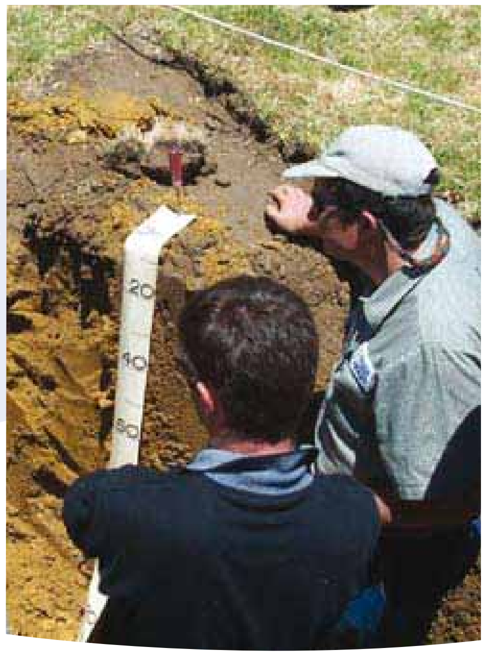
DairyingForTomorrow
DairyCatch

A Partnership for Sustainable and Profitable Dairy Farming in Western Australia

ENVIRONMENTAL BEST PRACTICE GUIDELINES
2.0 SOIL MANAGEMENT



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2.0 SOIL MANAGEMENT

Healthy soils are the basis of sustainable production. Physical state, biological health and chemical status determine the quality and health of a soil. These interact to determine soil fertility and sustainability of production.

The physical properties of a soil include texture, structure, hardness, infiltration rate, stability and wettability. The physical status of a soil is influenced by inherent qualities such as particle size and texture and is greatly affected by the way the soil is managed.

The biological health of a soil is important because it affects both its physical health and chemical status. Organic matter in the soil retains nutrients and moisture. Soil biological activity is the action of soil organisms that include fungi, bacteria, mites, worms and soil insects that consume and break-down organic matter in the soil. This releases nutrients slowly, helping plant root nutrient uptake, improving soil structure and providing pathways to aerate the soil allowing deeper infiltration of water into the root zone.

The chemical status of a soil is essentially the chemical factors that affect plant growth. It is complex to determine in full, but there is a standard set of tests that soil laboratories conduct for all soil samples. These tests indicate the availability of major plant nutrients in the soil, its acidity (pH) and salinity (expressed as electro-conductivity or EC). For certain soil types and situations, soil consultants may recommend additional laboratory tests such as phosphorus retention (PRI test), soluble aluminium, trace elements and heavy metals.

Soil is not indestructible and needs to be managed carefully to prevent erosion, soil structure decline and loss of fertility. All reasonable and practicable measures should be adopted to maintain good soil structure. If needed, soil structure should be repaired and good soil nutrition must be maintained.

Poor management or use of a site beyond its capability will result in a 'downward spiral' of soil decline. Loss of soil structure and biological activity leads to accelerating soil erosion and loss of the topsoil, which results in reduced soil organic matter content, which in turn leads to further soil structure decline.

In extreme cases of prolonged poor soil management, the productive capacity of a soil may be permanently lost. Soil erosion and decline in soil health are major interrelated issues that debilitate farming. Proper soil management practices are designed to maintain good soil structure and nutrition.

Careful soil management with the appropriate treatments employed at the optimum time can certainly control land degradation. However, seasonal conditions may over-ride good management so you should constantly monitor your soils.

Implementing good practice

Understanding soil dynamics is the first step to improving soil quality and health. In the past, farmers focused only on soil nutrient status which they managed by adding fertilisers. This alone is not sufficient to maintain healthy soils.

In general, as soil use intensity increases, so does the amount of organic matter and nutrients that must be replaced and the level of management needed to factor in husbandry practices such as irrigation. Even with the best management, every soil type has limits to how intensively it can be used.

It is your responsibility to ensure your soil management is sustainable.

The selection of soil management practices should be based on soil type, the environmental risks imposed by location and the kind of vegetation planted.

On sandy soils, appropriate soil management may include:

- Fertilising ‘little and often’ with commercial fertilisers and effluent
- Installing windbreaks
- Irrigation system designed for scheduled frequent, accurate waterings
- Applying soil amendments such as compost or clay, if and when needed.

On heavier soils, the management strategy may include:

- Applying effluent
- Earthworks to manage runoff
- Controlled traffic on wet soils
- A low rate sprinkler irrigation system

Benefits

- Increased productivity and income
- Improved soil properties, such as pH
- sustainable farming practices

A soil pit will clearly indicate to you your soil type and may help with identifying problems such as poor rooting depth.

