8 ASSESSING YOUR SOIL

The first stage of the soil health planning process is to assess soils to identify soils constraints across the farm.

There are a number of excellent resources available that outline methods for doing this, and the following discussion and Further Information and Tools section of this documents provide relevant links to these.

The following stages are suggested:

Mapping differences in soil, terrain, land use and productivity

Generate a map to be used to start adding details about differences in soils across properties and individual paddocks. This can be done with pen and paper or on computer. Free online mapping resources can be used to obtain aerial images of most properties in Victoria. Mapshare (http://mapshare.vic.gov.au/MapShareVic/) is a Victorian government resource that allows access to topographical, water way and aerial imagery mapping of properties. Images can be downloaded and used to create a farm map.

Other mapping resources are available. Visualising Australasia's Soils and Victorian Resources Online provide free soil map data that will provide some indication of broad soil types in your area. These are not precise enough to show specific details on you farm and are not a substitute for physically assessing your soil. Often aerial imagery will show differences in surface soil and vegetation colour and help to map possible differences across the farm. Google Earth provides recent aerial images and can be useful to checking differences in plant 'greenness' and surface soil cover and colour at different times of the year.

It is suggested you first identify and draw in:

- Different paddocks, and known variations within these – for example, you may already know that some sections of the farm have different colour, texture type (sand, loam, clay, gravel) and depth topsoils. You may have previous soil test results for different areas You may even know your subsoils from post-hole digging, other excavation or deep soil testing. You might also note whether paddocks are rocky or mostly clear or clear of rocks, and, if you know, what types of rock are present (e.g. basalt, sandstone, mudstone, granite). Differences in types and the abundance of surface rocks can indicate differences in soil types.
- Land use and history. The map should include notes about which areas are cropped and grazed and the history of management, including typical crop rotations and pasture re-sowing, yields of crops including cut hay, typical stocking rates and livestock productivity, and application of fertilisers, lime, gypsum and other soil amendments. This can help to identify paddocks that have higher/lower yields, have been used more/less intensively, and have had more/less inputs applied. It is also worth noting higher traffic areas from vehicles and livestock (e.g. near gates, stock 'camping' areas, and watering and feeding points) as these areas may have greater soil compaction and nutrition. This information is useful for identifying areas to test soil and for nutrient budget planning.

- Differences in terrain, water flow and ponding/waterlogging. Soils often differ from the top and bottom of hills and along creeks and flood prone areas. Hills and creek lines can sometimes mark stark differences in underlying geology/pedology and soil type.
- Observed differences in plant growth and productivity. Most farmers know which paddocks and which parts of paddocks perform better or worse than the average across the paddock. If you know these, draw them onto the map. The under-performing areas will be a good place to undertake soil assessments, and the best performing areas might be an indicator of what can be achieved across the farm with improved soil management.
- Observed difference in vegetation types. Differences in types of pasture species growing in paddocks can indicate differences in soil types and depths. Mapping treed areas (which should be obvious on aerial images) might be useful in assessing on-farm biodiversity and what undisturbed soils look like on your farm.

Choose the areas of the farm where you plan to assess soils and mark these on the map. It is suggested that you identify areas that you believe are representative of different landscapes and soils on your farm and areas that you know to be under-performing. These will the areas to focus on first, but it is suggested you start carrying a spade and 'poker' on the tray of your farm vehicle and every so often have a dig and poke across the whole farm.

Having a poke and dig

A focus of the Healthy Soil project is to look at both upper soils and sub-soils to a depth of at least 60 cm. In many parts of Central Victoria, the upper 10-30 cm of upper soil is a lighter clay-loam, loam or sandier soil overlying heavy clays, gravelly clays or even bedrock. Often these deeper subsoils have poor water infiltration or chemical characteristics that prevent deeper and healthier root growth, and this can only be determined by digging or taking cores of deeper soils.

When soil moisture is sufficient down the soil profile, a spade or shovel may be enough to dig a 60 cm hole, but often an auger, crow bar, pick or post-hole digger may be needed. If such tools are needed, this is usually an indication that there are sub-soil constraints to healthy plant growth.

