

SOIL HEALTH AND FERTILITY

3. soil testing

Key points

- Soil tests can give valuable information on nutrient deficiencies that may be limiting pasture growth, crop production or animal performance.
- Herbage tests, particularly of clover, are also recommended to give a more complete picture of the soil nutrient status.
- Important soil properties that are measured in a soil test include pH, cation exchange capacity, base saturation, levels of the macronutrients (N, P, K, S, Ca, Mg), trace elements (e.g., Zn, Cu, Co, Mn, Se, B), organic matter levels and the carbon:nitrogen ratio.
- It is also possible to get an idea of soil nutrient status from the presence of particular weed species which may indicate a low or high fertility level.
- Plant deficiency symptoms can also indicate soil nutrient status.

Why invest in soil tests?

Soil tests can reveal important soil properties such as the levels of plant available nutrients. When carried out regularly, soil tests show useful trends in soil fertility and other properties and give an indication of whether a fertiliser programme is adequate.

Some essential minerals can be naturally deficient in the soil and soil tests can reveal this information. Many New Zealand soils are deficient in selenium, phosphorous and sulphur. Continued cropping or pastoral use can run down soil banks of nutrients resulting in sub-optimal crops or animal growth.

Soil tests are not infallible however. Factors other than soil nutrient levels can affect plant performance – a more complete picture can be gained by herbage testing as well as soil testing. Clover is the pasture component most prone to nutrient deficiencies, so a clover herbage test can be very revealing of soil nutrient status.

Important soil properties which can be measured in a soil test include:

1. pH is usually the first thing to look at in a soil test as it has a fundamental effect on soil biology, health, structure and nutrient availability. It is a measure of the acidity or alkalinity of the soil – the lower the pH the more acid the soil. The pH of pasture should be in the range 6–6.2 to maximise clover growth and productivity.

If pH is high (say above 6.5), the metal trace elements (zinc, copper, iron and manganese) may become unavailable. If too low, soil biological activity is reduced which can slow the turnover of organic matter and reduce the release of nutrients. Lime application will raise pH. 1 tonne of lime per ha will raise pH by 1

unit on light soils; more will be needed on heavier soils.

2. CEC (Cation Exchange Capacity). CEC reflects the soil's ability to hold on to nutrient cations. In the soil, plant nutrients such as calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) exist as positively charged ions. They can be attached to clay particles and organic matter or may be free in the soil solution. There is a fairly constant ratio of cations in solution to cations on surfaces – this is the CEC which can be measured and gives a good indication of levels of these nutrients in the soil. A soil's CEC depends partly on its texture, the type of clay in the soil and its organic matter content. In general, the more clay and humus in the soil, the greater the CEC and the more fertile the soil.

3. Base saturation. The proportion of the CEC occupied by the basic cations (Ca, Mg, K, Na) is known as the base saturation of the soil. It is worth looking at the base saturation percentages of these cations as they give an indication of any imbalances: high levels of one can reduce the uptake and availability of others. High K levels can outcompete Mg for uptake and utilisation, especially in spring and early summer. Dolomite application can lift Mg although more plant-available sources are calcined magnesite or magnesium sulphate (note under organic certification these can be restricted inputs).

4. Phosphorus (P) levels. A Resin P test should be used if using reactive phosphate rock (RPR), and an Olsen P test gives a reasonable measurement of P levels if soluble P is applied. P should be applied annually, and if soil tests show levels are increasing, the amount can be decreased slightly, and vice versa. A test for phosphate retention should be included in

an initial soil test as it is an inherent soil property (i.e., does not change) and refers to the extent to which slowly available P is stored in the soil.

5. Trace elements. Soil tests for the trace elements boron (B), cobalt (Co), zinc (Zn), copper (Cu) and selenium (Se) are fairly reliable but testing plant tissue as well would give a better indication. Co and Se are essential for livestock so are usually tested in pasture and forage crops. Molybdenum (Mo) is essential for legumes and vegetable crops (including brassicas).

6. Nitrogen and Organic Matter (carbon). Organic matter is the main contributor to the soil's CEC and is the source of many nutrients, especially nitrogen (N). Soils with medium to high levels would generally be expected to have good structure, moisture retention properties and water percolation properties. The test for available nitrogen gives an indication of the quantities of N that could be readily mineralised from soil organic matter.

The total nitrogen and carbon:nitrogen ratio test estimates the total N content of the soil (excluding nitrate-nitrogen). This figure is then used to determine the carbon:nitrogen ratio which gives important information on the nature of the organic matter in the soil. A ratio of 10-12 is normal for an arable soil with good organic matter mineralisation, 15-20 indicates slow mineralisation of the organic matter, and ratios of greater than 25 suggests that the organic matter is not mineralising.

Soil tests without labs

Soil deficiencies can be indicated by the presence of particular weed species. For instance, large areas of the weedy annual grasses brome and sweet vernal may be symptomatic of low soil fertility (low availability of P, K or Mo) which have resulted in poor clover growth which in turn has failed to drive vigorous pasture growth. Browntop and sorrel may be symptoms of similar conditions and of low pH. Dock can also be a symptom of low pH but also of poor drainage or compaction.

Plant deficiency symptoms appear in old leaves first when the nutrient in question is a mobile one (e.g., N or Mg). Symptoms appear in young leaves first when

nutrients are immobile – this is common in greenhouse crops in spring. Calcium is often deficient in spring.

Nutrients and associated deficiency symptoms

Nitrogen – chlorosis (yellowing) of the whole plant, often with reddening

Phosphorus – dark green foliage, reddening or purpling of leaves

Potassium – older leaves show dead spots or marginal burn, younger leaves may develop red pigmentation or become interveinally chlorotic and show a shiny surface

Magnesium – marginal or interveinal chlorosis often quite strongly coloured

Molybdenum – general paleness in legumes. In non-legumes, mottled pale appearance, marginal burn of mature leaves, whiptail in cauliflower

Cobalt – symptoms appear in legumes only and have the same appearance as nitrogen deficiency

Calcium – growing point dies. In fruit crops, disorders of fruit appear (e.g., blossom end rot in tomato and pepper)

Sulphur – chlorosis of the whole plant, often younger leaves affected first

Copper – death of young leaves, chlorosis, failure of fertilisation and fruit set

Zinc – little leaf, rosetting, chlorotic mottling in less severe cases

Iron – interveinal chlorosis, in severe cases may result in total bleaching of young foliage, followed by necrosis (death)

Boron – death of growing points. In some species (e.g., grape) there may be leaf distortion. Fruit may be distorted or show woody pits or cracking of the surface. Petiole cracking in celery and hollowness in some root vegetable species.

References:

Cornforth, I. 1998. *Practical Soil Management*. Lincoln University Press.

Christchurch Polytechnic Institute of Technology. Fertiliser Use for Organic Production.

Dr Tim Jenkins. *Soil fertility notes* and *Soil testing without labs*. Tim can be contacted at tje@donaghys.co.nz

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