A travelling irrigator can effectively apply effluent to pasture

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2.1 MONITORING SOIL CONDITION

Good soil condition and fertility are basic to sustainable dairy production. Ideally, soils should be well drained, easily penetrated by air, water, and roots, have a good water-holding capacity, balanced nutrient supply and neutral pH. These provide an ideal environment for plant growth.

Monitoring soil condition will help you protect and improve its long-term productivity. Soil characteristics are used as health indicators, but the ultimate measure of a soil's health is its productive performance.

While much attention is paid to the nutrient status of soils with regular soil testing, little has traditionally been given to soil structure. Structure is very important for water and air movement and allowing plant roots to penetrate the soil to access water and nutrients. If soil structure is damaged, plant growth and productivity are reduced. Repairing soil structure is expensive and can take years.

You need to be able to identify and predict the effects of both short and long-term management practices on your soils to ensure that your land management is sustainable. Regular testing for nutrients and visual assessment of soil can identify the impacts of management practices over time.

Implementing Good Practice

Monitoring soil health change over time can be achieved by sampling a few representative locations. Assessing health trends is an important key to sustainable land management because it allows you to evaluate the impacts of your management practices and helps you focus your conservation efforts.
Agricultural land use can damage the chemical, physical and biological characteristics of a soil. Chemical characteristics include soil acidity, organic matter content and its ability to store and retain nutrients. Physical characteristics include stability of soil aggregates, compaction and water storage. Biological characteristics include activity of soil microbes and the presence of beneficial organisms.

Repairing damaged soil structure isn't easy or cheap. Seek expert advice.

The presence of earthworms in the soil is indicative that its condition is favourable for plant growth.

Regular soil sampling analysed by a reputable laboratory and interpreted by a competent, independent agronomist will allow you to determine the nutrient status of your soil. You can carry out several other useful tests yourself using home made tools. Such tests include percent cover, level of compaction, infiltration rate, root development and distribution, soil structure and aggregate stability, biodiversity and earth worm population and pH. All you need is the following:

A Wire Quadrat. This is simply a frame that outlines a constant known area when placed on the ground. It is used to obtain an accurate measure of anything found within its perimeter. You will need it to assess the amount of plant cover and variety of animal life. Take a wire coat hanger and open it out to form a square (each side will be approximately 24 cm in length). Leave the hook on so you can hang it in the shed between tests (Figure 2.1).

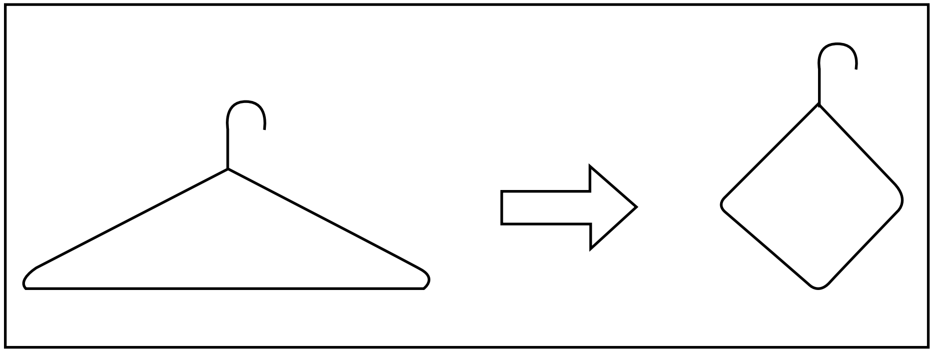


Figure 2.1. Reshaping a coat hanger into a wire quadrat

A *Penetrometer* is a device used to test the hardness of the soil. You can make your own from a 40 cm length of 3 mm fencing wire. Use 15 cm of the length to make a handle, and on the remaining 25 cm make file marks every 2 cm from the end (Figure 2.2).

