The Australian Wine Research Institute

Fact Sheet
VITICULTURE

What is soil health?

Introduction

Soil health is a recent term that has replaced the more rigorously defined concept of soil quality. Soil quality describes a soil's fitness for purpose, encompassing a range of inherent and dynamic soil properties. Soil health emphasises soil biology and the concept of a soil supplying ecosystem services more broadly. The main purpose of managing soil health in a vineyard is to optimise grapevine performance according to a grape grower's objectives for the yield and quality of fruit, and the style of wine to be made. Maintaining soil health is also important for the long-term sustainability of a vineyard business and for responsible stewardship of the land.

Soil health should take account of the condition of key physical, chemical and biological properties of a soil.

- **Physical properties:** These include the effective soil depth, land slope and erosion potential, stability of soil structure, aeration and drainage.
- **Chemical properties:** These include pH, nutrient deficiencies or excesses, salinity and sodicity.
- **Biological properties:** These include soil organic matter content and organisms, soil pests and disease.

The assessment of soil health can be further grouped into inherent and dynamic properties, as described in the Cornell Soil Health Assessment Tool: http://soilhealth.cals.cornell.edu/training-manual/.

Inherent properties are those that a grower cannot change except by drastic intervention such as through earth movement. These properties are inherited from the parent material (the geology) and are influenced by the environment (climate, land slope and aspect). They largely determine site selection for a vineyard.

Dynamic properties are those that can change relatively quickly and which a grower can manipulate through soil management. These are the properties that a grower is concerned about when actively managing soil health.

Measuring dynamic properties of soil

Dynamic soil properties are measured in a vineyard soil *in situ* or on soil samples taken for laboratory analysis. The AWRI fact sheet *Taking soil samples* describes methods for collecting soil samples. In most cases, the key physical properties are best observed in the vineyard by exposure of the soil profile in an excavated pit.

Physical properties

A key physical property is a soil's structure. This affects the rate of water infiltration, the soil's porosity, capacity to supply available water, ability to withstand compaction from vineyard traffic when wet and its resistance to root penetration and root growth.

The AWRI fact sheet *A method of assessing soil structure* outlines methods to describe a soil's structure. Related to this are other AWRI fact sheets entitled *Measuring the infiltration rate of water into soil, Measuring soil porosity, Measuring soil strength, Soil moisture monitoring* and *A method for examining grapevine root systems.*

Vine root development can be restricted by adverse soil physical and chemical conditions. For example, soil compaction through wheel traffic close to the vine rows can prevent horizontally growing roots from exploring the mid-row soil volume. A 'duplex' soil, comprising of a light–textured A horizon (e.g. sandy loam) over a clay B horizon that has poor structure can impede vertical root development. Figure 1 shows a profile of a duplex soil that has a naturally dense subsoil.

Figure 1 Duplex soil profile showing a sandy loam A horizon over a dense clay B horizon.

Chemical properties

The two major issues with soil chemical properties are 1) the supply of essential nutrients is optimum for vine growth, and 2) whether there are any excess concentrations or deficiencies that might inhibit root growth or nutrient uptake. From this viewpoint, a key chemical property is soil pH, which influences the availability of macronutrients including phosphorus (P) and micronutrients such as iron, manganese, copper, zinc and molybdenum. Nutrient deficiencies can be identified through soil and/or plant testing (see AWRI fact sheets on *Assessing soil health* and *Measuring soil pH*.

With respect to toxic effects, a soil pH less than 5.5, measured in water (approximately pH 5 in $CaCl_2$), may result in concentrations of exchangeable aluminium that inhibit root growth and P uptake by vines. Excess soluble salts in the root zone can also adversely affect vine growth (see *Soil acidification* and *Measuring soil salinity* fact sheets for more information). The most convenient way of measuring salinity is with an electrical conductivity (EC) meter using a 1:5 ratio of soil to distilled water. Depending on the soil's texture, these values can be converted to saturated paste values (EC_e), which should not exceed 2 dS/m for sensitive *Vitis vinifera* vines. Vines on rootstocks such as Ramsey, Schwarzmann or 140 Ruggeri can tolerate higher salinity levels than own-rooted *Vitis vinifera* vines.

