



MAKING SENSE OF CHEMICAL INDICATORS

Most indicators of soil chemical quality measure *dynamic* soil properties i.e. properties that change over time and with management. These indicators are used to guide management decisions over the period of a rotation. It is important to monitor these indicators as they can act as constraints to yield, restricting crop growth and preventing the yield potential from being achieved.

- Indicators falling in the **RED** zone are high risk and need to be investigated urgently.
- Indicators falling in the **AMBER** zone are moderate risk and should be investigated further.
- Indicators falling in the **GREEN** zone are low risk, regular monitoring should be continued.

Soil pH (acidity and alkalinity)

pH is a measure of the concentration of hydrogen ions in the soil solution. The pH unit scale runs from 1 to 14, with 1 being most acid and 14 being most alkaline; soils normally fall in the range 3–8. Acidic soils can restrict microbial activity, reduce the availability of essential nutrients and cause aluminium toxicity in the subsurface which retards root growth, restricting access to water and nutrients (figure 1) (see Soil Acidity fact sheet). Application of agricultural lime is effective in treating soil acidity. Some crops show greater tolerance of acid or alkaline conditions and rotations can be optimised to reduce the impact of pH constraints.

Topsoil pH in the acidic to neutral range



Subsurface soil pH in the acidic to neutral range



Figure 1: Aluminium toxicity retarded root growth of barley seedlings grown in acidic subsurface soil (pH 4.0) (right) compared to normal root growth in limed soil (pH 5.1) (left).

pH in the neutral to alkaline range



Electrical conductivity in topsoil

The concentration of soluble salts in the soil solution is measured by the electrical conductivity (EC) of the saturation extract. EC is expressed in units of deci siemens per metre (dS/m), known as E_c. Measurements of EC made in a 1-part soil to 5-part water suspension are first converted to E_c before comparison with the indicator values given below (see Electrical Conductivity fact sheet). EC is used to estimate the soluble salt concentration in soil, and is commonly used as a measure of salinity. The presence of high salt concentrations can stunt plant growth because water uptake by the roots is reduced by the increased osmotic potential of soil. Also, when salt concentration in the soil is high, there can be increased rates of leaf necrosis over the growing season. EC is very variable over time and across a paddock, so further investigations of the site should be carried out by an expert.

Electrical conductivity (E_c)



Water repellency

Water repellency occurs when the hydrophobic (or water repelling) waxy materials from plant residues decompose and coat soil particles. This can prevent water from entering the soil surface (figure 2). Water repellency typically occurs in soils with <10% clay. Sand soils are more prone to water repellency as it takes less hydrophobic material to coat individual particles. Water repellency is measured in the laboratory using the molarity of ethanol drop test (see Water Repellency fact sheet). The higher the strength of ethanol needed to penetrate the soil, the more severe the water repellency.

Water repellency (molarity of ethanol drop)



Figure 2: Water droplet on surface of non-wetting soil.

Boron toxicity

High concentrations of boron are toxic. However, boron toxicity is relatively rare and mainly occurs in low rainfall Mallee regions where the soils often have highly alkaline sodic clay subsoils (see Boron fact sheet for a map). The impacts of boron toxicity depend on the water dynamics in the soil and therefore on the rainfall patterns within a season.

Soil testing is not reliable where there are low levels of boron. Therefore this test cannot be used as an indicator of the risk of boron deficiency, which may be common on leached sand soils.

Boron toxicity (mg B/kg soil)



Nutrients

Indicators of the nutrient content of soil can be used to guide paddock by paddock decisions about how much fertiliser to apply and when. Soil sampling to support fertiliser application must be carried out carefully to provide zoned paddock samples which are representative of the paddock (figure 3).

Agronomic advice should be sought to guide the interpretation and use of indicators of soil nutrient status. Nutrient cycles in soil are complex (see Nitrogen, Phosphorus, Potassium fact sheets). A crop's uptake of one nutrient is often linked to the uptake of other nutrients. Therefore, nutrient management needs to be considered in an integrated way. Also, seedling toxicity can also result

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when very high fertiliser additions increase electrical conductivity in the topsoil soon after application. Decisions regarding nutrient management should also consider crop variety, crop rotation and yield potential, timing of seeding, in-season variation in the weather, as well as soil factors.



Figure 3: Phosphorus response in wheat following a pasture which followed a windrowed frosted wheat crop at Varley, WA. (Photo Chris Gazey, DAFWA.)

Cation exchange capacity

Cation exchange at the surface of soil particles is the hub of a dynamic system of nutrient exchange between roots, organisms, water, organic matter and minerals in soil. Cation exchange capacity (CEC) is an **inherent** characteristic of the soil, which means that it is largely outside a farmer's control. It is strongly related to soil texture and the type of minerals in the soil and is mostly determined by the parent material of the soil. CEC is increased by clay and organic matter (see Cations and Cation Exchange Capacity fact sheet). Although CEC is only weakly related to management, in sand soils, CEC can be increased by management practices which increase organic matter.

CEC is reported as either milliequivalents per 100 grams of soil or centimoles(+) per kilogram of soil; these units are numerically equivalent. In WA, CEC typically ranges from 1–15 milliequivalents per 100 g of soil. Soil with a CEC less than 10 may need careful management to be able to sustain high plant production. Soils with very low CEC will show relatively little residual effect from applications of potassium (K) and magnesium (Mg) fertiliser. This is because the K^+ and Mg^{2+} ions are not buffered against leaching by adsorption on soil surfaces.

The effective CEC is the sum of the five most abundant cations present in soil: calcium, magnesium, potassium, sodium and aluminium. In most situations, this is a good estimate of the CEC. However effective CEC is not a good measure of CEC when the electrical conductivity of the sample is high. This is because when effective CEC is being measured, sodium from salt increases the effective CEC.

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