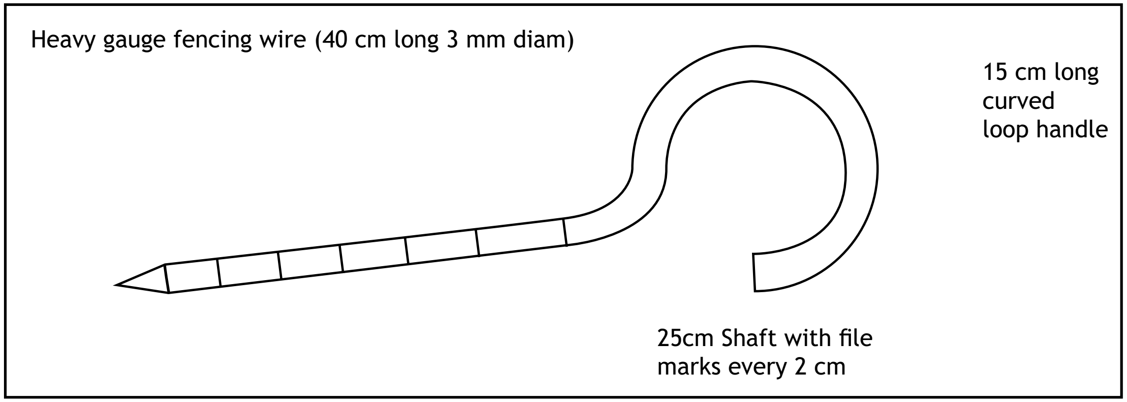
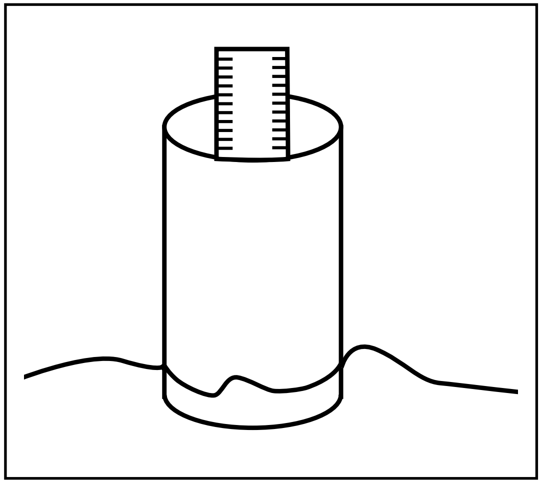


Figure 2.2. Home-made penetrometer.



An *Infiltrometer Tube* measures the rate at which a fixed volume of water soaks into the soil. Cut a 9 cm length of poly pipe 50 mm or more in diameter. (The larger the diameter the more water you will need to carry.) Bevel the bottom end to make it easier to push into the soil. Cut an old wooden ruler at the 0 cm and 7 cm marks and then cut the trimmed section in half lengthwise. Glue one half to the inside of the pipe so that the 0 cm mark is level with the top edge of the tube. When pushed 2 cm into the soil the 7 cm mark will be flush with the soil.

Figure 2.3. Home-made Infiltrometer tube

A clipboard and pencil
A record sheet for each set of tests planned
A spade
A measuring tape or metre stick
A heavy duty plastic tarp approximately 1m x 1m
A soil pH kit (available from most rural stores)
A small, wide mouthed jar with a lid, marked to show 125 ml level
A container of water (allow 300 ml of water per sample point)
A watch with a "seconds" display

Once you have your gear together, you need to decide where to test. We recommend you start with two sites, one in each of your 'best' and 'worst' areas. This will give you a good overview of how the tests relate to soil conditions on your land. Later you can select other areas to get a broader understanding of the health of your soil.

At each selected site, compare areas of different soil type or those that are managed differently if they are present. For example, comparing the results from samples located in the middle of a large paddock should be markedly different from those close to a gateway due to stock trampling. Mark the location of sampling sites on a map and label each site to help you reference analysed samples and ensure the same monitoring sites are used each year to compare results. This map should be kept in a safe place.

One possible sampling layout is presented in Figure 3.4. Sample are collected at equal intervals along the fence line. A larger area can be covered by collecting samples at equal intervals along a zigzag transect, using a compass or fence posts for direction. Start from an identifiable point such as paint on fence post. Stay within a single soil type for each sample. Take notes on the back of your record sheets about each sample point that you think may impact on the test results, such as distance to different soil type boundaries.

Best results are obtained in autumn, two to ten days after good rain. In order to make meaningful comparisons between years, be sure you sample under similar conditions. Avoid taking samples from overly wet soils or when they are overly dry. Avoid temperature extremes or within a few weeks of fertiliser or lime applications.

Once you are familiar with the tests, the entire exercise should take you around 20 minutes per set. Each test is described below.

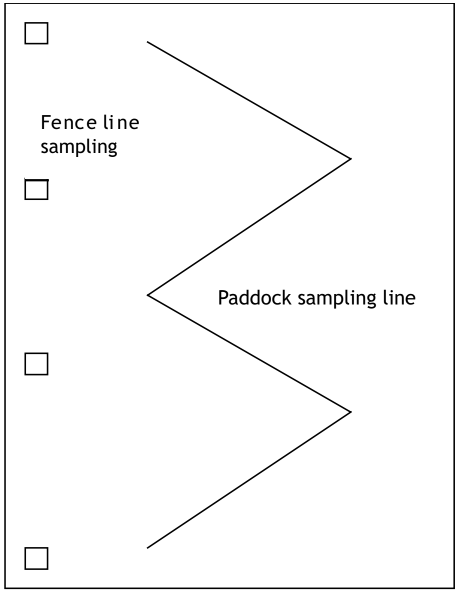


Figure 2.4. Paddock sampling layout.