A build-up of salinity, especially in a clay subsoil, can result in the exchangeable sodium percentage (ESP) of the cation exchange capacity (CEC) rising above 6. When this is associated with an exchangeable calcium: magnesium ratio <1, clay particles are likely to disperse and soil aggregates become unstable (see *A Method of assessing soil structure*). This behaviour is characteristic of a sodic soil, which has a poor structure.

Biological properties

A key and important biological property is the soil organic matter (SOM) content. SOM is the foodstuff for a huge variety of soil organisms ranging upwards in size from bacteria, archaea and fungi (the microorganisms) to earthworms, ants, termites and wood lice. This hierarchy of organisms constitutes a soil food web. As SOM is consumed by these organisms organic molecules with negative electrical charges are formed and combine with mineral particles such as clay and silt to form aggregates. The negatively charged organic matter has a CEC that can significantly augment the CEC of sandy soils. Other complex molecules such as polysaccharide gums and mucilages are also produced that aid in stabilising the aggregates. This is all part of soil structure formation. Organic matter is usually expressed as percent carbon (C), its main building block (see *Measuring organic carbon in soil*).

As microorganisms decompose organic matter, they derive energy for growth and absorb mineral nutrients such as nitrogen (N), P and sulfur (S). This is important for nutrient cycling. For example, if the C:N ratio of the organic matter is less than 20, the N present is likely to exceed the microorganisms' requirement and it is released as the mineral ion NH_4^+, which can be oxidised to NO_3^-. This process is called mineralisation, the reverse of which involves the immobilisation of N in microbial tissue (see Figure 2). Ammonium and NO_3^- are available for vine uptake (see AWRI fact sheet *Nitrogen fertilisation*).

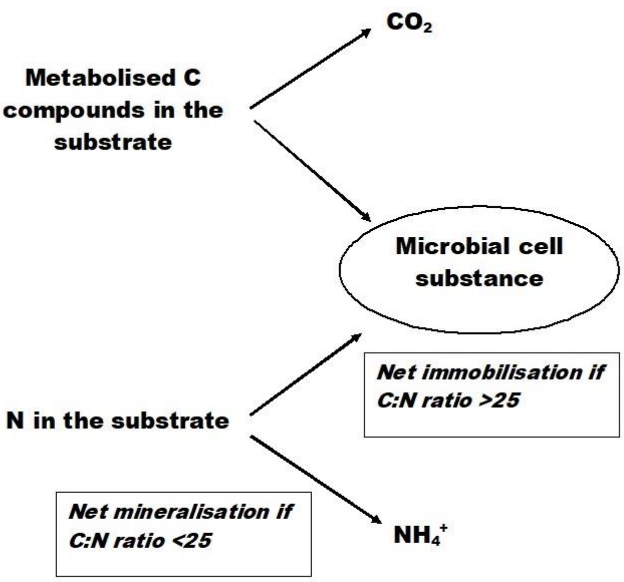

Figure 2. Diagram showing the balance between net mineralisation and immobilisation of N

Another important biological property is the microbial biomass carbon (MBC), which is a snapshot of the size of the viable population of microorganisms. A healthy soil should have an MBC of 100–400 mg C/kg. Organic C that is rapidly processed through the microbial biomass at the rate of 5–6% per year can form an intimate association with soil mineral particles. The result is a dark brown topsoil consisting of small friable aggregates, as shown for a grassed soil in Figure 3. Such a topsoil is excellent for water infiltration, aeration and root growth. Table 2 in the Fact Sheet *Measuring organic carbon in soils* gives desirable levels of SOM for soils of different texture.

Figure 3. Friable surface soil aggregates. The coin is a 20c piece

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References and further reading

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