



Fertilising pastures

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Most soils in south west Victoria require fertiliser applications to ensure that plants have an adequate supply of all the nutrients needed for high production of quality herbage.

Plants require major and minor (or trace) elements to develop and grow. Some of these elements (carbon, hydrogen and oxygen) are obtained from air and water. The remaining elements come from the soil. However, in productive pasture systems, fertilisers are required to meet the shortfall between the *available* nutrients in the soil and plant requirements. Nitrogen, phosphorus, potassium, sulphur and molybdenum are the elements that are most commonly applied as fertiliser in south west Victoria. Copper may also be required in the fertiliser mix as a precaution against molybdenum-induced copper deficiency.



Most pastures in south west Victoria require fertiliser applications to ensure an adequate supply of nutrients for pastures to produce the required amount and quality of feed for livestock
Photo: P. Schroder

Key points

- Soil testing and pasture observation should be used to determine which nutrients are needed in the pasture system
- Nitrogen is normally the first limiting nutrient, but due to relatively high cost nitrogen fertiliser is mainly used to fill feed gaps rather than correct deficiencies
- Phosphorus is the next most commonly limiting nutrient in south west Victoria, followed by potassium, sulphur and molybdenum
- Optimum annual phosphorus application rate varies from 0.4 to 1.3 kg/DSE depending on rainfall, soil and other factors
- Soil acidification occurs whenever nitrates are leached or product is removed, and liming is the most effective way of neutralising soil acidity

How to determine soil nutrient status

The nutrient status of the soil and its suitability for pasture production will vary from one soil type to the next, and from one grazing system to the next. Nutrient status must be determined on a paddock by paddock basis. There are several ways to determine the nutrient status of the soil:

- pasture observation
- soil testing
- plant tissue testing
- fertiliser test strips.

Pasture observation

Good observation, particularly in spring when

weather conditions are favourable for pasture growth, always generates information about the state of the pasture, and provides an indication of its underlying nutrient status.

High growth rates with a deep green colour, a clover content of at least 30% and clover leaflets at least 2.5 cm wide, all indicate a healthy productive pasture where fertiliser applications are meeting nutrient requirements.

Signs that a pasture is not growing to its potential are low clover content and low vigour. Clover leaves are a dull green-yellow colour, and weeds such as sorrel, dandelion, bent grass, onion grass, sweet vernal, meadow foxtail and moss are common. These signs reflect a deficiency of one or more elements.

Increased growth on dung and urine patches are signs that responsive pasture species are present, and that growth rates could be increased through additional fertiliser.



Soil testing

Soil test results over several years provide information on changes in soil nutrient levels. The trends help verify if there is a need to change fertiliser types and application rates. Collect soil samples every 2 years; and once the impact of grazing intensity and fertiliser rates is clear, it may be sufficient to analyse paddocks only every 4–5 years.

Soil sampling kits are available from many rural merchandise outlets. To get meaningful information about soil nutrient status over time, a soil testing program should be carefully planned.

Soil test reports normally include a description of whether the nutrient level in the soil is marginal or adequate. Use the soil test interpretation guides in Tables 5.1 and 5.2 to supplement the information supplied by the laboratory.

Guidelines for a soil testing program

- Take soil samples from the same paddocks and parts of each paddock at the same time of year.
- Mark the position of one or two transects (lines) across the path taken by the fertiliser spreader, by painting fence posts white or marking other landmarks. Position the sampling transects across representative parts of the paddock avoiding stock camps, watering points, headlands and trees.
- Samples should consist of a composite from at least 30 spots taken with a tool that removes a 10 cm deep core of soil. Much of the available phosphorus is concentrated in the top few centimetres of the soil, so inaccurate sampling depth will markedly affect the results.
- Send soil samples to laboratories accredited by the National Analytical Testing Authority (NATA) to ensure that approved testing standards are used and the tests results are accurate and reliable.

