WHAT IS MY *Paddock* TELLING ME?

A guide to identifying paddock problems in East Gippsland

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The Top Soils Project

This glove box guide is an information resource produced as part of Top Soils.

Top Soils is a multi-partner East Gippsland region project focused on improving soil condition for farm profitability through farmer-driven focus groups and research sites.

The aim is to encourage and support change towards best practice in soil health.

Top Soils 1 was developed in 2013 as a 5-year project and was highly successful, enabling Top Soils 2 (1 July 2018 to June 30 2023) to continue the project's good work.

The need for the project was determined through the Australian Bureau of Statistics data that showed that sustainable land management practices were not widely adopted in the East Gippsland region.

The first few years saw partner agencies gather soil and plant data across well over 100,000 hectares in East Gippsland to benchmark (then) current soil condition, soil fertility and farming practices. Top Soils 2 will see some of these sites retested to determine change over the 10 years of the project.

Following the collation of soil and plant data, was the establishment of 5 farmer-driven focus groups, each group based in a separate geographical area across the region; Plains, Foothills, High Country, Far East and Deddick/Bendoc. There was also the development of several research and demonstration sites investigating the effects of nutrients and strategic grazing on weed loads in native pasture systems, the effects of nutrients and rotational grazing on weed loads in improved pasture systems and soil requirements, including micro and macro nutrients.

The Top Soils program is supported by the East Gippsland Catchment Management Authority through funding from the Australian Government's National Landcare Program. Project partners include Southern Farming Systems, Agriculture Victoria, East Gippsland Landcare Network, Far East Victoria Landcare and Snowy River Interstate Landcare Committee.

TopSoils

Introduction

Soil is vital to supporting plant and animal life and therefore agricultural production. Whether it's growing food for human consumption or for livestock, maintaining healthy, sustainable soils is the key.

Do you know how to tell if your soil is healthy when out in the paddock?

Plants and surface indicators can tell us a lot about the condition of the soil before we even test it. You could have patches of waterlogging, weeds growing in a particular location, discolouration of leaves, or clumps of rapid growth in your pasture. All of these signs are symptoms of an unhealthy soil that can be fixed.

About this book

This book has been developed for East Gippsland farmers to help them better understand their soils, look for signs in the paddock and confirm paddock problems. Farmers are encouraged to seek the advice and support of agricultural professionals to come up with solutions for their paddock problems.

This book provides an easy reference for **SPECIES THAT ARE PRESENT** and **SIGNS AND SYMPTOMS** that can be found in the paddock.

Gathering baseline information

Before starting to analyse the health of your paddock it is a good idea to gather any information you have, such as soil test results, fertiliser applications and management of the paddock. This information can be used, with the support of agricultural professionals, to help you understand what is happening in your paddock.

Testing

To assist in understanding what is happening in your paddock a soil test or plant tissue test is recommended. A soil test measures the quantity of nutrients in the soil and a plant tissue test measures what nutrients the plant is accessing.

This guide helps you understand your test results. For more information on testing, see pages 74 (soils) and 91 (plant tissue) of this guide.

NJ

Species present

I've found a plant in my paddock.

What is it telling me?

What are these plants telling me?

Onion grass

Romulea rosea

What is my paddock telling me?

Onion grass is a perennial herb that rises annually from a brown coated, globular corm about 1 cm in diameter and flowers in spring. The bright lavender flowers are very distinctive, making it easy to spot in the paddock.

What could this indicate?

- General indicator of low soil fertility particularly phosphorus (P), low soil organic matter and sometimes low soil pH (acidic soils).

How can I confirm this?

Conduct a soil test focusing on soil pH and phosphorus (P) levels, noting that an Olsen P between 8 and 13 is deemed adequate in dryland pastures.

When seeking the assistance of an agricultural specialist, take along your soil test results and visual assessment of the percentage of onion grass in your paddock. If heavily infested, re-sowing the paddock maybe required.

SPECIES PRESENT

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Barley grass

Hordeum leporinum

What is my paddock telling me?

Barley grass is a tufted annual grass with rough 'bristle-like' seed heads and a fibrous root system.

What could this indicate?

- High soil fertility, particularly nitrogen (N) and phosphorus (P).
- Paddock has had bare or open areas over the summer or autumn break.

How can I confirm this?

Visually assess your paddock and note where the barley grass is present. It is often found in stock camps, gateways or adjacent to tree plantations as it establishes in bare or open patches.

Aim to reduce grazing pressure resulting in bare ground, particularly in late summer as it provides ideal germination conditions for barley grass.

Conduct a soil test focusing on nitrogen (N) and phosphorus (P) levels, noting that an Olsen P between 8 and 13 is deemed adequate in dryland pastures.

SPECIES PRESENT


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Flatweed

Hypochaeris radicata

What is my paddock telling me?

Flatweed is a perennial herb 10–80 cm high with yellow daisy type flowers. Leaves form a flat, basal rosette suppressing other pasture growth.

What could this indicate?

- General indicator of low soil fertility particularly low potassium (K).
- Paddock has repeatedly been cut for hay and/or silage.

How can I confirm this?

Flatweed is common on light textured soils, as potassium readily leeches.

Conduct a soil test focusing on potassium (K) levels, noting that target Colwell K levels vary depending on soil type, with a target level of 60 for sandy soils to 130 for clay soils.

SPECIES PRESENT

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Sorrel

Acetosella vulgaris

What is my paddock telling me?

Sorrel is a rhizomatous herb with arrow-shaped leaves and reddish-brown seed heads.

What could this indicate?

- General indicator of low soil fertility particularly low potassium (K).
- Sorrel is an acid tolerant plant, indicating you could have increased soil acidity.

How can I confirm this?

Sorrel is common on light textured soils, as potassium readily leaches.

Conduct a soil test focusing on soil pH and potassium (K), noting that target Colwell K levels vary depending on soil type, with target levels of 60 for sandy soils to 130 for clay soils.

Extended sheep grazing in sorrel-dominant pastures can cause oxalate poisoning. If this occurs, speak to an agricultural specialist who can recommend a course of action.

SPECIES PRESENT

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Sweet vernal grass

Anthoxanthum odoratum

What is my paddock telling me?

Sweet vernal grass is aptly named for its sweet fragrance. It is a tufted perennial grass with green to golden-brown seed heads.

What could this indicate?

- Sweet vernal grass thrives where soil is poorly structured and often waterlogged.

