maintenance of soil structure, biological suppression of plant pests etc. A healthy soil will have a high and diverse population of beneficial organisms to carry out these functions and thus help maintain a healthy soil status.
Low weed pressure	Weed pressure is a major constraint in crop production. Weeds compete with crops for water and nutrients that are essential for plant growth. Weeds can interfere with plant establishment, block sunlight, interfere with harvest and cultivation operations, and harbour disease-causing pathogens and pests.

SOURCE: *Cornell Soil Health Assessment Training Manual, Edition 1.2.2*

HOW TO MEASURE SOIL HEALTH

1. Physical Inspection

Digging with a spade provides a simple way to assess the physical aspects of your soil. Record your thoughts on the following;

- What does it feel and smell like?
- What is the texture of your soil (sand, loam or clay)?
- How easily does it break up and how hard is it to dig?
- What plants are growing in it and how deep are the roots?


Photo: Cradle Coast NRM

SIGNS TO LOOK FOR WHEN EXAMINING THE HEALTH OF YOUR SOIL

	Good	Poor
Soil surface	✓ Textured, rough ✓ Good water drainage ✓ Good plant cover & growth	× Crusted, surface sealing × Water sheets/ runs off/ ponds × Moss/algal growth
Soil aggregates (structure)	✓ Rough faces on surface of aggregates ✓ Assorted-sized aggregates (ideal is 1-5mm) ✓ Friable ✓ Crumbly ✓ Lots of pores	× Sharp angles, "clean" faces × Larger aggregates × Falls to powder (no crumbs) × Clods × Few or no pores × Compacted, layers parallel to surface (at any depth) × Settles to blocks/bricks
Rusty colours/ mineral deposits in topsoil (water logging)	✓ Few/ small/ not noticeable	× Many/ noticeable
Plants	✓ Lots of roots in the soil	× Few or no roots in the soil

2. Chemical Soil Testing

A soil test will give you an indication of the chemical properties of your soil.

There are many soil testing laboratories that can undertake soils tests for you, local agronomists and fertiliser reps will be able to advise you on these.

When choosing a lab it is preferable to use one that is Australian Soil and Plant Analysis Council Inc (ASPAC) and National Association of Testing Authorities (NATA) accredited. It is advisable to take samples at the same time of the year and to use the same lab over time so that you can compare your results. Not all laboratories use the same testing methods and procedures.


Photo: Ag Vita Analytical

WHAT CAN BE FOUND ON A SOIL TEST?

Test	Description
Organic Matter (OM) & Organic Carbon (OC)	Organic Matter / Organic Carbon are essential for soil structure and nutrient retention. They are measured as percentages and the amount of OM is roughly twice the amount of OC. Ideal OC levels will depend on soil type and generally range from 2.5 – 4 %.
pH	pH refers to a soil's acidity or alkalinity. pH affects nutrient availability. pH is measured on a scale of 1 -14, with 7 being neutral, <7 is acidic and >7 is alkaline. Most plants prefer a soil with a pH range of 6 – 7.
Electrical Conductivity (EC)	EC is the soil's electrical conductivity. The more ions present, the greater the conductivity. EC is often used to indicate salinity. EC <0.15dS/m is safe for most crops on most soil types.
Chloride	Chloride (Cl) levels are related to salinity, and may become elevated when using fertilisers that contain Chloride.
Macronutrients	Macronutrients (Nitrogen (N), Phosphorous (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg)) are required by plants in large amounts. P and K may become "locked up" in some soil types.
Cation Exchange Capacity (CEC)	CEC is related to soil texture (sand, clay, loam etc). The higher the CEC, the higher the nutrient holding capacity (sand < loam < clay)
Sodium	Sodium (Na) interferes with plant nutrient and water uptake and soil structure. Sodic soils have Na levels >6% CEC. Maximum recommended levels vary depending on soil type.
Ca / Mg, Ca / K & P / Mg ratios	Calcium / Magnesium, Calcium / Potassium and Potassium / Magnesium ratios indicate whether the soil's cations are balanced. Major cations are Ca, Mg, K, H, Na and Al. They have a positive charge.
Trace Elements	Trace elements (=micronutrients such as zinc, iron, manganese, copper, boron) are important for plant health, but required in small amounts.