Table 5.1 Recommended nutrient levels for phosphorus, potassium and sulphur at moderate and high stocking rates

Nutrient element	Extraction method	Adequate nutrient level (mg/kg)	
		Moderate stocking rates (7–12 DSE/ha)	High stocking rates (13–20 DSE/ha)
Phosphorus	Olsen	9	15
	Colwell	21	35
Potassium sands	Skene or Colwell	80–100	100–120
		all other soils	120–150
Sulphur	KCl-40	6.5	8.5

Table 5.2 Recommended levels of soil pH and aluminium for pasture plants of 3 tolerance categories to soil acidity

Extraction method	Highly sensitive plants (e.g. lucerne)	Sensitive plants (e.g. phalaris, canola)	Tolerant plants (e.g. sub clover, perennial ryegrass, tall fescue)		
	pH*				
	pH in calcium chloride (1:5)	4.7 +	4.3 +	4.0 +	
	pH in water (1:5)	5.4 +	5.0 +	4.7 +	
Aluminium*	Calcium chloride extract (mg/kg)	0.5–2.0	2.0–4.0	4.0–8.0	
	% ECEC**	EC 1:5 < 0.07 dS/m	9–16	16–21	21–32
		EC 1:5 0.07–0.23 dS/m	2–8	8–12	12–21
		EC 1:5 > 0.23 dS/m	0.5–2.0	2–6	6–10

*Note that plant growth is likely to be restricted at pH levels below those listed, and at Al levels above the range listed.

** ECEC is the “effective cation exchange capacity”, calculated as the sum of available cations – calcium, magnesium, potassium, sodium and aluminium. Interpretation of aluminium levels is affected by soil salinity.



Plant tissue testing

Testing plant tissue (usually clover leaves) is the best way to determine the trace element status of a pasture.

Molybdenum is the main trace element of interest for pasture growth in south west Victoria but the level of other elements can be of value if investigating poor pasture performance and trace element problems with stock, particularly copper.

Kits for plant tissue testing are available from rural merchants.

Guidelines for a tissue testing program

- Plant tissue samples are best collected in late winter-early spring, prior to flowering.
- Collect samples as soon as the clover leaves are a reasonable size to make collection easy, and when there is very little mud in the paddock, according to directions in the sampling kit.
- Interpreting results for samples collected in mid to late spring is difficult because the nutrients are redistributed around the plant as it matures.
- Any soil should be washed off the plant material with cold water, but washing time should be minimised to avoid nutrient leaching.
- Send tissue samples to NATA accredited laboratories to ensure that approved testing standards are used and the tests results are accurate and reliable.

The results of a plant tissue test should be combined with local knowledge and experience before finalising a course of action.

Fertiliser test strips

Fertiliser test strips are good for determining what fertilisers to use but are of little value in determining the best rate to use. Be aware that growth responses to molybdenum may not be apparent until the year after application.

Putting down fertiliser test strips

- Strips can be put out at any time between May and late August.
- Locate the strips on pasture that has not been fertilised in the current year. Avoid areas that are not typical of the paddock (e.g. boundary fences, near yards gates and hay stacks).
- Run the strips out from a fence line, so they can be fenced off.
- Make each strip a reasonable size (2 m x 10 m, i.e. 20 m²) so the outcome is not strongly influenced by the fertiliser being put on a particularly good or poor piece of pasture.
- Use high rates of fertiliser so any effect can be clearly seen (suggested rates are shown in Table 5.3).
- Exclude stock from the strips for 4–6 weeks so the effects of the fertiliser can be assessed.
- Keep the test simple – no more than 10 strips in a set. Use the same order of treatments for each set. It is best to put out at least three sets of strips around the paddock or property.
- Recommended nutrients, products and rates to apply to the strip are presented in Table 5.3.

Table 5.3 Application rates for hand spreading fertiliser on 2 m x 10 m test strips

Strip	Fertiliser to apply per strip	Amount of nutrient supplied
phosphorus	0.5 kg triple super	52 kg P/ha
phosphorus, sulphur, potassium	1 kg single super 0.5 kg muriate of potash	44 kg P/ha, 55 kg S/ha 125 kg K/ha
control	No fertiliser	
phosphorus, sulphur, potassium, lime	1 kg single super 0.5 kg muriate of potash 10 kg lime	44 kg P/ha, 55 kg S/ha, 125 kg K/ha 5 t lime/ha
phosphorus, sulphur, potassium, molybdenum	1 kg super moly 0.015% 0.5 kg muriate of potash	44 kg P/ha, 55 kg S/ha, 125 kg K/ha 75 g Mo/ha
phosphorus, potassium	0.5 kg triple super 0.5 kg muriate of potash	52 kg P/ha 125 kg K/ha
phosphorus, sulphur	1 kg single super	44 kg P/ha, 55 kg S/ha



Assessing fertiliser test strips

- Assess the test strips after stock has been excluded for 4–6 weeks in June–July, and then graze the plot again.
- Assess strips visually. Consider growth (height) and colour, clover content, plant density, and presence of weeds.
- Exclude stock again for 4 weeks from mid September and then assess spring growth.
- The area must be grazed short by the following autumn break to ensure good clover germination. A further assessment should be made the following winter and spring.

