Government of South Australia
Adelaide and Mount Lofty Ranges
Natural Resources Management Board

Managing Soils for Sustainable Production

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Soils are dynamic ecosystems containing vast numbers of living organisms, mineral particles and organic matter which provide water, nutrients and air for plant growth.

Introduction

Nutrient levels, soil acidity and erosion can all impact on the health of a soil. Acidic soils can be detrimental to plant growth because they restrict the availability of plant nutrients, thereby limiting plant growth which can often lead to a lack of ground cover, increased weed growth and erosion.

Correcting soil nutrient levels by applying fertiliser is important, however, overuse of fertiliser can be a source of pollution. For example, applications of phosphorus in excess of plant requirements can pollute watercourses and impact on water quality. This is an important issue to consider throughout the high rainfall areas of the Mt Lofty Ranges.

Testing soils for nutrient and acidity levels

Laboratory tests on soil samples will diagnose and monitor the nutrient status of soils and indicate the level of soil acidity (pH).

Summer and Autumn is the best time to test soils, while they are dry, since this is when the nutrient levels are most stable. Test results are most reliable and comparable to previous tests at this time.

Leaf tissue tests are sometimes required to accurately measure trace element deficiencies e.g. copper, zinc and manganese. Test kits should provide details of sampling procedures.

It is important to test soils on a regular basis (every three to four years) and sample different soil types separately.

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Your sampling technique should be consistent so that results can be accurately compared from one sampling period to the next.

If testing pasture or cropping paddocks, approximately 30 cores to a depth of 10cms should be collected and mixed thoroughly for laboratory testing. Soil samplers are available from most natural resource centres.

Where perennial horticulture is being planned it is advisable to engage a qualified professional to undertake a full soil survey which involves examining soil at depth.

Soil test results should include recommendations when deficiencies are identified, but if further assistance is required when calculating the level of fertiliser to apply contact your nearest natural resources centre, agricultural outlet or local agronomist.

Understanding soil acidity

Soils are often characterised as being acidic, or alkaline, and measured using the term pH. The pH scale covers a range from zero to 14.0 with 7.0 being neutral (see Figure 3).

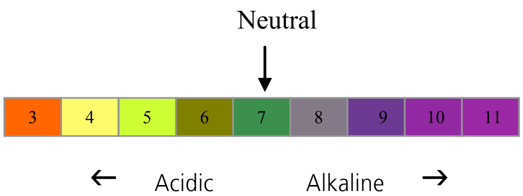

Figure 3: Soil pH scale

If soils are measured at less than pH 7.0 (in water) they are considered to be acidic. If they are less than pH 5.5 (in water) they are considered to be strongly acidic and can severely reduce plant growth. The ideal pH range for most plants is from 6.5 to 8.5.

Figures 4a, 4b and 4c shows three plants that are indicators of soil acidity.

A field kit can give an indication of soil pH (see Figure 5). However, a laboratory soil test should be undertaken to determine the precise pH reading.

Most laboratories measure pH by two methods (pHwater and pHcalcium chloride). pHcalcium chloride is a slightly different method of measuring soil pH which often gives a more stable reading than pHwater. Typically pHcalcium chloride is about 0.8 to 1.2 units lower than pHwater. It is important to know which measurement has been used.

Figure 4a: Guildford grass (*Romulea rosea*)

Figure 4b: Sorrel (*Rumex acetosella*)

Figure 4c: Fog grass (*Holcus lanatus*)

Figure 5: pH field test kit

Causes of soil acidity

In high rainfall areas, such as the Mt Lofty Ranges, soils are often naturally acidic because nitrogen compounds can be leached from the soil profile, leaving acid conditions behind.

However, the following land management practices, can accelerate the acidification process:

- Intensive legume (clovers and medics) based pasture production.

» Removal of nutrients in farm products (e.g. hay and silage).

» Adding nitrogen fertilisers such as urea, ammonium sulphate and ammonium nitrate.

Consequences of soil acidity

Most of the detrimental effects of soil acidity are due to the impacts on the availability of plant nutrients (see Figure 6). Some plants, such as phalaris and lucerne, are especially susceptible to aluminium toxicity at low pH, and overall production can be severely reduced.

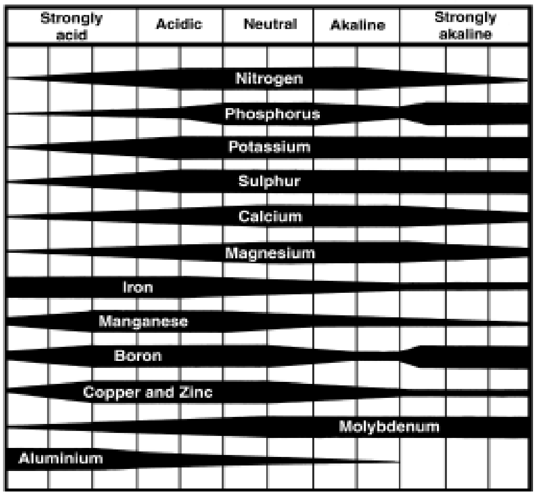

Figure 6: Nutrient availability

Correcting soil acidity

Acidity is a form of soil degradation which can be corrected by the addition of lime (calcium carbonate), (see Figure 7). The lime neutralises the acid and raises the pH.