SOURCE: *Serve-Ag/NLP Sustainable Agriculture Project*

3. Biological Soil Testing

A soil test will give you an indication of the chemical properties of your soil.

Soils with good physical and chemical condition usually have good soil biology. Some laboratories offer soil biological testing. Ask your local agronomist for details of labs that offer this service.

Soil organic matter is an essential food source for soil microbes and organisms and therefore soils with high organic matter will have higher soil microbial populations.

Healthy Root System
Photo: D. Blaesing

SOIL ISSUES TO LOOK OUT FOR

Erosion

Erosion is the loss of soil due to water or wind, which can result in the loss of valuable top soil, increase sediment and nutrient loads in waterways and destabilise the banks of rivers, streams and gullies.

Keeping good ground cover especially during winter and maintaining riparian vegetation will help to reduce the risk of erosion.

buck's horn plantain - a common indicator of salinity

Sodicity

Soil sodicity refers to an excess of sodium in the soil. It is measured by the proportion of sodium in the cation exchange capacity (CEC) and expressed as % sodium (Na) or exchangeable sodium percentage (ESP).

Sodicity affects the uptake of potassium (K), calcium (Ca), and magnesium (Mg). Sodic soils are usually poorly structured, hard setting when dry and sticky when wet and can be susceptible to water erosion due to their dispersive nature. Sodicity can be managed by building soil organic matter, and applying soil treatments eg. gypsum.

Compaction due to traffic

Erosion on a dam bank

Salinity

Soil salinity is the accumulation of salts in a soil profile such that it limits plant growth. Salinity can be identified by;

- Plant and soil symptoms in affected areas eg. salt scalds, surface crusting of salt, poor areas within crops often in lower lying areas, yield losses, stunted plants or burnt leaves
- The presence of plant species that like salty conditions in affected areas (eg. sea barley grass, buck's horn plantain, water button)
- Measurement of the electrical conductivity (EC) in soil and or water samples

Saline areas can be managed by maintaining deep rooted vegetation in the landscape, ensuring effective drainage, planting salt tolerant plants, building soil organic matter and applying soil treatments.

Erosion in a sodic clay soil

Compaction

Compaction occurs from frequent traffic over soils especially when wet. Compaction restricts rooting depth of plants, impedes drainage and leads to soil structure decline.

Using designated roadways (controlled traffic) and not working soils when wet will reduce the risk of compaction.

SOIL ISSUES TO LOOK OUT FOR

Acidification

Acidification is a decrease in soil pH that usually results in a reduction in plant vigour.

Acidification of topsoils, and more seriously, subsoils will lead to lower yields, reduced pasture and crop options and contribute to wider catchment problems such as weed infestations, salinity and erosion.

In acidic soils, aluminium, iron and manganese can reach concentrations toxic to the roots and there may be deficiencies in molybdenum, boron, calcium, magnesium and potassium. (DPI, Victoria)

Acidity can be managed through the application of lime.

Measuring Soil pH
Photo: S. Folder


Waterlogging
Photo: S Folder

Waterlogging

Waterlogging occurs when soil pores are saturated with water for significant periods of time because of impeded drainage due to poor soil structure or in low lying areas.

Drainage work to take water away from the area and building good soil structure can reduce the impact of waterlogging on plant and crop health.

Soil Structure Decline

Soil structure describes how individual soil granules bind together and aggregate, and therefore, the arrangement of soil pores between them.

Compaction and loss of organic matter, surface crusting, increase of surface run-off, poor infiltration, poor water holding, loss of drainage, hard setting, cloudiness, poor workability and low resistance to erosion are signs of poor or degraded soil structure. (*RMCG*)

Soil structure can be maintained through good soil management practices including, minimal tillage, not working when wet, using designated roadways, building soil organic matter and good crop rotations with pasture phases.


Poor Soil Structure
Photo: S Folder

FURTHER INFORMATION

For more information please refer to NRM South's Healthy Farming & Environment Reference Guide: http://www.nrmsouth.org.au/

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