Table 1 provides a worksheet for assessing and scoring surface appearance, and upper soil/ topsoil and subsoil layers. This can be printed off or photocopied or to allow you to keep a record of changes observed throughout the year. Not every test needs to be undertaken every time, but it provides a tool for recording information and rating how soils are performing at different assessment points. Many of the tests allow performance to be scored on a 0 to 5 scale, and this helps to quickly identify where soils are under-performing and monitor future changes. A valuable guide to use during this process is the North Central Catchment Management Authority's Soil Health Guide which provides more details about some of the tests. This is an excellent reference, and it is strongly recommended that it is used as a guide when undertaking soil assessments.

A suggested method for assessing soils is to:

1. Randomly select where to dig. Avoid areas that might be atypically compacted or fertile due to stock movement such as near water troughs, feeders, gates and stock traffic lines, 'camp' areas, and manure patches, etc and come in at least 20-30m off fence lines. Choose the area you want to sample and throw a stick 2-3 metres from where you are standing. Dig where it lands. This stops you picking a spot to sample based on solely on appearances.
2. Assess the appearance of the soil surface noting type and extent of groundcover, organic matter cover, the types of plants growing, surface cracking, sealing or crusting, and evidence of burrowing animals (earthworms, insects, arachnids).
3. Check how easily the soil can be penetrated with a spade – first pushing with your foot gently and then with more force. Can it get all the way down without full force? Can it get down with full force? Note the depths at which digging gets harder or the blade will not go any further. Unless you have hit a rock, these depths tell you where your soil becomes more compacted. Ideally you should be able to get to a full spade head or moist soil without full force. You can also use a poker or 'penetrometer' made of high tensile wire or metal rod. These are useful for quickly testing differences across and area and are particularly useful on stony soil. See the Soil Health Guide for details. The levels of soil moisture will influence how easily soils can be penetrated, so it is suggested this test is undertaken throughout the year to see how hard-setting soil layers are when they are dry and how quickly soils dry out down the profile. Penetrometer testing can be useful to detect compaction 'hardpans' from historic or current tillage, stock and vehicle traffic management – sometimes pushing through a hardpan occurring at 20-30cm depth will reveal less resistant soil below this level, indicating that working to break up the hardpan could give roots access to deeper soil nutrient and moisture.
4. To undertake the dig tests, spread a groundsheet (e.g. a small tarp) and then quickly cut out an upper sod that is a spade head wide and long

(usually around 15cm X 15cm) and to a depth of the spade head, or around 25-30 cm (or as far as the spade it will go in), and dig put the sod and place it on the groundsheet so the soil surface is near the top edge of the sheet. The reason to dig the 25-30cm sod quickly is to capture earthworms which may move away from the digging if you are slow.

5. Dig the next layer or layers to a depth of 60cm, noting the depths at which it becomes difficult to dig and any changes in texture (sand, clay, gravel, silt), colour, moisture content and root depth. As you dig out the soil, place each depth below the original sod on the groundsheet to get an indication of changes in the soil the profile. Often you'll need to expand the depth and width of the hole to get to the soil further down the profile, and if you do, place these layers next to the original excavation to avoiding mixing the layers. Looking and measuring depths inside the hole is also a good way to assess changes in the soil profile and the depth of root growth.
6. If the soil still has some moisture (usually between April/May and September/October in the north central Victoria, but potentially all year around in the southern part of the region), it is suggested you undertake an earthworm count noting the depth at which they are found and the number and size of earthworms. Also look at the extent to which earthworm activity has aerated soil through burrows and 'ped' (small 'ball') formation. These are good indicators of soil health. You should see at least 2-4 large earthworms per 15cm X 15cm X 30cm spade head cut sod. The presence of large 'adult' earthworms immediately following the Autumn break indicates that they were able to 'hibernate' over summer by digging down to soil with enough soil moisture to sustain them, and this is an indicator of a healthier