How can I confirm this?

Sweet vernal grass is common on light textured soils, as potassium readily leeches.

Conduct a soil test focusing on potassium (K) levels, noting that targeted Colwell K levels vary depending on soil type, with target levels of 60 for sandy soils and 130 for clay soils.

When seeking the assistance of an agricultural specialist, take along your soil test results and your visual assessment of the percentage of sweet vernal grass in your paddock. If heavily infested, re-sowing the paddock maybe required.

SPECIES PRESENT

Silver grass

Vulpia bromoides

What is my paddock telling me?

Silver grass is a tufted annual grass with narrow, shiny leaves. The fairly narrow one-sided seed head turns silvery when mature.

What could this indicate?

- Paddock has had bare or open areas over the summer or autumn break.

How can I confirm this?

Visually assess your paddock and note where the silver grass is present. Is it in areas that were bare or open over summer and autumn?

Conduct a soil test focusing on nitrogen (N) and phosphorus (P) levels, as well as soil pH.

When seeking the assistance of an agricultural specialist, take your soil test results as a lime application may be recommended as silver grass is less dominant in limed soils.

SPECIES PRESENT

Fog grass

Holcus lanatus

What is my paddock telling me?

Fog grass is a softly tufted perennial grass growing to one metre high. It has soft, pink to grey seed heads when mature.

What could this indicate?

- General indicator of low soil fertility particularly nitrogen (N), but also phosphorus (P), potassium (K) and sulphur (S).
- Fog grass is an acid tolerant plant, indicating you could have increased soil acidity.
- Fog grass grows in poorly structured and often waterlogged soils.

How can I confirm this?

Stock often avoid grazing fog grass due to its low palatability. Grazing hard in spring and summer can be a method of management.

If growing in waterlogged soil, conduct a soil test focusing on nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and soil pH. Seek expert assistance as both soil nutrients and wet area management may need addressing.

SPECIES PRESENT

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Bent grass

Agrostis capillaris

What is my paddock telling me?

Bent grass is a mat-forming, tufted perennial grass with rhizome growth underground and occasional runners above ground.

What could this indicate?

- General indicator of low soil fertility particularly nitrogen (N), but also phosphorus (P), potassium (K) and sulphur (S).
- An acid tolerant plant; could indicate soil acidity.
- Often found in higher rainfall areas where pastures have been under grazed over spring.

How can I confirm this?

Visually assess your paddock to determine where the bent grass is growing, the percentage of cover and the quantity of total feed on offer in your paddock over spring.

Conduct a soil test focusing on nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and soil pH.

When seeking professional assistance, your soil test results and the percentage of bent grass in the paddock will help determine the best management options.

SPECIES PRESENT

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Capeweed

Arctotheca calendula

What is my paddock telling me?

Capeweed is a dense rosette forming annual herb with broad, deeply lobed leaves and yellow daisy-like flower.

What could this indicate?

- High soil fertility, particularly nitrogen (N) as well as phosphorus (P). Nitrate poisoning in livestock can occur, especially after spraying.
- Paddock has had bare or open areas over the summer or autumn break.

How can I confirm this?

Visually assess your paddock and note where capeweed is present. It is often found in stock camps, gateways or adjacent to tree plantations and establishes in bare or open patches as it has a high temperature tolerance where there is no competition from perennial grasses.

Aim to reduce grazing pressure resulting in bare ground, particularly in late summer as it provides ideal germination conditions for capeweed.

Conduct a soil test focusing on nitrogen (N) and phosphorus (P) levels.

SPECIES PRESENT

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Erodium

Erodium spp.

What is my paddock telling me?

Erodium, also called corkscrew or storksbill, is an annual or short-lived perennial (depending on species) herb with pink to white flowers and sharp, corkscrew-like seeds.

What could this indicate?

- High soil fertility, particularly nitrogen (N) and phosphorus (P).
- Paddock has had bare or open areas over the autumn break.

How can I confirm this?

Erodium species colonise areas that are bare at the autumn break, often heavily grazed over summer (primarily sheep) paddocks on well drained, dry gravelly rises and ridges. They can also be found where hay has been cut.

Aim to reduce grazing pressure resulting in bare ground by managing stock rotation to avoid overgrazing in late spring and summer. Establish and maintain a competitive perennial pasture.

SPECIES PRESENT


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Rushes

Juncus spp.

What is my paddock telling me?

Rushes grow in tufted clumps, having round green stems, often with knobbly seed heads.

What could this indicate?

- Rushes are predominately found in wet soils, suggesting poor drainage where the soil surface may be crusting or compacted. Most species are found in freshwater, but some will grow in brackish waters and a few will tolerate salinity.

How can I confirm this?

Soils with poor structure often have a poor calcium to magnesium ratio (Ca:Mg), indicating a potential calcium or magnesium deficiency. Conduct a soil test to identify if any deficiencies exist.

When seeking the assistance of an agricultural specialist, take along your soil test results and a map of your paddock's hydrology, as both soil nutrients and wet area management may need addressing.

SPECIES PRESENT


NJ


KC


NJ


NJ

Nettles

Urtica spp.

What is my paddock telling me?

Nettles are known for their toothed leaves with stinging hairs located on the leaves and stems.

They can be found taking advantage in heavily grazed pastures.

What could this indicate?

- Soil is high in nutrients, especially phosphorus (P) and nitrogen (N), and this is why you often see nettles amongst the cow pats in paddocks or around chicken coops.
- Nettles often favour moist soils that are rich in organic matter.

How can I confirm this?

Visually assess your paddock and note where the nettles are present, they are often found taking advantage of heavily grazed pastures or bare ground.

Aim to reduce grazing pressure resulting in bare ground as nettles easily spread via wind dispersed seeds.

SPECIES PRESENT

Mosses

What is my paddock telling me?

Moss occurs in moist or shaded areas or areas with no other plant cover.

When dry, together with lichen, moss can form extensive soil crusts.

What could this indicate?

- Poor to no soil structure leading to anaerobic conditions – no air in the soil.

How can I confirm this?

Visually assess your paddock, identifying where the moss is most common, paddock condition and the surrounding environmental conditions, including using a shovel to dig a hole to investigate the soil's heath.

When seeking the assistance of an agricultural specialist, take along your paddock assessment results as paddock drainage, soil structure, organic matter and soil nutrient may need addressing.

SPECIES PRESENT

Umbrella sedge

Cyperus eragrostis

What is my paddock telling me?