Fertilisers for pastures

The growth of a pasture is limited by the nutrient in lowest supply. There is no point in putting on more phosphorus if a lack of potassium or sulphur is restricting pasture growth.

Phosphorus

When first settled, all soils in south west Victoria had very low phosphorus (P) levels, the only exceptions being those around the old volcanoes. Regular applications of phosphorus, along with the introduction of improved pasture species such as perennial ryegrass, phalaris, and subterranean and white clovers, have resulted in massive increases in pasture productivity.

Phosphorus is most commonly applied as single superphosphate (8.8% P), double superphosphate (17.1% P), triple superphosphate (20.7% P), mono-ammonium phosphate (MAP, 21.9% P), or di-ammonium phosphate (DAP, 20% P). These products all contain readily soluble phosphorus.

Another phosphorus fertiliser is reactive rock phosphate, which is currently used in niche applications such as organic farming. Much of the phosphorus in reactive rock phosphate is not readily soluble and requires soil reactions to change the phosphorus into a form that is available to plants. A series of trials in western Victoria in the 1990s found that reactive rock phosphate was less effective than soluble fertilisers in supplying the phosphorus requirements of the pasture in the year of application. However, it had similar effectiveness as soluble fertiliser on acid soils (pH_c less than 5.2), where the annual rainfall was greater than 800 mm and fertility had been built up previously with soluble fertilisers.

Phosphorus is the most commonly applied nutrient in south west Victoria. Suggested application rates are 10 kg P/ha (applied as 100

kg/ha of single superphosphate) for stocking rates of 10–15 DSE/ha and 20 kg P/ha (as 120 kg/ha of double superphosphate) for stocking rates of 15–25 DSE/ha.

A more comprehensive approach to determine application rates is shown on pages 50 and 51 of this chapter.

Potassium

Soils in most of south west Victoria had adequate levels of potassium (K) in the 1800s. However, regular cutting of pasture for hay and silage, and high levels of nutrient export in stock products and transfer to stock camps, have resulted in pasture responses to potassium fertiliser becoming increasingly common.

An application of potassium will influence pasture growth for 6–8 years on clay loam soils but only 1–2 years on lighter soils. Typical application rates are 50–100 kg K/ha (usually as 100–200 kg/ha of muriate of potash) every 5–10 years on clay soils, or 20 kg K/ha annually on lighter soils. After a hay or silage crop, 15 kg K/ha needs to be applied for each tonne per hectare removed.

Muriate of potash (potassium chloride) is the most cost-effective source of potassium and consists of 50% potassium and 50% chloride (Cl). The application of chloride to pastures by using potash should not be of concern. The amount added with potash fertiliser (25–50 kg Cl/ha per application) is less than that in natural rainfall, about 170 kg Cl/ha.year at the coast, decreasing to 22 kg Cl/ha.year in the northern part of the region.

Potassium sulphate, containing 42% potassium, is also available but is much more expensive and generally only recommended in horticulture.

Sulphur

In their unimproved state, most soils in south west Victoria did not contain sufficient sulphur (S) to support productive pastures. As levels of pasture productivity increased, sulphur requirements were not detected because the superphosphate originally used to correct phosphorus deficiency also had a high sulphur level (11%), and concurrently overcame any sulphur deficiency.

In the 1980s, high-analysis fertilisers became available in Australia, making it possible to apply phosphorus with little or no sulphur. At the same time, soil tests for sulphur became available. This made it possible to recognise and assess the need for regular applications of sulphur, independent of phosphorus.



Sulphur in fertiliser is either in the sulphate or elemental form. The sulphate form is soluble and can be quickly taken up by the pasture plants but on light sandy soil, it can also be leached. This may result in sulphur deficiency appearing in the pasture in spring. Elemental sulphur is insoluble and needs to be changed into a soluble form by soil bacteria before plants can use it. The finer the particles of elemental sulphur in the fertiliser and the warmer the soil, the quicker it becomes available to the pasture.