Bare soils are more prone to soil and water erosion

Ground cover. Toss your quadrat onto the ground at random and estimate the percentage of bare soil within the frame. Subtract this from 100% to calculate ground cover. Examine surface litter or mulch to estimate its depth. On the test sheet note the grade which best matches your soil. Both ground plants and mulch contribute organic matter to the soil that will feed soil animals and microbes. Roots also help maintain good soil structure.

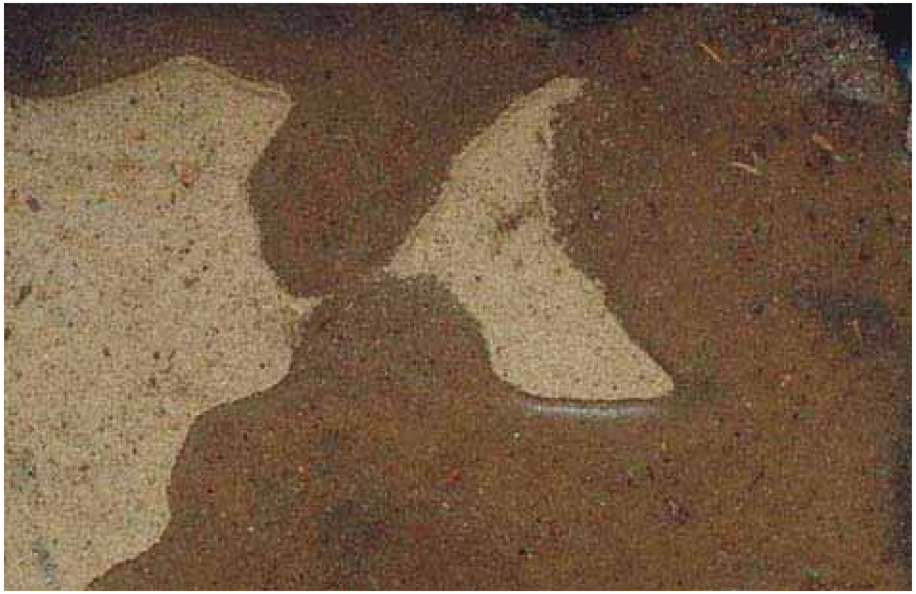
Soil compaction. Push your penetrometer into the soil as deep as you can with modest effort. Record the depth of penetration on your assessment sheet. If you hit a rock, choose another spot. The easier it is to penetrate the soil, the deeper will be its root development and water infiltration.

Water infiltration. Push your infiltrometer tube one to two cm into the soil, avoiding cracks and other holes in the ground. Gently fill the tube with water and record how much the water level falls in 60 seconds. A higher rate of infiltration will mean your soil will absorb rainfall more quickly, resulting in less run off and erosion.

Fauna diversity. Toss your quadrat onto the ground in an area not disturbed by earlier tests. Examine the surface for soil animals then carefully sift through the litter. Note how many different varieties of soil animals you find such as ants, beetles, spiders and millipedes. It is the variety that is important, not the numbers. A column of ants counts as one variety.

Root development. Using your spade, cut a 20 cm square hole to a depth of 20 cm. Lift the soil out, trying to keep it in one block, and place it on your plastic tarp. Examine the distribution of plant roots to determine whether soil structure is restricting the plants' access to nutrients. **In the case of annual pastures, this test should be delayed for two weeks after the break of the season.**

Soil Structure. Break a small handful of soil away from near the original surface of the block you have dug up and examine the size and arrangement of the soil aggregates or 'crumbs' (discrete clumps of soil particles). Under firm finger pressure soil should be friable, breaking into crumbs varying in size up to about 10 mm. There should also be evidence of root penetration throughout the block. Poor structure may be seen either as overly solid soil (hard crumbs, soil layers or clods) or as very loose soil (absence of even small crumbs, as for example in beach sand). Good structure results in easy passage of air and water, an ability to hold water and superior resistance to erosion.



A non-wetting soil

Slaking or aggregate stability. Select three or four pea-sized soil aggregates from about 5 cm depth, avoiding small stones. Drop the aggregates into 125 ml water in the small wide mouthed jar and allow to stand for one minute. Observe if the aggregates break apart or stay intact. If they are intact after one minute, gently swirl the bottle several times and observe again. If they are still intact, swirl the bottle vigorously and check again. The aggregates of a healthy soil are normally more stable than those of a less healthy one. Poor aggregate stability is associated with greater susceptibility to erosion. Repeat the test with a sample from a depth of 20 cm.

Earthworms. Break up your entire soil block into crumbs and place all worms found into your jar. Count the number of worms longer than 25 mm then return all worms to the hole. A large number of long earthworms indicate favorable soil conditions such as high organic matter content, high pH and low chemical residue concentrations.