Umbrella sedge is a perennial with shallow roots, long leaves, triangular stems and globular seed heads. Similar to nutgrass (*Cyperus rotundus*).

What could this indicate?

- Umbrella sedge is common in wet, open and disturbed soils, indicating the paddock may have poor drainage and becomes waterlogged. Most species are found in fresh water, but some will grow in brackish waters.

How can I confirm this?

Take a visual assessment of the paddock as umbrella sedge are found in waterlogged areas and if found to be widespread, improved drainage across the paddock may be a management option.

SPECIES PRESENT

Marshmallow

Malva parviflora

What is my paddock telling me?

The marshmallow, or small-flowered mallow, is an erect or sprawling herb with small white or pink flowers that swell into fruits resembling tiny pumpkins.

What could this indicate?

- High soil fertility, particularly nitrogen (N) but also phosphorus (P).
- Paddock has had bare or open areas over the summer or autumn break.

How can I confirm this?

Visually assess your paddock and note where the marshmallow is present. It is often found in stock camps, gateways or adjacent to tree plantations as it establishes in bare or open ground.

Aim to reduce grazing pressure resulting in bare ground, particularly late summer as it provides ideal germination conditions for marshmallow.

SPECIES PRESENT

NJ

PP

PP

Buck's-horn plantain

Plantago coronopus

What is my paddock telling me?

Buck's-horn plantain is a low growing, strongly tap-rooted, perennial with a rosette leaf growth.

What could this indicate?

- A good indicator of saline soils.
- Low soil salinity – leaves are a dull grey-green colour.
- High soil salinity – leaves have a red colour.

How can I confirm this?

Buck's-horn plantain is a salt tolerant species that grows in the cooler months and often dies off in summer. Conduct a soil test and note the electrical conductivity (EC), a soil is classes as saline when the ECe is 4 deci-siemens per metre (dS/m) or more and at those levels many crops and pastures are effected.

SPECIES PRESENT


LM


IC


IC

Sea barley grass

Hordeum marinum

What is my paddock telling me?

Tufted annual grass growing to 50 cm high and similar to *Hordeum leporinum,* except the *Hordeum marinum* flower head spike is semi-flattened, not cylindrical.

What could this indicate?

- A good indicator of saline soils.

How can I confirm this?

Sea barley grass is a salt tolerant species that colonises low-lying disturbed areas and is a good indicator of saline soils. Conduct a soil test and note the electrical conductivity (EC), a soil is classed as saline when the ECe is 4 deci-siemens per metre (dS/m) or more. Many crops and pastures are affected at those levels.

SPECIES PRESENT


LM


IC


IC

Yellow buttons

Cotula coronopifolia

What is my paddock telling me?

Yellow buttons, or water buttons, is a hairless low-growing herb to 20 cm high that has distinctive yellow button-like flower heads.

This is a salt tolerant species that grows in damp, periodically flooded, low-lying areas from fresh to saline conditions.

What could this indicate?

- A good indicator of saline soils.

How can I confirm this?

Yellow buttons are a salt tolerant species that grow in damp, periodically flooded, low-lying areas from fresh to saline conditions. Conduct a soil test and note the electrical conductivity (EC). A soil is classed as saline when the ECe is 4 deci-siemens per metre (dS/m) or more, and at those levels many crops and pastures are affected.

SPECIES PRESENT


KC


LM


KC

Symptom check

My paddock is looking sick.

What is it telling me?

What are these symptoms telling me?

Bronzing or red on sub-clover leaf margins

What is my paddock telling me?

Bronzing or red on sub-clover leaf margins that develop into pale grey spots.

Seen in later winter and early spring.

What could this indicate?

- Potassium (K) deficiency
- Avoid confusion with red-legged earth mite feeding damage which occurs randomly across the leaves.
- Soil acidity
- Low phosphate (P), boron (B) and/or nitrogen (N).
- Red leaf virus

How can I confirm this?

With a magnifying glass inspect the plants, to see if any insects can be found.

Conduct a soil test and note the potassium levels.

Take a plant tissue test to send for analysis. Take your test results to an agricultural specialist and they will help confirm what is happening in your paddock.

SYMPTOM CHECK

JE

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Small, stunted or dark green leaves on sub-clover

What is my paddock telling me?

Slow and poor growth of pasture occurs from ‘hidden hunger’ of all nutrients before appearance of leaf symptoms. Sub-clover leaves with adequate fertility should be the size of a 20-cent piece.

Observed in early spring when clover is adequately growing.

What could this indicate?

- Phosphorus (P) deficiency.
- Only when phosphorus deficiency is extreme do leaf symptoms appear.

How can I confirm this?

Conduct a soil test focusing on phosphorus (P) levels, noting that an Olsen P between 8 and 13 is deemed adequate in dryland pastures.

When seeking the assistance of an agricultural specialist, take your soil test results as they will assist to confirm what is happening.

SYMPTOM CHECK


LM


LM


LM

Stunted sub-clover, usually pale green in colour

What is my paddock telling me?

Slow growth of sub-clover plants followed by rapid death. Seen in autumn and winter.

What could this indicate?

- Increased available soluble aluminium (Al) in the soil (occurs in acidic soils). Aluminium retards root growth, which restricts water and nutrient uptake by the plant.
- Sulphur (S) and/or molybdenum (Mo) deficiency.
- Fusarium rot – a common plant fungal disease.

How can I confirm this?

Take a visual assessment of the clover plants. Aluminium effects root growth, sulphur deficiency causes new leaves to be paler in colour than older leaves, molybdenum can impact leaf colour, similar to nitrogen, and Fusarium rot causes plants to wilt in hot weather.

Conduct a soil test noting soil pH, aluminium (Al), sulphur (S), nitrogen (N) and molybdenum (Mo) as well as a plant tissue test to identify any trace element deficiencies. Take the test results to an agricultural specialist to confirm what is happening in the paddock.


SYMPTOM CHECK
SB

Yellow roots with reduced or pruned branches

What is my paddock telling me?

Roots are yellow with reduced or pruned branches and they may also have brown / black lesions.

What could this indicate?

- Soil-borne diseases are caused by four main pathogens: *phytophthora, pythium, aphanomyces* and *rhizoctonia*.

How can I confirm this?

Conduct a DNA based soil test (PREDICTA® B). This test can be conducted prior to sowing as well as during the growing season. Take your test results to an agricultural specialist and they will help confirm what is happening in your paddock. Management will be determined by the identified disease.