On soils with a clay loam or clay texture, and low general fertility, sulphur in the sulphate form is preferred. Some sulphur in the elemental form is considered important on lighter soils where leaching occurs.

Because sulphur leaches into deeper layers of the soil more readily than phosphorus, the soil sulphur level in the top 10 cm increases at a slower rate with superphosphate application than the soil phosphorus level.

Where pastures are expected to benefit from having sulphur applied, it is generally best to apply it annually. On clay loam or clay soils, apply at least 5 kg S/ha.year as single superphosphate or double superphosphate. Use a higher rate of 5–15 kg S/ha.year on light sandy and free draining soils.

Fertiliser and the environment

It is possible that some of the phosphorus and nitrogen fertilisers applied to pastures may end up in streams and groundwater, reducing water quality and potentially causing algal blooms. Runoff from well-fertilised sheep pastures contains 2–5 times more phosphorus than comparable unfertilised pastures. Landholders have a responsibility to minimise the impact of high fertility soils on stream water and downstream water users.

Molybdenum

Responses to molybdenum (Mo), commonly called moly, were first seen in south west Victoria in the 1940s. Substantially better pasture growth followed an application of molybdenum on most basalt plains and coastal plains soils, any soil with a high buckshot gravel content and very light sandy soils.

Molybdenum is normally applied as an additive to another fertiliser such as superphosphate, to ensure even distribution over a paddock. Molybdenum can also be sprayed onto a pasture. Liming makes the molybdenum held in the soil more available, but application of molybdenum is generally much cheaper than liming, unless the soil pH also needs correction.

There is an interaction between molybdenum and copper (Cu). Applying molybdenum reduces the availability of copper to the animal. If the soil copper level is marginal, this change can cause copper deficiency to appear in livestock. This is common on light (loam or sand) soil but is unlikely on clay loam or clay soils.

Typical application rates of molybdenum are 0.05 kg Mo/ha every 5–7 years. If copper deficiency is likely, apply 1.0–2.0 kg Cu/ha at the same time.

Pasture management that takes into account the way that surface runoff is generated can minimise the effect of high soil fertility on the environment. Surface runoff from pasture areas close to streams, soaks and other wet spots contributes most of the water that eventually reaches streams and waterways. These areas should be managed as low-fertility pastures, i.e. minimal or no fertiliser applications, while the remainder of the paddock can be fertilised for productive purposes.



Orange areas show "wet spots" in this landscape, which are sources for a high proportion of surface runoff. The amount of nutrients entering streams can be significantly reduced by eliminating fertiliser application to areas generating surface runoff.



Nitrogen

Nitrogen (N) fixation by bacteria in the root nodules of clovers and other legumes provides sufficient nitrogen for pasture growth rates that are acceptable under most conditions. However, growth rates can usually be increased by application of additional nitrogen.

Nitrogen fertiliser should be considered as a form of supplementary feeding rather than a means of overcoming a nutrient deficiency. Dairy farmers apply nitrogen to reduce the amount of supplementary feed required during winter. In sheep enterprises, nitrogen application should be considered, to boost pasture production:

- when there has been a late break to the season
- when the soil profile is much drier than normal at the end of winter, leading to a high probability of below-average spring growth
- to allow earlier harvest and higher yields of hay and silage crops.

Figure 5.1 illustrates the ideal times to apply nitrogen to maximise pasture production. Nitrogen application is a way of producing more feed during the time of reliable moisture in early spring. Each kilogram of nitrogen per hectare on good pasture in winter, will produce an extra 5–10 kg DM/ha of growth, and in spring, an extra 15–20 kg DM/ha.

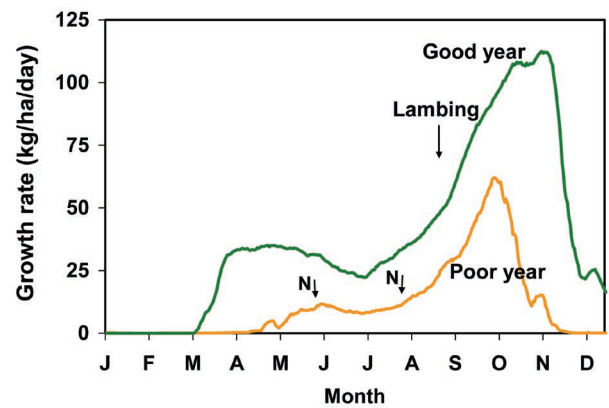


Figure 5.1 Nitrogen can be used to reduce the year-to-year variability in pasture growth. The lines show growth rates at Hamilton for good and poor years, and arrows indicate when nitrogen should be used in poor years to boost pasture production. Good years (green line) start with an early autumn break and have an extended period of rapid growth during spring. Poor years (orange line) start with a late autumn break, and have a lower peak growth rate in October.