Earthworms

Earthworms play a major role in aerating soil and converting organic matter into plant available nutrients. Healthy earthworm populations can 'turn over' and 'manure' many tonnes of upper soil per hectare per year and are useful for moving organic matter from the surface soil to lower layers. Earthworms are also a great indicator of soil health. A healthy soil will have an average of at least 2-4 adult earthworms in each spade sod dug to 25-30cm when soil has sufficient moisture (generally between June and October). Ideally populations will be even higher. Sometimes you will not find earthworms but will see evidence of their burrows and friable spherical 'casts'/droppings. To thrive, earthworms need organic matter; a healthy population of soil bacteria and fungi to feed on; soil moisture; and aerated and uncompacted soil. Drought, tillage and chemical use that disrupts soil biology and their food chain will reduce earthworm activity. Most earthworms are slow to reproduce, and it can take more than a year for populations to. Adult earthworms can hibernate in clay subsoils during dry periods for up to 3-4 months, but otherwise rely on the survival of their eggs in soil over dry periods. Finding adult earthworms in the weeks after the autumn break tells you that adults are surviving over summer, which is a good sign of healthy soil. If few adults are surviving over summer, then juvenile hatchlings will be less able to work and manure soil before the onset of dry conditions.

and deeper soil. If only juvenile earthworms are found during the first few months following the autumn break, this suggests few if any adults survived over summer and means the population is sustained by eggs. This reduces the time over which earthworms get to breed before late spring and summer and can result in smaller populations and less benefit from earthworm activity. Low earthworm counts between May-September usually indicate low soil organic matter and other chemical and physical constraints to earthworms and other soil biology. See the section in earthworms for further details.

7. Look at how soil changes down the soil profile. Conduct assessments and tests for aggregate strength and size, texture/clay content, colour, pH, slaking and dispersal and root depth. The Soil Health Guide provides methods assessing these factors.
8. To make up a soil sample to be sent for laboratory testing, take and mix sub-samples at least 5-10 points across an area, keeping the upper soil and sub-soil samples in separate buckets. This is for the purposes of assessing soil profile characteristics. If you are testing in to decide fertiliser application rates, it is recommended you take at least 10-30 sub-samples from the upper 10-20cm to get a more accurate sample. Soil testing laboratories will provide details of how much soil they need and how samples should be stored and sent for sampling.

You can also use the dig to assess water infiltration at various depths. This can be done by digging a shallow hole (10cm), medium depth hole (20-30cm) and deep hole (50-60cm), gently filling each hole with around 10cm of water (fill it initially, and then top it up to 10cm after 5 minutes) and then noticing how quickly (or not) the water drains away. Ideally a depth of 10 cm of water should drain from within 1 hour, and the more rapidly it drains the better. A more advanced infiltration testing using a section of pipe or tubing can also be conducted – see: SoilsforLife - Infiltration. This test tells you how porous the soil is, and how easily rainfall will be absorbed down the soil profile when the soil is dry or wet. Water infiltration will often vary depending whether soils are wet or dry. Dry clay soils that have deep cracking and good aggregate formation can have good water infiltration and this indicates that summer and initial autumn rainfall will be more readily absorbed. However, many clays in central Victoria swell and can become less permeable when they are wet. Where such soils have poor aggregation and porosity, growing season rainfall can be lost as runoff and increase soil erosion and loss of surface organic matter. In some area, subsoil clays become heavy and impermeable, and this can result in waterlogging. Some sandy and fine textured silt and clay soils can develop water-repellency when very dry.

It is suggested basic 'dig test' soil assessments are taken throughout the year, but particularly during the months following the autumn break (when soils and plants first respond to rewetting), in mid spring (when soils and plants should be at their prime, but may be drying), and in February (when conditions are dry, and the drought resilience of soil and plants can be assessed).

You don't have to do all the tests at every sample point every time you test, but the intent is you keep copies of the assessment sheet in farm vehicles and periodically test areas when you are in the paddock and have time. It is suggested samples are sent to laboratories for testing from at least some testing areas initially, and re-tested at least every few years if the area is cropped, cut for hay, or is grazed intensively. Lower intensity grazing properties can lab test soils less frequently. All farms can use the assessment sheets to see whether soil health and function is improving, remaining the same, or getting worse over time.