Figure 7: Lime spreading on pasture (Source: PIRSA, Rural Solutions SA)

Good lime should have a neutralising value of at least 80 (i.e. 80% as effective as pure calcium carbonate) but should not be so fine that it blows away when spread, or too course that it reacts extremely slowly in the soil (see Figure 8). Dolomite lime (calcium magnesium carbonate) should be used where soil test indicates a deficiency in magnesium.

Figure 8: Particle sizes and colour will vary between lime products

Lime requirements

The amount of lime required to reduce acidity will depend upon

» Soil texture

» Initial pH

» Target pH

In all situations lime should be added to prevent the pH from falling below 5.5(H_2O). See Table 1 and 2 for information on assessing lime requirements and target pH.

Table 1: Lime requirements to raise soil pH by approximately 1 unit

Soil texture	Mean (t/ha)
Sand, loamy sand	2.0
Sandy loam	3.25
Loam, sandy clay loam	4.5
Loamy clay	5.0

Table 2: Target pH for different land uses

Land use	Target pH ($CaCl_2$)	Target pH (water)
Extensive grazing	5.0 - 5.5	5.8 to 6.3
Intensive cropping and grazing	5.5	6.3
Most horticultural crops	5.5 to 6.5	6.0 to 7.0

Correcting alkaline soils

In alkaline soils (high pH) phosphorus can become tied up and unavailable to plants, while molybdenum can become toxic in some soils. Boron may also be toxic in soils with high pH, but be deficient in acid soils (low pH).

Alkalinity can be reduced by adding sulphur, however few soils show an economic response due to excessive amounts of free limestone which counters the impact of sulphur. Growing legume based crops, such as clover, field peas, lucerne and annual medics, may help to reduce pH to some extent, but to avoid poor plant growth it is important to grow crops which tolerate a high pH.

Table 3 shows the preferred ranges of pH for a variety of commonly-grown agricultural and horticultural crops.

Table 3: Preferred ranges of pH (H_2O) for some agricultural crops

Crops	Preferred pH (H_2O) range
Triticale	4.5 to 8.5
Lupins	5.0 to 7.0
Cocksfoot	5.0 to 7.5
Clovers	5.5 to 7.0
Wheat	5.5 to 8.5
Apples	6.0 to 7.0
Lucerne	6.0 to 8.0
Phalaris	6.0 to 8.0
Barley	6.0 to 8.5
Strawberry	6.5 to 7.5

Figure 9: Apples prefer a pH (H_2O) of 6.0 to 7.0

Contribution of farming systems to soil acidification

The rate at which soil is acidified depends on particular farming systems. Acidification rates are expressed as the amount of lime required to counter acidity (see Table 4).

Table 4: Soil acidification rates (kg lime/ha/year to counter acidity)

Acidifying land use system	**Typical acidification rate**
Low intensity grazing	50
Medium intensity grazing with some hay cuts	100
High intensity grazing with regular hay cuts	150
Cropping with pasture rotation	100
Intensive cropping with pasture and high inputs of nitrogen	200
Continuous cropping with high inputs of nitrogen	250
Horticulture with high inputs of nitrogen (acidifying forms)	Up to 500
Dryland grazed lucerne	80

The addition of urea, ammonium sulphate and ammonium nitrate fertilisers have a major acidifying effect.

Fertiliser requirements

Plants require a range of nutrients to grow successfully and if levels of these are not adequate in soil, production will decline and animal health may be affected. Important nutrients to monitor include:

» Phosphorus (P) commonly deficient

» Nitrogen (N) commonly deficient

» Potassium (K)

» Sulphur (S)

» Magnesium (Mg)

» Calcium (Ca)

» Copper (Cu) only trace amounts required

» Zinc (Zn) only trace amounts required

» Manganese (Mn) only trace amounts required

» Molybdenum (Mo) only trace amounts required

» Iron (Fe) only trace amounts required

» Boron (B) only trace amounts required

Any product removal from paddocks, be it hay, milk, meat, wool, etc., depletes the nutrient "bank" in the soil (see Table 5).