Guidelines for achieving a good nitrogen response

- Apply nitrogen to the best pastures – those with an Olsen P of at least 12 mg/kg and more than 60% desirable species.
- Apply to pastures which have enhanced growth visible on dung and urine patches after a short lock-up period.



Signs of a pasture suitable for nitrogen application: without nitrogen application (right) there are patches of vigorous growth where dung or urine has supplied nitrogen to about 20% of the area, and the remaining 80% has much lower growth rates. With nitrogen application (left), the whole area has growth rates approaching those of dung and urine patches.



- Wait 4 weeks after the autumn break before applying nitrogen, until plants have taken up soil nitrogen from the previous season.
- Apply nitrogen at 20–60 kg N/ha per application (40–120 kg urea/ha), with applications spaced 8 weeks apart in winter and 4 weeks in spring.
- In spring, ensure there is sufficient soil moisture before applying nitrogen to ensure growth is not restricted by a shortage of moisture for the following 4 weeks.
- Short-term ryegrass is the most nitrogen-responsive pasture, followed by annual ryegrass, perennial ryegrass then phalaris.
- Do not apply nitrogen fertiliser to waterlogged soils.

Urea is normally the most economical nitrogen fertiliser, despite small losses to ammonia volatilisation. DAP is a cost-effective source of nitrogen if phosphorus is also required, and sulphate of ammonia if sulphur is required.

There is no withholding period between nitrogen fertiliser application and grazing on perennial ryegrass pastures. However, if the pasture contains capeweed, grazing cereals, annual ryegrass, short rotation ryegrass or volunteer brassicas, it should be left 21 days to avoid nitrate poisoning.

The response to nitrogen will be maximised with rotational grazing. Grazing should commence when the pasture has reached 2000 kg DM/ha, and it should be grazed down to about 1000 kg DM/ha.

Other elements

For most soils in south west Victoria, there are no clear data on responses by pastures to the application of the trace elements zinc, copper, cobalt, boron or manganese. There are, however, special cases such as lighter soils where experience has shown that some trace elements are necessary (see Chapter 2, *Soils for pastures*). It usually takes a combination of local knowledge, tissue testing and strip tests to resolve exactly what elements are required.

Selenium, cobalt and copper are important for animal nutrition and spreading them on the pasture may be the most economic way of getting them into the animal. Blood tests, and the results of treating a few animals, are the best way of determining if stock will benefit from additional supplies of these elements.

How much fertiliser?

Decisions about fertiliser use have a large impact on farm profitability, so it is appropriate to put some time and money into making sure the best decisions are made.

There are two main approaches to deciding the best rate of fertiliser to apply.

A soil test can be conducted and if the results show a deficiency, apply the limiting nutrients at a rate that has worked in the past. This is the normal approach for potassium and sulphur.

Alternatively, the nutrient requirements can be estimated from a relationship between fertiliser rate and the gross margin for the livestock enterprise. This latter approach is normally used to determine the appropriate phosphorus application rates.

In south west Victoria, farmers are fortunate to have the results of the Hamilton Long-term Phosphate Experiment available to calibrate phosphorus application rates. Using the results of this experiment, a “phosphorus calculator” has been developed. The actual amount of phosphorus to apply needs to consider the stocking rate run on the particular farm or paddock. The calculator gives a recommended rate of phosphorus fertiliser to apply per DSE/ha. The calculator also considers a wide range of variables that will affect the required phosphorus rate for a paddock including:

- average rainfall
- type of soil
- grazing system used (rotational or set stocked)
- steepness of the paddock
- pasture species present.

Tables 5.4 and 5.5 can be used to determine the phosphorus application rate for a wide range of situations – several of which may occur on one farm. An example calculation of how to use this information is on the next page.

This method of choosing fertiliser requirements allows fertiliser rates to be tailored to individual paddocks. It ensures that more fertiliser is used in paddocks with high removal rates, and less is used in paddocks with poor carrying capacity.