Inspect roots of suspect plants during the growing season.

To prevent disease spread practice good equipment hygiene.

SYMPTOM CHECK

ABOVE: ROOTS HAVE BEEN IMPACTED BY SOIL-BORNE DISEASES.

RIGHT: HEALTHY, WELL-DEVELOPED ROOTS.

Milky, tea coloured water on soil surface after rain

What is my paddock telling me?

Slow growth of plants.

After rain there is milky, tea coloured water on the soil surface.

'Soupy' soils when wet and 'hard-setting' when dry.

What could this indicate?

- Dispersive soils.
- Individual clay particles separate from one another when soil becomes wet. This is due to excessive calcium and insufficient organic matter to bind the soil together.

How can I confirm this?

Conduct a soil dispersion test.

If the problem is isolated, an option is to apply gypsum and increase soil organic matter.

It the problem is widespread, talk to an agricultural specialist who can recommend a course of action.

SYMPTOM CHECK

RS

Soil forms surface crust, sets hard when dry

What is my paddock telling me?

Stunted growth and root development. Germination of seedlings is slow and patchy.

Soil crumbs break apart when wet due to low organic matter which results in surface crusting. Often seen around gateways.

What could this indicate?

- Soil aggregate instability or slaking.

How can I confirm this?

Conduct a soil aggregate or slaking test.

Retain groundcover, minimise tilling and traffic and establish cover crops during non-growing season.

If the problem is widespread, talk to an agricultural specialist who can recommend a course of action.

SYMPTOM CHECK

Soil disturbance with soil crumbs on surface

What is my paddock telling me?

Soil crumbs in small mounds on the surface, usually seen in moist soil in winter and spring.

What could this indicate?

- Can be an indication of earthworms. The disturbed soil is excreted waste called casts.
- Can be an indication of dung beetles, the disturbed soil is from tunnelling to bury dung balls.
- The black-headed cockchafer forms mounded tunnels.

How can I confirm this?

Dig in the soil to find the insect responsible.

If you find earthworms or dung beetles, leave them as they increase soil fertility.

If you find cockchafers, identify the species and then seek advice from your agricultural specialist.


DUNG BEETLES
SYMPTOM CHECK
LM


EARTHWORM
LM


BLACK-HEADED COCKCHAFER
LM

Dark-green patches, short yellow-green elsewhere

What is my paddock telling me?

Increased or fast pasture growth surrounding manure pats and urine patches, shorter paler green growth elsewhere.

Best time to look is late winter and early spring.

What could this indicate?

- Pale green grass deficient in nitrogen (N), potassium (K), phosphorus (P) or sulphur (S).

How can I confirm this?

Conduct a soil test with reference to potassium, nitrogen, phosphorus and sulphur.

Conduct a plant tissue test, in both the pale and dark green growth areas, to compare differences.

Take your test results to an agricultural specialist and they will help confirm what is happening in your paddock and recommend a course of action.

SYMPTOM CHECK


LM


LM


LW

Yellowing or pale green pastures

What is my paddock telling me?

Large-scale yellowing or pale green colour seen in later winter through to spring.

What could this indicate?

- Deficiency in potassium (K), nitrogen (N) or sulphur (S) or trace elements such as molybdenum (Mo).
- Waterlogging, resulting in transient nitrogen (N) loss.
- Maturing or flowing winter grass (*Poa annua*).
- Dying plants caused by red-headed cockchafer pruning plant roots.
- Yellowing could be caused by rust.

How can I confirm this?

Inspect your paddock, looking for red headed cockchafers, winter grass or rust on plant leaves. See if this aligns with the yellow or pale green patches in the paddock.

Conduct a soil test to determine any nutrient deficiencies and conduct a tissue test to identify a molybdenum deficiency.

SYMPTOM CHECK

LM

NJ

WINTER GRASS

LM

COCKCHAFER BEETLE

JA

Grass dominant pasture, little or no legumes, slow growth

What is my paddock telling me?

Grass dominant pasture, with little or no legumes and slow growth seen in late winter to mid spring.

What could this indicate?

- Possible phosphorus (P) or molybdenum (Mo) deficiency.
- Low soil pH (soil acidity).
- Inappropriate sub-clover management, such as leaving too much dry material at the autumn break, long rotations encouraging grass dominance or cutting hay in later maturing clovers.

How can I confirm this?

Conduct a soil test with reference to phosphorus, pH and aluminium to determine nutrient deficiency.

Tissue test plants for molybdenum deficiency.

Reduce dry material litter to 1–2 handfuls in 0.1m^2 quadrat.

SYMPTOM CHECK

LM

LM

Reduced summer growth, bare patches, salt crystals

What is my paddock telling me?

Areas that stay green during summer but have reduced growth. Bare patches remain. White salt crystals visible on the soil surface.

Different plants growing to the rest of the paddock. Best seen in late spring.

What could this indicate?

- Salinity caused by a salty water table less than two metres below the soil surface.
- Saline areas often only support salt-tolerant plants such as Buck's-horn plantain, sea barley grass, yellow (water) buttons and rushes.

How can I confirm this?

Conduct a soil test for electrical conductivity (EC).

Plant deep-rooted perennial pastures (including natives) and/or salt tolerant plants. Plant trees in groundwater recharge zones.

Investigate land management options for waterlogged areas.

SYMPTOM CHECK

LM

LM

MM

Lucerne won't establish, stunted or poor growth

What is my paddock telling me?

Lucerne won’t establish.

Lucerne stunting or patchy poor growth following establishment. Seen in the first 3 to 4 months after establishment.

What could this indicate?

- Soil acidity with associated high soil aluminium (Al).
- Aluminium affects the root growth, causing stunting, sideways growth of roots and plant loss.
- Waterlogging may cause a similar effect.

How can I confirm this?

Conduct a soil test with reference to pH and aluminium.

Take your test results to an agricultural specialist and they will help confirm what is happening in your paddock and recommend a course of action.

Stunted lucerne with J-shaped roots from poor growth patches (right) compared to healthy plants.

NJ-AV

Whitish nodules on legume roots after germination

What is my paddock telling me?

Whitish nodules, instead of the usual healthy pink, observed on legume roots 12 weeks after germination into early spring.

What could this indicate?