Soil pH. Take two small samples of soil from the side of the hole, one from 5 cm and one from 20 cm depth. Test each sample for pH, following the instructions included in the kit. Acidity has a strong effect on the ability of plants to take up soil nutrients as well as upon the wellbeing of soil organisms.

Review your results and follow up on poor areas

Table 3.1 lists some soil health indicators at three different ratings. Line up your test sheets for areas you wish to compare and look for similarities and differences among your scores for each test. See if you can explain the differences. If your neighbours are also testing you may wish to get together and compare notes. Discuss your results with your agricultural consultant who may be able to suggest ways to improve your soil health.

Table 2.1 Indicators and ratings of soil health

Soil Indicator	Rating		
	Good	Fair	Poor
Structure	pliable, crumbly; clods fall apart easily	Firm, some large clods; clods can be broken apart with medium force	Hard dense chunks; tight, poor structure; difficult to break up clods by tillage
Compaction	Little resistance to penetration, no hard pan	Some resistance to penetration	High resistance to penetration, shallow hard pan present
Infiltration & drainage	Soil drains well after rain, little ponding or runoff after rain	Water drains slowly with some ponding	Water ponds or runs off following most rains; soil surface crusted
Erosion	No gullies or rills; runoff is clear; deep topsoil	Some visual signs of erosion; cloudy runoff	Obvious signs of erosion; muddy runoff; shallow topsoil; subsoil at surface
Surface cover	Soil surface covered year-round; little bare soil	Some residue or vegetation present but covered; bare soil during part of year	Little or no soil cover; bare soil for much of the year
Fauna diversity & earth worm populations	Signs of earthworms and other soil life common	Occasional signs of earthworms and other soil life	No visible signs of earthworms and other soil life
Soil organic matter	Dark color; visible organic material; earthy smell; high soil organic matter test	Medium soil organic matter test	Light colour; no visible organic matter in soil; no smell; low organic matter soil test
Plant growth	Healthy, uniform plant growth; consistent good yields; crops resist stress, such as drought	Plant health varies; inconsistent yields; crops somewhat resistant to stress	Spotty, uneven crops; plants unhealthy; consistently poor yields; crops susceptible to stress
Plant roots	Robust, large, deep, well-dispersed root system; no obvious restriction to root growth; many fine roots	Roots present in profile; some misshapen roots; some restriction to root growth	Few or no roots present; roots are short, coarse, not uniformly distributed; roots growing sideways; obvious restrictions

Each combination of soil type and land use requires a different set of practices to enhance soil health. However, several principles apply in most situations.

Adding organic matter. Organic matter, and the organisms that eat it, can improve water holding capacity, nutrient availability and can help protect against erosion. Organic matter may be applied as green manure (crop residues and the roots of cover crops), animal manure and compost.

Avoid excessive tillage. Tillage has positive effects, but it also triggers excessive organic matter degradation, disrupts soil structure and can cause compaction.

Carefully manage fertiliser and pesticide use. Improper use of fertilisers and pesticides can harm non-target organisms and pollute water and air. Manure and other organic matter can also become pollutants when applied to the wrong areas at the wrong time of the year.

Maximise ground cover. Bare soil is susceptible to wind and water erosion, drying and crusting. Ground cover protects soil, provides a habitat for larger soil organisms, such as insects and earthworms and can improve water availability. Cover crops, perennials and surface residue increase the amount of time that the soil surface is covered each year.

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2.2 AVOIDING TRAFFIC ON WET SOILS

During wet periods of the year or during non-seasonal rainfall periods stock need to be managed to avoid pugging and compaction of soils and pasture damage which can take seasons to repair.

Pasture damage by stock trampling can result in 30 - 60% reduction in pasture growth and reduces the amount of feed a cow can eat off the paddock. Cows will also not eat heavily soiled pasture. If pasture utilisation decreases, supplements may need to be purchased to cover the shortfall. This can be expensive as you will be paying for the trampled pasture as well as the purchased supplement. Nutritional stress also reduces milk production and this adds to lost income.

The weight of stock and machinery can lead to severe damage to soil structure that expresses itself as pugging and wheel ruts through the paddock. The carryover effects on pasture production can last several seasons. Corrective options such as working up the paddock and sowing down a new pasture can be expensive.

The risk of environmental mastitis within the herd increases if cows are wintered on muddy paddocks. The risk is especially high at drying off and calving. The average cost of treating a cow with mastitis is high and if she must be culled because of mastitis the cost is much greater.

Wet paddocks can limit machinery access around the farm. Managing stock and machinery in muddy conditions can place stress on you and your staff.

Avoid traffic on wet soils which can create wheel ruts and soil compaction.