Summary

- Map difference on your farm and pick areas to assess based on observed under-performance
- Assess plant growth and soil conditions at the surface in areas you assess. Look for weak or patchiness of growth and symptoms of deficiencies, lack of surface ground cover, and surface crusting, cracking and friability.
- Dig holes to 50-60cm depth, making particular observations about:
    - The depth at which the soil becomes hard to dig
    - The depth and strength of root growth
    - Changes in soil texture and colour and the depths at which these occur
    - The friability/porosity of soil at different depths
    - The presence or absence of earthworms and visible organic matter
    - pH at different depths
    - water infiltration
    - stability, dispersion and slaking of aggregates
- Take samples for laboratory testing and use the results to assess likely nutrient deficiencies, soil organic matter levels, pH, nutrient/cation exchange, calcium-to-sodium and magnesium levels, and potential toxicities.

Laboratory testing of soil samples

Initial and periodic laboratory testing of soil samples helps to identify or confirm soil constraints more accurately than field assessments. There are many commercial soil testing services and laboratories available. It is recommended that an independent NATA (National Association of Testing Authorities) certified laboratory is used, as these use standardised and accurate testing methods and are not promoting use of particular products or services. Most laboratories can provide a report summarising the results and indicating deficiencies or other constraints associated with tested parameters. The table below is suggested as guide to interpreting results for key soil testing parameters. It is suggested initial soil testing includes most of these to identify likely constraints, and later testing focuses on these constraints. Most laboratories will provide analysis of results for an additional fee. Section 9 of this Guide provides a table for recording the status of the nutrients you decide to test for.

Table 8.1: Soil assessment tool – this provides a guide for assessing soil health in the paddock. Sending soil samples for laboratory analysis is also useful for identifying possible nutrient deficiencies and imbalances that impact on plant health and soil structure and performance.

Sample area (paddock and location)	
Time of year	
Recent conditions (e.g. dry, wet, paddock history)	
Other observations re: area/paddock	

Soil health factor	What to look for / How to measure	Observations/notes	Score of condition (0=very poor, 5=very good) 0	1	2	3	4	5
Surface assessment								
% cover	Pace across the paddock/ area and every 10-20 paces stop and look at the roughly 30cm X 30cm area in front of your leading foot. Look what % of the surface is uncovered soil, and what proportion of the cover is dead organic matter, or dormant or growing plant matter. The % cover = 100% minus any uncovered area. Score: 0 = <10% cover; 1 = 10-20%; 2= 20-40%; 3 = 40-60%; 4 = 60-80%; 5 = 80-100%.							
Plant vigour and type	Note dominant and other plant species present and how well they are growing for the time of the year. Look for any signs of possible nutrient deficiency. Note plant types and any signs of possible nutrient deficiencies (see Figure 3 and Table 3). Score according to vigour from 0 = very weak/poor to 5 = very strong and healthy.							
Soil surface appearance	Look for friability/'crumbliness', crusting, cracking, mosses, bio-crusting, and salt residues where surface soil is exposed. Score from 0 = smooth, hard and sealed/crusted through to 5 = very crumbly and friable.							
Evidence of soil fauna (animal) activity	Look for insect, spider and worm burrows ('macro pores') in soil. In pasture, look for dung beetles and worms in and under dung piles. Score from 0 = no evidence to animal activity through to 5 = very high level of observable soil fauna activity.							

Soil health factor	What to look for / How to measure	Observations/notes	Score of condition (0=very poor, 5=very good) 0	1	2	3	4	5
Soil depth penetration test	Use poker/penetrometer to see how easy it is to penetrate the soil and gauge compaction at depth. Score: 0 = <5cm; 1 =5-10cm; 2=10-15cm; 3 =15-20cm; 4 =20-30cm; 5 = >30cm							
Soil water infiltration (optional when soil is wet/ moist – the penetration test and assessment of porosity (below) will usually, but not always, provide an indication of infiltration)	Assess how quickly water soaks into the soil. This involves pushing a piece of open tubing or pipe vertically into the soil, gently compacting the soil on the outside of the pipe to form a seal and then filling the pipe with water to a depth of 10 cm and measuring how quickly this infiltrates the soil. Score from 0 = no/very little (<1 cm) infiltration after 30 minutes, to 5 = free draining = 10cm of water infiltrated into soil within 10 minutes. Different depths of the soil can be assessed by digging holes to different depths and filling them to 10cm and noting how quickly they drain. Sections of piping or tubing driven into the soil can be used to stop infiltration out the sides.							
Presence and strength of organic layer (in upper soil only)	Note whether there is a darker surface organic layer and the depth of this layer.	Score from 0 = no organic layer; 1= <0.5cm weak layer; 2 = 0.5-1cm layer; 3 = 1-2cm; 4 = 2-4cm; 5 = >4cm-						
Depth of upper soil (indicated by strong roots and more friable texture)	Score from 0 =<5cm, 1 = 5-10cm; 2 = 10-20cm; 3 = 20-30cm; 4 = 30-40cm; 5 = >40cm	Friable soil depth: ______cm Strong root depth until ______cm Depth where there are no longer visible roots: _____cm						