- Soil acidity and high soil aluminium (Al).
- Insufficient rhizobia (nitrogen fixing bacteria) in the soil as a result of land management practices.
- Residual herbicide damage.
- Molybdenum (Mo) and/or sulphur (S) deficiency.

How can I confirm this?

Inspect nodules – you want big pinkish nodules, not small whitish nodules. If you squash/cut a nodule in half, you want a pink colour flesh and juice.

Conduct a plant tissue test to identify a molybdenum deficiency.

Talk to an agricultural specialist and they will help confirm what is happening in your paddock and recommend a course of action.

SYMPTOM CHECK

WHITE NODULES

JP

Soil tests

How do I test my paddock's soil?

What are the results telling me?

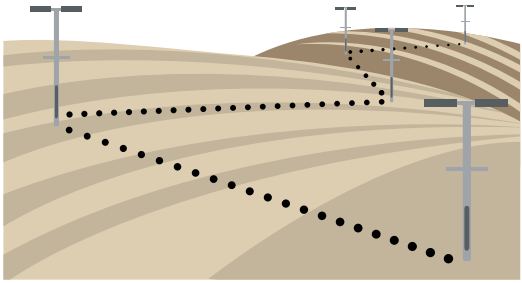
Testing your soil

Testing the soil across your paddocks can help you maintain good soil health for long-term, sustainable production. By knowing what condition your soil is currently in, it can help determine what actions need to be taken – whether additional nutrients are required, drainage improved, or even planting a different crop or pasture species to better suit the conditions.

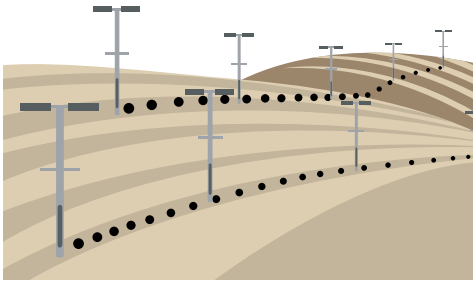
Plan

Before all of this action begins, you first need to plan for testing.

- Develop a plan for sampling your paddock/s. You can use a pattern format, such as zigzag or grid, which provides for optimal coverage across the paddock. Alternatively, a transect pattern across the paddock is good for monitoring changes over time.



Soil sampling - zigzag pattern

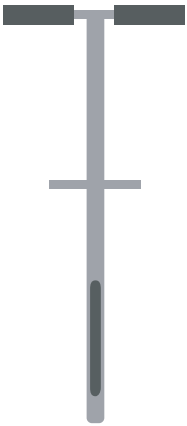


Soil sampling - paddock transects

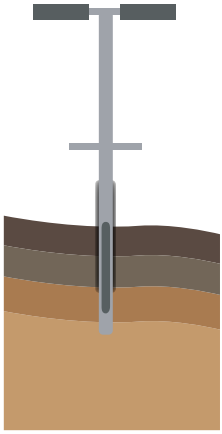
- Plan to choose a range of sites across your paddock for your soil test sample, making sure to get a good representation of your land use. Take note of changes in soil type and submit a separate sample from each.
- Plan to take 20–40 cores across the paddock to make up your sample.
- Sampling is best conducted at the same time each year, in late winter to early spring. Grazing pasture should be tested every 3–5 years, while production that has a higher nutrient requirement (such as cropping) should be tested more frequently.
- Don't sample within 3 months of fertiliser application as it will affect your results.
- Most soil testing laboratories will supply soil test bags on request.

Sample

Once your plan is in place, next is to conduct the sampling. Samples need to be clean (free from other contaminants) and conducted in the same manner each time for consistency.



- Use appropriate equipment for sampling including:
  - soil corer or auger that is able to collect a sample to the required depth and ensure the tool/s are clean (e.g. rust free) otherwise your test results will be compromised
  - gloves
  - clean bucket
  - sample bags big enough for 20–40 cores per sample
  - record keeping materials – GPS/mobile phone, property map, notebook and marker/pen.
- Sample to the correct depth based on your land use and soil conditions, avoiding stock camps, troughs and high traffic/compacted areas.
- When sampling, make sure to record the location of each sample on a map, preferably with GPS coordinates. Alternatively, you can map your location on your mobile phone's Map app and look up the coordinates back at your home or office.



- Take photos during the process of taking your samples. This is not necessary but may be useful if you are planning for long-term monitoring.
- Your soil testing laboratory will provide you with forms that may include a barcode or other codes. Make sure that these are assigned to the correct sample bag.

Dispatch

While out in the paddock, it is good practice to store your sample in a cool, dark, sealed container, like an Esky. This helps to avoid prolonged chemical changes in the soil after it's been disturbed and exposed to air.

- Complete all forms required by the testing laboratory and pack your forms and soil samples together. Always double check the details on your laboratory testing form(s) before sending.
- Make sure your sample is well-sealed to avoid further exposure and for biosecurity reasons with transporting soils across the State.
- Your sample bag(s) should be sent back to your soil testing laboratory as soon as possible. If you can't, store the sample in a refrigerator until sent. Send via express post on a Monday, Tuesday or Wednesday otherwise samples can be left in transit for long periods of time in often warm conditions, which will influence test results.

Understanding your soil test

Upon receiving your soil test results from the lab, it can sometimes be confusing to know what all the numbers and units mean. Some results may be obvious, such as soil texture or pH, but it is also important to understand the other data, such as the different nutrient levels and exchangeable cations.

In this section you can find out what the results mean, the target levels you want to achieve for good production and, in some cases, what can be done to fix the problem. Having test results available will make it easier when talking to an agricultural specialist about managing your pasture.

Please take note that there are many soil-testing laboratories offering a range of soil tests, so it is important to clarify which test(s) you want carried out.

Texture

Soil texture is determined by the percentage of sand, silt or clay particles in a soil. These values are used to classify the soil type such as: loam, silty loam, clay loam, sandy clay, silty clay etc.

Understanding the soil texture can help identify management methods for your paddock/pasture as a soil's texture influences both soil structure (drainage, strength, aggregation and friability) and fertility (cation exchange, available water and retention of organic matter).