Short term management options that can be used during wet weather

Keep vehicles and farm machinery off wet paddocks. In addition to compaction, wheel ruts can concentrate storm water runoff that erodes the soil, forming gullies.

Installing several watering points and shade areas will help break up the herd into smaller groups, thereby reducing soil compaction in these areas.

Maintaining a dense mat of pasture cover will help cushion the effect of the cattle hooves on the soil. Compaction is more severe where the soil is bare or pasture cover is sparse.

Placing fences strategically so that they separate the drier locations from those prone to waterlogging makes it easier to keep stock off wet areas.

Low-lying wet paddocks should be grazed early to minimise the need to utilise them later in the wet season. Known dry paddocks should be targeted for later grazing.

Cows can eat their daily ration within 3 hours. Consider removing them from paddocks after they have spent the morning or afternoon grazing. Sacrifice paddocks reduce the damage on the rest of the farm by localizing the problem on one part of the farm. Paddocks targeted for pasture renovation may be ideal for this role.

Back-fencing not only prevents cattle moving over grazed areas and damaging them, but also increases pasture growth rate. Back fencing is an important strategy when long rotations are in place.

Use wider gateways to take the pressure off the same narrow access to paddocks. This can be achieved by dropping the whole fence so that cows cross a wider area.

Using an electric wire will concentrate stock in the dryer areas of paddocks and prevent them from overgrazing other areas.

Further information

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2.3 IMPROVING ORGANIC MATTER CONTENT

Soil organic matter comprises all living soil organisms, and the remains of those previously living, in various stages of decomposition. The living organisms can be animals, plants or micro-organisms and range in size from the readily visible to the microscopic. When plant and animal debris is added to soil, it is broken down by macro and micro-organisms, initially into particulate organic matter and finally into humus.

Organic matter is widely regarded as a vital component of a healthy soil because of its impact on soil functions and properties. It provides the energy source for soil micro-organisms and is a reservoir of nutrients, especially nitrogen, phosphorus and sulphur released when microbes break down organic matter. It also binds soil particles together into aggregates necessary for soil structural stability. Organic matter is involved in the adsorption of important plant nutrient cations such as calcium, magnesium and sodium that can significantly influence soil water holding capacity, especially in more sandy soils. Organic matter is also important for the pH buffering capacity of soil.

Solid effluent separation systems like the one above provide a source of organic material that can be added to the soil to improve soil structure.

The amount of organic matter in the soil can be used as a broad indicator of soil condition and is largely determined by the presence of surface litter, manure, dead organisms and root material and the rate at which soil microbes break these down.

Organic matter content, estimated by measuring organic carbon levels in the soil, varies with depth. Levels are usually highest in topsoil. Organic carbon concentrations in the soil commonly range between 0% and 15% on a percentage by weight basis. Some laboratories still report %OM in their results. This is calculated by multiplying organic carbon levels by 1.72. However, as this conversion factor is not the same for all soils, % organic carbon is a more accurate measure.

The amount of carbon in a soil depends on a range of factors, and reflects the balance between accumulation and breakdown. The main factors are:

- **Climate** – For similar soils under similar management, carbon is greater in areas of higher rainfall and lower in areas of higher temperature. The rate of decomposition doubles for every 8 or 9° C increase in mean annual temperature.
- **Soil type** – Clay helps protect organic matter from breakdown, either by binding organic matter strongly or by forming a physical barrier which limits microbial access. Clay soils in the same area under similar management will tend to retain more carbon than sandy soils.
- **Vegetative growth** – The more vegetative production, the greater are the carbon input. Also, the more woody this vegetation is (greater C:N ratio), the slower it will breakdown.
- **Topography** – Soils at the bottom of slopes generally have higher carbon because these areas are generally wetter and have higher clay contents. Poorly drained areas have much slower rates of carbon breakdown.
- **Tillage** – Tillage will increase carbon breakdown. However, the impact of tillage is generally outweighed by the effect of management on the amount of carbon grown and returned to the soil. An exception to this is where tillage leads to increased erosion.

Further Information

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2.4 LIMING

Liming is the practice of adding agricultural lime (calcium carbonate) to soils to raise the pH to the level that optimises crop and pasture production. Plant productivity falls when soil pH drops below 4.5. Soil acidity is increased through the repeated application of ammonia-based fertilisers, product harvesting and the use of legumes.

The starting point of any soil discussion should always be the pH of the soil (a measure of relative acidity or alkalinity) and the organic content of the soil. Nowadays, soil pH is measured using a soil sample in a 0.1m solution of calcium chloride ($CaCl_2$) to reduce the confounding effect of soil moisture at the time of sampling that may distort accuracy due to dissolved salt concentrations. Commonly, pH is now presented as pH ($CaCl_2$).