Soil health factor	What to look for / How to measure	Observations/notes	Score of condition (0=very poor, 5=very good)					
			0	1	2	3	4	5
Noted depths of changes in texture, density and/or colour	Note depth at which changes occur and the nature of these changes. Add the depth and circle the texture and colour at different levels. In most soils in Central Victoria the upper 'friable' soil and sub-soil will be observable within the upper 40-60cm – sometime this difference will be very stark (e.g. strongly different texture and colour), but sometimes it will be more subtle (e.g. a clay soil becomes slightly heavier/more dense down the profile, but otherwise colour remains similar, with the main difference being root depth and earthworm activity making the upper soil more porous and friable). Some soils will only show one change in 'layers' down the profile over 60cm, others will have three or four distinct layers – e,g, sand-loam upper soil, friable brown clay-loam upper subsoil over red clay-gravel over heavy mottled clay.	Upper/top soil = 0 - ____cm Texture: Sand, Loam, Clay-loam, Clay, Heavy clay Colour: White/pale, light yellow, light grey, grey, red, brown, black						
		Upper sub soil = ____ - ____cm Texture: Sand, Loam, Clay-loam, Clay, Heavy clay Colour: White/pale, light yellow, light grey, grey, red, brown, black						
		Deeper subsoil = ____ - ____cm Texture: Sand, Loam, Clay-loam, Clay, Heavy clay Colour: White/pale, light yellow, light grey, grey, red, brown, black						
		Deeper subsoil = > ____ cm Texture: Sand, Loam, Clay-loam, Clay, Heavy clay Colour: White/pale, light yellow, light grey, grey, red, brown, black						
Presence, depth and colour of mottling	Note red/orange, blue/grey and black mottling and the depth at which this occurs. Mottling typically indicates that anaerobic waterlogged conditions have occurred, and can also indicate pH changes in the soil.	Mottling present – Yes / No Depth at which mottling observed _______cm						

Soil health factor	What to look for / How to measure	Observations/notes	Score of condition (0=very poor, 5=very good)					
			0	1	2	3	4	5
pH	Use pH test kit or accurate meter. Have pH tested when soils are sent to laboratories. Note pH and score 0 = <4. or >9.0; 1 = 4-4.5 or 8.5-9.0; 2 = 4.4-5.0 or 8.0-8.5; 3 = 5.0-5.5 or 7.5-8.0; 4 = 5.5-6.0 and 7.0-7.5; 5= between 6.0-7.0 (both 4 & 5 are good pH levels)	Upper/top soil 0 to ___ cm pH = _______						
		Upper sub soil ___ to ___cm pH = ______						
		Deeper subsoil ___ to ___ cm pH= _____						
Structure, strength and porosity in layers	Use pull test and drop test to assess friability and aggregation, and observation to assess porosity and structure. Score from 0 = no/low structure and porosity to 5 = highly friable and porous.	Upper/top soil 0 to ___cm						
		Upper sub soil ___ to ___cm						
		Deeper subsoil ___ to ___ cm						
Dispersion and slaking test.	Use dispersion and slaking test to score from 0= highly dispersive to 5 = highly stable aggregates.	Upper/top soil						
		Upper sub soil						
		Deeper subsoil						
Visible organic matter and roots	Look for obvious living and dead roots and other organic matter and where this occurs. Score from 0 = no roots or organic matter at the depth through to 5 = strong root growth and obvious organic matter at depth	Upper/top soil						
		Upper sub soil						
		Deeper subsoil						
Earthworm numbers and evidence of activity	Pull apart a 15cm X 15xm X 30cm deep sod and count large mature earthworms. Look for evidence of pores and 'balls' from burrowing and note any smaller earthworms. Record number of earthworms and score 0 = none and no evidence of activity; 1 = none, but evidence of some earthworm activity; 2= 1 mature earthworm; 3 = 2-3 mature earthworms; 4 = 4-6 mature earthworms; 5 = >6 mature earthworms							

Table 8.2: Key soil testing parameters and what to look for when reading laboratory results.