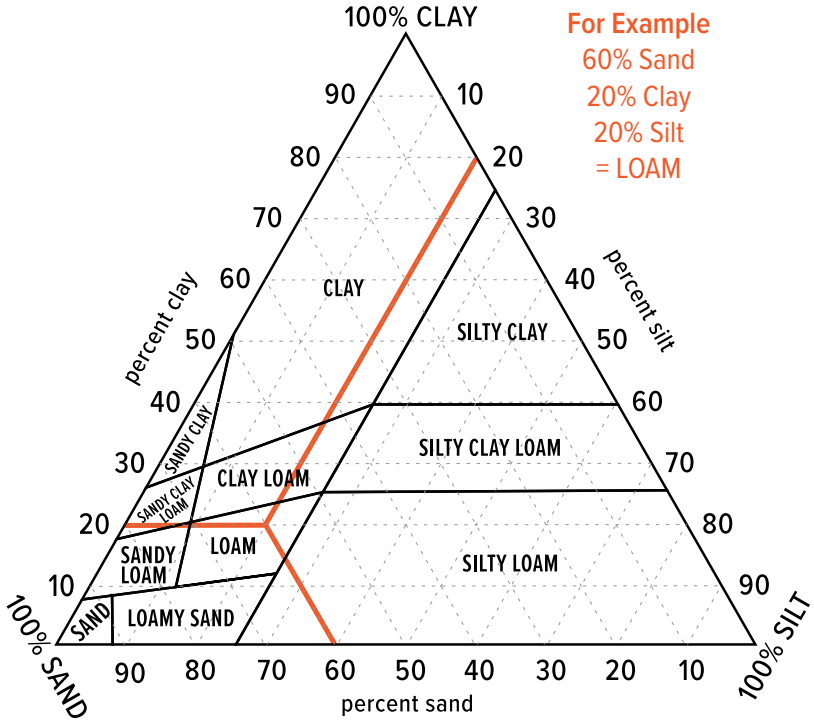


Diagram: Soil texture percentage triangle

pH

Soil pH is a measure of the soil's acidity or alkalinity in units. A pH of 7 is neutral. As the pH number decreases soil becomes more acidic, and as it increases soil becomes more alkaline. An extremely acidic soil would be a pH of 3 and high alkaline soils would be a pH of 10. As soils become more acidic, some elements can become more available, like aluminium, which can be toxic to plants.

Soil pH is measured as either pH (water) or pH ($CaCl_2$). Optimum pH depends on what plant you are aiming to grow, but as a general rule target levels are:

- pH (water) 5.8 to 6.5
- pH ($CaCl_2$) 5.0 to 5.8

Conducting a soil acidity test.

LM

Salinity – $EC_{1:5}$

Electrical Conductivity is the salinity level in your soil. It is often prepared in a 1:5 solution (1-part soil to 5-parts water) and measures the level of dissolved salts (Sodium Chloride – $NaCl_2$). $EC_{1:5}$ results are often provided in deci-siemens per metre (dS/m). Salinity can be identified in the paddock by using salt indicators plants as well as visible salt crystals on the soil surface.

Your crop or pasture's tolerance to salinity can vary depending on the plant species. To generate a plant tolerance EC value (EC_e), your $EC_{1:5}$ is multiplied by a factor based on your soil texture. As a rule of thumb, a soil salinity of 1 dS/m will have minimal impact on most agricultural crop yields, while 6 dS/m will see most agricultural crops being affected.

Bare patches caused by high salinity levels.

LM

Table 1: Plant salt tolerance multiplication factor

Soil texture group	Multiplication factor
Sands, loamy sands	13
Sandy loams, fine sandy loams	11
Loams, silty loams, sandy clay loams	10
Clay loams, silty clay loams, sandy clays, silty clays, light clays	9
Light medium clays	8
Medium clays	7
Heavy clays	6

Table 2: EC_e results required for specific pasture plants

Salinity rating	EC_e (dS/m)	Species that will grow
Very low	< 1.8	All pastures and clovers
Low	1.8–3.8	Most pastures, crops, legumes
Moderate	3.8–6.5	Grass, some legumes
High	6.5–8.6	Grass, not clovers
Extreme	> 8.6	Salt tolerant plants, some barley grass

Example: Determining your soil's salinity rating (EC_e)

You have a light clay soil with a $EC_{1:5}$ result of 0.8 dS/m.

$EC_{1:5}$ x multiplication factor = EC_e (salinity rating)

0.8 x 9 = 7.2 dS/m

Salinity rating is HIGH.

Cation Exchange Capacity

Cation Exchange Capacity (CEC) is a measure of the soil's ability to hold positively charged ions (cations). Many nutrients exist as cations, such as calcium, magnesium, sodium and potassium. The higher the CEC, the more fertile the soil; meaning it has a greater ability to store cations/available nutrients.

CEC is expressed as centimoles of charge per kilogram – cmol(+)/kg. Soil tests will also include the percentage of total cations. The CEC value can change depending on the clay content, pH and organic matter. Low CEC soils can develop potassium and magnesium deficiencies.

Table 3: Target levels for exchangeable minerals

Cation	Value cmol(+)/kg	Percentage of total cations
Exchangeable Calcium	5–10	65–80%
Exchangeable Magnesium	1–3	10–20%
Exchangeable Potassium	0.3–0.7	3–8%
Exchangeable Sodium	<0.7	<1%
Exchangeable Aluminium		<1%

Exchangeable cations

The major cations present in soil are Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na).

In acid soils, Aluminium (Al), Hydrogen (H) and Manganese (Mn) cations can occur in high concentrations:

Exchangeable Calcium: Many soils have inadequate concentrations for a healthy soil structure. High levels of exchangeable calcium increases flocculation and can improve soil structure in the soil.

Exchangeable Magnesium: Excessively high levels of magnesium can cause a potassium deficiency.

Exchangeable Potassium: Potassium is the only key nutrient that is also exchangeable. High CEC potassium levels can lead to magnesium deficiency in plants and animals.

Exchangeable Sodium: Although not needed for plant growth, sodium is needed by animals. A high CEC sodium value can cause crusting / dispersion in sodic clay soil with low organic carbon. Exchangeable Sodium levels are a key indicator of sodic soils, and to further define a sodic soil a dispersion test needs to be conducted.

Exchangeable Aluminium: High concentrations are common in very low pH (acidic) soils. This can be toxic to plants. If the percentage of aluminium cations is 10% or higher, lime is required for good growing conditions. Lime will help raise the pH above 5.7 and aluminium levels will fall to safe levels.

Calcium to Magnesium Ratio

Soils contain calcium and magnesium cations, which are positively charged and are attracted to the negative exchange sites on clay and organic matter. Calcium and magnesium are plant essential nutrients, and the ionic form is readily taken up by plants.