Low pH values indicate soil acidity where the major elements required for plant growth (nitrogen, phosphorus and potassium) are less available to the plants. Pasture and hay production acidify soils at a fast rate because they remove more plant material and require more fertiliser. Plant tissue is generally alkaline and when it is removed the soil becomes more acidic, especially in the root zone. Significant yield reductions will occur for nearly all plants when the pH ($CaCl_2$) falls below 4.5.

Regular and substantial lime applications are necessary to maintain soil productivity. Fertilisers such as ammonium sulphate, ammonium nitrate, di-ammonium phosphate, elemental sulphur and to a lesser extent urea, all cause soil acidity. The most acidifying are the ammonium fertilisers that release H^+ ions when ammonium is converted to nitrate in the soil. Nitrogen use will also accelerate soil acidification. Acidification is made worse if the fertiliser is leached below the root zone and not used by the plant

Implementing Good Practice

Productive agriculture causes the originally acidic to neutral sandy soils of the agricultural areas of south-western Australia to acidify. These soils comprise about 75% of the 18 million hectares used for agriculture, so about 13.5 million hectares. Most of these soils have developed soil acidity in both the top 10 cm of soil, called top soil acidity, and in the 10 to about 40 cm, called subsurface acidity. Most of these soils have been allowed to acidify so pH values of about 4 or less have developed to about 40 cm.

Subsurface acidity is the major problem and requires a long-term liming strategy to ameliorate (improve/amend). Subsurface acidity has yet to develop in many soils in high rainfall areas of the region, but it will unless the soils are treated with sufficient lime to prevent the problem from developing.

You should collect soil samples at 0-10, 10-20 and 20-30 cm to measure pH.

If the pH in the top 10 cm is less than 5.5, but the pH below 10 cm is greater than 5.0, then top soil acidity is the problem. To ameliorate top soil acidity, and prevent the development of subsurface acidity below 10 cm, you need to apply lime to raise the pH of the top 10 cm of soil to 5.5 or greater. If the pH in the 10-30 cm zone is less than 5.0, subsurface acidity is a problem, and is ameliorated by adding sufficient lime to the topsoil to raise the pH in the top 10 cm of soil to 5.5 or greater. Only then will sufficient alkali from the lime applied to the topsoil move deeper into soil to ameliorate subsurface acidity.

A long-term strategy is required to apply sufficient lime over many years to first ameliorate top soil and then subsurface acidity. The amount of lime to apply to ameliorate both top soil and subsurface acidity varies with soil type and no firm recommendations are available in south-western Australia for the diverse soil types encountered.

Soil testing for pH is the tool used to detect, ameliorate and then monitor soil acidity in Western Australia. Most farmers can not afford to apply large amounts of lime in one operation, so smaller applications (1-2 t/ha per year) is required to eventually ameliorate the problem. You should then monitor soil pH at 0-10, 10-20 and 20-30 cm and apply lime to prevent the re-development of top soil and subsurface acidity as required.

Certain crops and pastures do have varying sensitivities to soil pH and are presented in Table 2.2.

Table 2.2. Acid sensitivity of various pasture and crop species

<table>
<tr><th>Species</th><th>Sensitivity</th><th>Critical pH ($CaCl_2$)</th></tr>
<tr><td>Lucerne</td><td rowspan="3">Highly sensitive</td><td rowspan="3">5.0</td></tr>
<tr><td>Annual medic</td></tr>
<tr><td>Barley</td></tr>
<tr><td>Phalais</td><td rowspan="4">sensitive</td><td rowspan="4">4.8</td></tr>
<tr><td>Persian clover</td></tr>
<tr><td>Berseem clover</td></tr>
<tr><td>Wheat</td></tr>
<tr><td>Maize</td><td rowspan="12">Moderately sensitive</td><td rowspan="12">4.5</td></tr>
<tr><td>Forage sorghum</td></tr>
<tr><td>Red clover</td></tr>
<tr><td>White clover</td></tr>
<tr><td>Sub. Clover</td></tr>
<tr><td>Ryegrass</td></tr>
<tr><td>Tall fescue</td></tr>
<tr><td>Millet</td></tr>
<tr><td>Cocksfoot</td></tr>
<tr><td>Millet</td></tr>
<tr><td>Oats</td></tr>
<tr><td>Triticale</td></tr>
<tr><td>Cereal rye</td><td rowspan="7">tolerant</td><td rowspan="7">4.1</td></tr>
<tr><td>Cowpeas</td></tr>
<tr><td>Cocksfoot</td></tr>
<tr><td>Kikuyu</td></tr>
<tr><td>Paspalum</td></tr>
<tr><td>Couch grass</td></tr>
<tr><td>Setaria</td></tr>
<tr><td>Serradella</td><td rowspan="2">Very tolerant</td><td rowspan="2">Less than 4.1</td></tr>
<tr><td>Lotus</td></tr>
</table>

Further Information

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2.5 CARRYING CAPACITY

Carrying capacity is defined as the stocking rate that a particular area can support for a given period without damaging land condition. Carrying capacity can vary according to land condition and intensity of management. It also varies over time when there are extended runs of years of below or above average rainfall.