Table 5: Nutrient loss from a paddock

Product	**Kg of nutrient/ha/year**		
	Phosp[1]	**Pot[2]**	**Sulph[3]**
Hay (4.5t/ha meadow hay	11	45	9
Milk (irrigated, 3 cows/ha	14	27	8
Meat (7.5 crossbred lambs/ha	2	1	2
Cereal crop (barley, 2.5t/ha	7	13	4
Legume crop (peas, 2.5t/ha	11	25	6
Wool (30kg/ha)	0.2	0.4	1.4

1. Phosphorus. 2. Potassium. 3. Sulphur

Choosing fertilisers can be confusing, so in order to determine how much of a particular product to add, the 'nutrient analysis' for each fertiliser should be known (see Table 6). This is usually expressed as a ratio. For example, DAP (di-ammonium phosphate) has a ratio of 18:20:0:1.6 where the nutrients are N:P:K:S (Nitrogen:Phosphorus:Potassium:Sulphur).

Table 6: Examples of fertilisers

Fertiliser	N:P:K:S*
Conventional	
Super phosphate low analysis	0:8:0:11
Triple superphosphate	0:20:0:0
Urea	46:0:0:0
Sulphate of ammonia	21:0:0:23
Blends	
Super potash 4/1	0:7:10:8:8
Blends with trace elements	
Organic	
Sheep manure	1.7:0.8:0.6:0.2
Slow release	
Reactive rock phosphate (acid soluble)	0:12.5:0:1.4

* Nitrogen:Phosphorus:Potassium:Sulphur

Note: Fertiliser analyses vary between suppliers and suppliers will change the analyses of their products from time to time. Contact your supplier for current product analyses.

When estimating how much phosphorus to replace in pastures the stocking rate and soil type should be taken into account. In many cases this is approximately 1kg phosphorus/ha/DSE. The term DSE is used to represent a 45kg dry (non-lactating, non pregnant) sheep.

Soil erosion

Soil erosion events can be significant. A loss of 1mm of top soil represents 10 to 12 tonnes per hectare, with the loss of approximately 10kg/ha of nitrogen and 2 kg/ha of phosphorus.

Large tracks of primary production land can be lost due to gully erosion (see Figure 10), while silt in watercourses and dams can damage aquatic habitats and interfere with the respiration of fish and other biota.

Figure 10: Severe gully erosion

Cereal cropping areas (<450mm per annum)

Light sandy soils in particular are very susceptible to both wind and water erosion once the surface is loose, whether by cultivation or grazing animals. The keys to minimising the risk of erosion are:

» Maintain adequate surface cover of native vegetation, pasture or stubble (see Table 7).

» Minimise the time that cultivated land is exposed and without cover.

» Use conservation farming practices (i.e. no-till and stubble retention).

» Fence off sand dunes and permanently stabilise by planting perennial vegetation.

» Establish windbreaks to reduce surface velocity and combat the erosive forces of the wind.

» Construct contour banks in cereal paddocks with 4% to 12% slope to reduce water erosion.

Table 7: Surface cover needed to protect soil from wind and water erosion in cropping land

	Minimum cover		Desirable cover	
	%	T/ha*	%	T/ha*
Wind erosion				
Loam	15	0.5	35	1.0
Sandy loam	20	0.6	50	1.5
Sand	50	1.5	70	2.5
Water erosion				
Level land	60	2.0	75	3.0
Sloping land	75	3.0	85	4.0

Source: DWLBC 2008, Fact Sheet 89

* wheat stubble measured in tonnes per hectare

It is worth noting that grain legume stubble (see Figure 11) is far less effective than cereal stubble in holding soil together and can sometimes be blown away. Careful management is required.

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Figure 11: Grain legume stubble


Figure 12: Adequate stubble retention will help to reduce erosion in cropping land


Figure 13: Erosion due to overstocking

High rainfall areas (>450mm per annum)

High rainfall areas of the Adelaide and Mt Lofty Ranges are at risk of water erosion if land management practices are not appropriate.
To reduce the likelihood of erosion:

- Maintain 70% surface cover at all times.
- Do not overstock.
- Adopt appropriate grazing management strategies.
- Avoid cultivation of steep land.
- Direct drill new pasture.
- Stabilise watercourses by planting appropriate native vegetation.

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Improving soil structure

Structure refers to the way that soil particles (sand, silt and clay) clump together into aggregates. A well structured soil relies on the formation of small soil aggregates which remain stable when wet and contain pore spaces which allow water and air to penetrate (see Figure 14).

Soil structure is generally inherent to the soil, however, land management practices can improve or decrease structure and condition to some extent. Excessive cultivation and animal or vehicle traffic on wet soils can result in compaction and loss of soil structure.

Most soils will benefit from the addition of organic matter, which not only encourages good aggregation, but also releases nutrients to assist plant growth. The structure of most heavy clay soils can also be improved by the addition of gypsum (calcium sulphate) which helps soil particles to aggregate.

No structure. Sandy soil. Lacks organic matter.

Good structure. Allows water and air into soil.

Poor structure. Heavy impermeable clay. Improved by organic matter.

Figure 14: Variations in soil structure