The ratio of exchangeable calcium to exchangeable magnesium provides a guide to a soils structure. A well-structured soil has a calcium to magnesium ratio of greater than 2, in other words the calcium cations are more than two times greater than the magnesium cations. A calcium to magnesium ration exceeding 10, could indicate a magnesium deficiency in pasture species.

Carbon

Carbon (C) is one of the building blocks of life and is essential for plant growth. Organic carbon content ensures good soil structure, supplies and retains nutrients in the soil, and allows air and water to be available for plant roots.

Organic carbon levels will vary according to the soil type, rainfall, pasture or crop type, farm management including stocking rate and grazing management.

If organic carbon levels are above 3%, the soils should have good structural condition and high structural stability.

Nitrogen

Plants require nitrogen (N) for good growth, however only 2% of the mineral form is available to plants. The other 98% is locked up in organic matter and can be converted into mineral nitrogen when micro-organisms decompose the organic matter.

Testing for nitrogen levels can be misleading as the availability of nitrogen can change quickly in transit from collecting the sample to the testing laboratory. The results provide an indication only and the desired level of nitrogen will depend on your pasture's requirements.

Phosphorus

Phosphorus (P) is vital for the general health and vitality of all plants. It is extremely important for early root formation and growth, improved flower and seed production, and increases legume nodulation and nitrogen fixation in the soil.

Not all forms of phosphorus in the soil are available for plants to use. Soil tests will provide one or two core sets of values:

- **Olsen P** measures plant available phosphorus and used for grazing systems.
- **Colwell P** measures immediately available phosphorus and used for cropping systems.

Table 4: Availability of phosphorus at various Olsen P values

Irrigated pastures (Olsen P mg/kg)	Dryland pastures (Olsen P mg/kg)	Availability
< 12	< 8	Low
12–17	8–12	Marginal
18–25	13–8	Adequate
> 25	> 18	High

To determine the adequate levels of phosphorus in your soil using the Colwell P value, the soil Phosphorus Buffering Index (PBI) needs to be considered. The PBI is a measure of your soil's tendency to chemically absorb phosphorus. The higher the PBI, the quicker and tighter the phosphorus binds to soil particles, the tightness of the bonds determines the amount of phosphorus available for plant uptake.

Table 5: Target Colwell P levels based on Phosphorus Buffering Index

PBI Category	Target P
0-70	20–30 mg/kg
71-140	21–36 mg/kg
141-280	36–44 mg/kg
281-840	44–64 mg/kg
>840	64–84 mg/kg

Sulphur

Sulphur (S) is often classed as a secondary nutrient, but it is just as important for pasture growth as some of the other nutrients. It aids in the formation of proteins and vitamins, in chlorophyll production and helps plants resist stress.

Most sulphur in the soil is in organic matter and unusable by plants until it is converted by soil bacteria to its sulphate form. This is a process known as mineralisation.

Tests for available sulphur include:

- CPC (Calcium Phosphate plus Charcoal) test
- MCP (Mono-Calcium Phosphate) test
- KCl 40 (Potassium Chloride) test.

The results from these tests can vary depending on soil moisture and temperature as these factors affect the mineralisation process. It will be lower during dry periods and be higher in warm, wet conditions.

Table 6: Target levels for plant available sulphur

Test	Value
CPC or MCP	4–6 mg/kg
KCl 40	8–12 mg/kg

Potassium

Potassium (K) is one of the major nutrients for plant health. It is important for plant cell walls, flowering, seed set and helping plants be more resistant to stress and disease.

Potassium is abundant in soil, but its availability for plants to use is controlled by soil chemistry and minerology. Clay soils can hold a higher concentration of nutrients and need higher levels of available potassium than sandy soils. Therefore, interpreting potassium results needs to take soil texture into account as the critical value increases with increasing clay content.

Table 7: Target levels and dependent on the soil type

Soil type	Value mg/kg
Sands	101–150
Sandy loam	121–200
Clay loam	151–250
Clays	180–300
Peats	351–600

Exchangeable Potassium is a measure of readily available potassium. High levels of exchangeable potassium can cause animal health issues, such as grass tetany, and can pose an environmental risk due to the likelihood of leaching through the soil profile in wet conditions. See page 84 for target levels of exchangeable potassium.

Plant tissue tests

How do I test my paddock's plant tissue?

What are the results telling me?

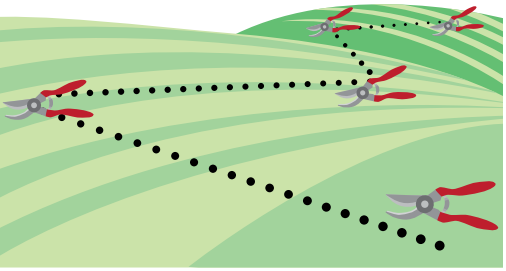
Testing your plant tissue

Testing the tissue of the plants in your paddock, in combination with a soil test can help to identify the cause of many issues as well as inform on fertiliser use performance.

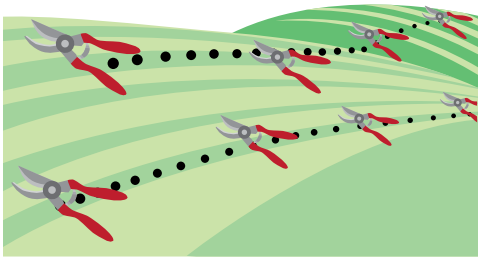
Plan

Before any action begins, you first need to plan for testing your plant tissue.

- Develop a plan for sampling your paddock/s. You can use a pattern format, such as zigzag or grid, which provides for optimal coverage across the paddock. Alternatively, a transect pattern across the paddock is good for monitoring changes over time.

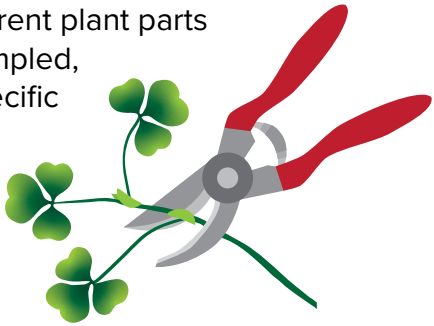


Soil sampling - zigzag pattern

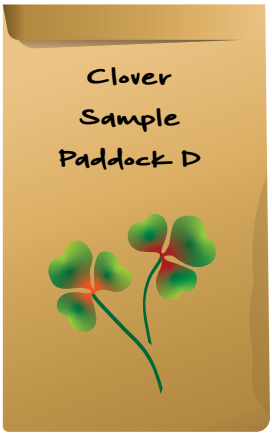


Soil sampling - paddock transects

- Plant tissue samples are taken from areas within the paddock displaying poor or unusual growth. To assist in identifying an issue, plant tissue samples are also often taken from an area displaying good growth, to compare results. Please note, if you are also taking a soil sample, ensure it is taken in the same location as the plant tissue sample.
- Different plants require different plant parts and growth stages to be sampled, laboratories also require specific amounts of material to be tested. It is best to seek advice from your testing laboratory before going into the paddock, as it will differ for each situation.