Stocking rate is the major factor influencing pasture utilisation, with increased intensification and large amounts of supplementary feed being used on many dairy farms today. Improved grazing management, irrigation, drainage, rate of fertiliser and timing of fertiliser application also have an effect. Higher pasture utilisation allows less grain to be fed, so higher profits can be gained largely from savings in purchased grain. On some farms, there may be difficulties associated with higher stocking rates, particularly effects on pasture and soil during winter.

Further Information

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2.6 NUTRIENT BUDGETING AND MAPPING

The efficient use of nutrients is essential to farm productivity. Nutrient budgeting is based on understanding the responsiveness of soils to fertilisers through soil and pasture monitoring and matching nutrient inputs to outputs. Nutrient exports must at least be matched by inputs to maintain productive capacity.

Nutrient budgeting requires the quantification of many different nutrient movement paths.

Nutrient inputs include those contained in

- mineral fertilisers
- organic fertiliser, soil amendments, animal wastes, imported manures & by-products
- purchased feed (grain, hay & silage)
- purchased stock
- irrigation water
- released from soil fixation or mineralised from organic matter.

Nutrient outputs are those

- contained in products (hay, milk & meat)
- leached below the root zone
- lost in run-off, including nutrients associated with eroded soil particles

For some of these, standard material nutrient content (such as grains) can be used to quantify inputs or outputs. In other cases, researchers have quantified typical nutrient movement rates or relied on educated guesses.

Without maintenance application of fertiliser, the removal of nutrients associated with animals and their products being redistributed on and off farm, soils would eventually decline in fertility. This would result in the progressive loss of desirable species such as clovers and perennials causing an overall decline in pasture production. Similarly, the removal of nutrients in hay and silage would result in a progressive decline in soil fertility if not replenished through nutrient inputs.

Fertiliser application should be matched to pasture or crop requirements. Application should balance out nutrient exports in products and wastes and take into account anticipated soil response. Requirements should be based on soil and plant tissue monitoring results.

Nutrient budgeting ensures the correct amount of inputs is deposited on areas of high yield and also enables corrective action on areas producing below their potential.

Implementing Good Practice

- Develop and implement environmental monitoring and benchmarking of soil fertility and pH
- Through the whole farm plan, develop an understanding of land capability and soil types as they link to nutrient application rates
- Understand pasture and crop nutrient requirements
- Keep accurate records of all products coming into and leaving the farm

Nutrient balances are normally calculated by adding up the amount of nutrient inputs (mainly nitrogen and phosphorus), brought onto the farm (feed, fertiliser and animals) and subtracting from this the amount of product sold or removed off- farm (milk, animals and hay). Nutrient use efficiency is calculated by dividing the calculated amount of nutrient inputs by the amount of nutrient outputs.

Nutrient mapping can provide useful insight on nutrient distribution within a farm. For instance, always harvesting silage from one paddock (A) and feeding it out in another (B) will lead to a transfer of nutrients from A to B. Similarly, reapplying dairy effluent to just a small part of the farm will lead to a build up of nutrients in that area. Even within a paddock, the gate end of a pasture is likely to receive more dung and urine than the end furthest from the gate. Over time this will lead to a considerable nutrient gradient from one end to the other.

Benefits of nutrient budgeting and mapping

- User-friendly and cost-effective methods of determining how efficient you are at transforming imported nutrients into products
- Lets you Identify nutrient loss pathways that need to be managed
- Highlights nutrient wastage and environmental risks
- Determines fertiliser input requirements for various paddocks
- Encourages you to monitor the movement of nutrients within the farm and replace nutrients only when and where they are needed
- Helps maintain or improve soil fertility and pH to match pasture or crop requirements
- Helps maintain desirable pasture composition, groundcover and water balance

Costs

Nutrient Budgeting is a very simple tool that all farmers can use. Good record keeping is essential to be able to accurately quantify all farm inputs and outputs. Essential records include fertiliser use, imported feed, hay production and all product sales (milk, animals and hay). The nutrient content for most products used on a farm is available from the internet or through direct consultation with fertiliser and feed companies. A consultant can be used to initially demonstrate the nutrient balance procedure but once you see how easy it is to complete, you should be able to complete a nutrient balance for your property quite routinely and improve your farm nutrient efficiency rate.

Further Information

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