Testing parameter	Significance /importance	What to look for
pH	High. Soil acidity is common in much of the Health Soils Initiative area, and overly-acidic conditions effects the availability of nutrients and the health of soil biology. pH is measured using either a water (H_2O) or calcium chloride (CaCls) test, and these produce slightly different numeric results. Water based pH testing can be more variable and reflect seasonal conditions. Field pH kits can provide a good level of accuracy.	Ideally, pH will be in the range of 5.5 -7.0 (H_2O) or 5.0-7.0 ($CaCl_2$), and more serious problems occur at pH levels less than 5.0 (H_2O) or 4.5 ($CaCl_2$) or greater than 8.0 on either scale.
Phosphorous (P) – total and available	Very high. P is essential to plant health and yield and is commonly deficient in centra Victoria. Some acidic clay soils with high Al and Fe ions can make P less available.	Olsen P >15-20 mg/kg On acid soils refer to Bray 2 test - Levels of total P > 60 mg/kg On neutral to alkaline soils refer to Colwell test – levels of P > 50-60 mg/kg may be needed in central Vic due to moderate high PBI (see below) Levels of soluble P > 10 mg/kg
Phosphorous buffering index (PBI)	Moderate – PBI indicates how available any added sources of P may be, and whether there are likely to be 'stocks' of P that might be made more available by correcting soil pH and promoting active soil biology. Phosphorous is typically less plant available on acidic soils with high Al and Fe levels, and this is common in central Victoria.	The PBI will indicate how much P is likely to be available and should be looked at with reference to the Colwell test results. For low PBI, then lower Cowell results (<40 mg/kg) should be adequate, but the higher the PBI than the higher the Colwell result will need to be.
Nitrogen (N) – total	Very high – it is essential to healthy plant growth and pasture and crop yield and quality. Total N tells you how much N is present in organic matter, or as ammonia and nitrate (see below).	Ideally total N levels will be higher than 25-50 mg N/kg of dry soil and higher in clay soils. Other than fertiliser, most N in soil comes from decaying organic matter and increasing organic matter returned to the soil will make more N available to plants.
Nitrogen as nitrate	High – this is a measure of how much plant-available and soluble N is at the time of soil testing.	Ideally levels will be higher than 10-15 mg/kg of dry soil
Potassium (K)	High for cropping in particular – some central Victorian soils are prone to K and S deficiency under cropping and hay cutting	Colwell K of > 160 mg/kg
Sulphur (S)		Soluble S of > 8 mg/kg
Calcium (Ca)	Moderate for pasture. Many central Victorian soils have adequate but low levels of Ca, and the quality of fodder can be reduced if high N:P:K produces vigorous growth. High Ca levels can reduce the availability of P.	Soluble Ca levels of >700-750 mg/kg Exchangeable Ca of 1-3 cmol+/kg and 65-80% of total exchangeable cations.