- When taking plant tissue samples, timing is very important, samples must be taken at the correct growth stage and/or time of year. The time of day is also important, so samples should be collected before 10am wherever possible.
- Plant tissue samples should be sent to the laboratory in a paper bag only, as plastic bags can sweat and cause the sample to deteriorate. Most laboratories will provide suitable sample bags on request.



Sample

Once your plan is in place, conduct the sampling. Samples need to be clean (free from other contaminants) and conducted in the same manner each time for consistency.

- Use appropriate equipment for sampling including:
  - gloves – do not use your bare hands
  - clean bucket
  - sample bags – paper only
  - record keeping materials – GPS/ mobile phone, property map, notebook and marker/pen.

- Sample the correct plant parts, as advised by your testing laboratory. Generally, avoid soiled, damaged, dead or dying plants or plants effected by disease or insects. Do not sample within two months of applying fertiliser, either foliar or soil.
- When sampling, make sure to record the location of each sample on a map, preferably with GPS coordinates. Alternatively, you can map your location on your mobile phone's Map app and look up the coordinates back at your home or office.
- Take photos during the process, this is not necessary but may be useful if you are planning for long-term monitoring.
- Your testing laboratory will provide you with forms that may include a barcode or other codes. Make sure that these are assigned to the correct sample bag.

- Samples need to be cooled immediately and chilled to less that 5°C in a refrigerator as soon as possible, please note that you are not to freeze the sample.

Dispatch

While out in the paddock, store your sample in a cool, dark, sealed container, like an Esky containing ice bricks. This helps to avoid deterioration of the sample.

- Complete all forms required by the testing laboratory and pack your forms and plant tissue samples together. Always double check the details on your laboratory testing form(s) before sending.
- Make sure your sample is well-sealed to avoid further exposure and for biosecurity reasons with transporting across the State.
- Your sample bag(s) should be sent back to your testing laboratory as soon as possible. Send via express post on a Monday, Tuesday or Wednesday otherwise samples can be left in transit for long periods of time in often warm conditions, which will cause deterioration of your samples.

Understanding your plant tissue test

Plants require light, water, oxygen, carbon dioxide, suitable temperatures, and minerals to grow. These all need to be available within specific ranges and in balance for optimum plant growth. A plant tissue test measures the concentration of minerals present in the plant and compares them with the concentrations required for optimum plant growth and yield.

Individual plant species and different growth stages require different concentrations of minerals, so it is best to consult your agricultural specialist to fully understand your plant tissue test results.

To assist in understanding the importance of the roles each of the minerals play in the plant's health, see below the minerals often tested for in a plant tissue test.

Phosphorus (P)

Phosphorus is used in energy transfer around the plant and plays a very important role in nucleic acids, the foundations for plant genetic code. Phosphorus is also important for root growth, seed production and crop maturity. Phosphorus is most needed during transitional periods of plant growth, such as moving from vegetative stages to flowering stages.

Potassium (K)

Potassium plays a major role in enzymatic reactions and also assists the leaf guard cells to regulate the exchange of gas and water through the plant's leaves.

Nitrogen (N)

Nitrogen is found in many parts of the plant and plays a critical part in the development of proteins, the building blocks of cells. Nitrogen also plays a role in the production of chlorophyll (the green colour in plants), where light energy is converted into carbohydrates which plants feed on.

Sulphur (S)

Sulphur is a critical partner to nitrogen and assists to convert nitrogen to amino acids and chlorophyll. Sulphur also activates growth hormones.

Pale green grass could indicate a deficiency in nitrogen (N), potassium (K), phosphorus (P) or sulphur (S) – see pages 87-90.

LM

Calcium (Ca)

Calcium plays a role in cell wall and root development and certain enzymatic reactions.

Magnesium (Mg)

Magnesium is a key component of chlorophyll, as it is the central atom in the chlorophyll molecule and is essential for photosynthesis.

Iron (Fe)

Iron is used in the formation of chlorophyll as well as part of the enzyme that is responsible for the reduction of nitrate-N to ammoniacal-N. Iron also assists in carrying oxygen around the plant.

Boron (B)

Boron works in partnership with calcium and is important in forming cell walls and moving sugars around the plant. Boron also aids in the plant's ability to uptake calcium.

Manganese (Mn)

Manganese is involved in the production of plant energy, through chloroplast production and is essential in triggering germination and new growth in plants of all ages.

Copper (Cu)

Copper is essential in converting amino acids into proteins used for new cell development.

Zinc (Zn)

Zinc is essential in the production of plant enzymes and plays a role in plant growth regulation by balancing hormone levels.

Molybdenum (Mo)

Molybdenum plays a role in metabolising nitrogen as well as in the formation of flower pollen.

Chloride (Cl)

Chloride plays a role in balancing the ion charges within the plant and reducing susceptibility to diseases.

Whiteish flesh on legume root nodules instead of the usual healthy pink, could indicate a molybdenum deficiency – see page 72.

JP

References

Visual indicators of Soil Condition Online Edition
Developed by Cam Nicholson (Nicon Rural Services), Lisa Miller and Jess Brogden (Southern Farming Systems) on behalf of Meat and Livestock Australia (MLA). Some photos from this resource have been supplied for use in this publication.
mla.com.au/globalassets/mla-corporate/extensions-training-and-tools/documents/soil-poster-booklet-mobile.pdf

Pasture Paramedic
Developed by Cam Nicholson (Nicon Rural Services), Lisa Miller and Jess Brogden (Southern Farming Systems) on behalf of Meat and Livestock Australia (MLA). Photos have been supplied by MLA from *Pasture Paramedic* for use in this publication.
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Understanding your soil test: Step by step
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vro.agriculture.vic.gov.au

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TopSoils