Testing parameter	Significance /importance	What to look for
Exchangeable cations and Cation Exchange Capacity (CEC)	Provides information about how readily soils hold nutrients and make these available to plants. Can also indicate lower soil fertility and the capacity of soils to retain organic carbon. Information about exchangeable Ca, Na and Mg levels can indicate potential sodicity, aggregate dispersion, porosity and risk of compaction.	>14 cmol+/kg is preferred on clay-loams and clay soils. Lower levels on sands are to be expected. Low levels on clay and clay-loams can indicate a very weathered and leached clay with low inherent fertility. High Na and Mg relative to Ca can indicate heavy and sodic/dispersive clays prone to compaction and poor porosity.
Magnesium (Mg)	Moderate – not commonly deficient in central Victoria	Exchangeable Mg of 1-3 cmol+/kg and 10-20% of total exchangeable cations. Many central Victorian soils have high Mg relative to Ca, which is indicative a heavy magnesic clay that can become impermeable and dense when wet, but will typically crack when dry unless it is also sodic (see below).
Sodium (Na)	Na is mainly of concern do to soil sodicity, but can also be an indicator of soil salinity with high Cl and/or high EC readings Subsoil clays commonly have high Na levels in central Victoria and many soils are moderately to strongly sodic.	Exchangeable Na of <0.7 cmol+/kg and < 1% of total exchangeable cations. If levels are >6% then the soil is sodic. Many central Victorian clay soils have high Na to Ca and are commonly sodic and dispersive, with poor soil structure and compaction. EC <3.8 dS/M.
Aluminium (Al)	Mainly of concern due to potential toxicity and making P less available on acidic soils. High Al is common on many central Victorian soils.	Exchangeable Al of <0.5 cmol/kg and <1% of total exchangeable cations is preferred Greater than 10% in an acidic soil indicates a need to neutralise pH with lime (which will also add Ca) or other soil ameliorant.
Manganese (Mn)	Not commonly deficient on most of central Victoria. Usually only potentially deficient on alkaline soils. Higher levels can pose toxicity risk on acidic soils.	Between 5-20 mg/kg is adequate on acidic soils.
Copper (Cu) **Zinc (Zn)**	Commonly low and potentially deficient in central Victoria. Low levels can affect pasture/fodder nutrition and reduce plant vigour.	>5mg/kg is preferred on clays.
Molybdenum (Mo)	Commonly low and potentially deficient on acidic soils in central Victoria. Can reduce root and plant growth vigour and reduce nitrifying nodulation of legumes.	>1.0 mg/kg should be sufficient on acidic clays for pasture, but higher levels may be need to sustain availability in cropping.
Boron (B)	Potentially low and deficient. Can reduce plant and root growth vigour.	>1.5-2.0 mg/kg preferred on acidic clays.

Other nutrients (note: looking for visual signs of deficiencies in plants and plant tissue testing are often the best method for assessing whether such deficiencies are impacting on plant growth and fodder quality. Test strips of additives containing the elements can also help determine whether plants will have a yield response)

Testing parameter	Significance /importance	What to look for
Iron (Fe)	Rarely deficient in central Victoria, but often very high in clay soils and subsoils and can result in toxic effect and low P availability of acidic soils. High Fe clays can also strongly hold water making it less available to plants.	Look for high levels of Fe and low pH.
Other trace elements (e.g. Selenium, Cobalt, Silicates)	These nutrients are required in low levels and are typically less significant than those listed above. They are rarely critically low, but plants can respond to their addition in fertilisers. Co and Se are more likely to be expressed as a deficiency in grazing livestock than plants, and are more likely to be deficient on granitic sands and clays. Silicates play a role in water uptake and cell strength and although most soils have high silicon levels, weathered and leached soils can develop low plant-available silicate under cropping systems.	

Key messages

- Assessing soil health requires a combination of in-field observations and laboratory analysis of soil samples.
- Soils vary down their profile. Digging to at least 50-60cm is a good way to identify physical, biological and pH constraints to root and plant growth.
- Common nutrient deficiencies in central Victoria include phosphorous, zinc, copper, molybdenum and sometimes potassium, sulphur, and other trace elements. Nitrogen levels can be low due to poor nitrogen-fixing nodulation of legumes and low organic matter.
- Many clays in central Victoria have high levels of aluminium and iron that can create toxic effects and lower phosphorous availability on acidic soils,
- pH correction through the addition of lime or other soil ameliorants can often improve the availability of nutrients, reduce toxicities, and add calcium to address soil sodicity and magnesium imbalances that make soils more susceptible to compaction.
- Plant tissue tests can be used to assess whether nutrient deficiencies are affecting plant and grazing livestock health.
- Once nutrient deficiencies and pH constraints have been amended, nutrient budgeting and periodic re-testing of known deficiencies can be used to maintain and monitor good soil nutrition.
- Visual assessment of the health of plant and root growth remains a key strategy of assessing soil health and likely nutrient deficiencies.
- Keeping a spade on the back of farm vehicles and stopping to dig and assess areas where growth is sluggish is a good way to understand and monitor soil health across your farm.