The next step is to express the stocking rate in terms of DSE/ha. The average stocking rate for the paddock is calculated from paddock records from the previous year. If individual paddock information is not available, use an average stocking rate for the farm. The DSE values for different classes of livestock are shown in Table 5.6.



Calculating a phosphorus rate

The paddock is a sandy loam in a 600 mm rainfall zone growing improved pasture. It is set stocked on flat to rolling country

- the soil loss factor will be **medium** (Table 5.4)
- the animal loss factor will be **low** (Table 5.4)

Having selected the soil and animal loss factors for the paddock, and taking into account improved pasture, slope and 600 mm rainfall the appropriate phosphorus rate per DSE is determined from Table 5.5.

→ 0.76 kg P/DSE is recommended

Table 5.4 A description and rating of phosphorus loss factors in sheep and beef cattle grazing systems based on soil type, grazing management and landscape

Soil loss factors

Soil type	Loss factor
Clay loam (rainfall less than 500 mm), soils derived from Ordovician sediments and granite, or younger basalts (if high in available phosphorus)	Low
Clay loam and sandy loam (rainfall over 500 mm), soils derived from older quaternary basalts, or Cretaceous sediments	Medium
Podosols (acid sands), peats or soils derived from younger basalts (if low in available phosphorus)	High

Animal loss factors

Grazing management	Landscape	Loss factor
Intensive rotational grazing	Flat and rolling (mostly less than 10° slope)	Very Low
	Easy hills (mostly less than 25°)	Low
	Steep hills (1/3 of paddock greater than 35°)	Medium
Set stocked or intermittent grazing	Flat and rolling	Low
	Easy hills	Medium
	Steep hills	High

Table 5.5 Recommended phosphorus rate (kg P/DSE) for maximum profit, according to loss factors, pasture type and rainfall

Soil loss factor	Animal loss factor	Undeveloped pasture			Improved pasture		
		Annual rainfall (mm)			Annual rainfall (mm)		
		400	600	800	400	600	800
Low	Very low	0.38	0.42	0.44	0.40	0.44	0.48
	Low	0.50	0.52	0.56	0.50	0.56	0.62
	Medium	0.60	0.64	0.70	0.62	0.68	0.76
	High	0.72	0.76	0.82	0.72	0.82	0.90
Medium	Very low	0.56	0.60	0.64	0.58	0.64	0.70
	Low	0.66	0.72	0.76	0.68	0.76	0.84
	Medium	0.78	0.84	0.88	0.80	0.88	0.98
	High	0.88	0.94	1.00	0.92	1.02	1.12
High	Very low	0.74	0.78	0.84	0.76	0.84	0.92
	Low	0.84	0.90	0.96	0.86	0.96	1.06
	Medium	0.94	1.00	1.08	0.98	1.08	1.20
	High	1.06	1.14	1.20	1.08	1.20	1.32



Table 5.6 Dry sheep equivalent (DSE) values for different classes of livestock, at different liveweights

Sheep	30 kg	40 kg	50 kg	60 kg
Dry ewes or wethers (maintaining weight)	-	0.9	1.0	1.2
Last month of pregnancy (singles / twins)	-	1.2 / 1.4	1.4 / 1.6	1.6 / 1.9
Lactation (singles / twins)	-	2.6 / 3.7	2.7 / 3.9	2.9 / 4.4
Weaners (growth rate 100 g/d)	1.1	1.3	-	-
Average (year) ewe	-	1.5	1.6	1.8
Beef cattle	400 kg	500 kg	600 kg	
Dry cows or store steers (maintaining weight)	6	7	8	
Dry cows or store steers (growth rate 0.5 kg/d)	8	11	12	
Dry cows or store steers (growth rate 1.0 kg/d)	11	13	15	
Last 3 months of pregnancy	8	9	11	
Cows with 0–3 month calves	13	14	17	
Cows with 3–9 month calves	19	21	24	
Average (year) cow	15	16	19	

Calculating a fertiliser rate

In the example, the paddock is stocked with 60 kg wethers, running at 10 head/ha.

A 60 kg wether has a DSE value of 1.2 (Table 5.6), so the stocking rate of the paddock is 10×1.2

→ 12 DSE/ha

The amount of fertiliser to apply per hectare will be:

$$\frac{100 \times \text{kg P/DSE} \times \text{DSE/ha}}{\%P}$$

If single super with a phosphorus content (%P) of 9% is used, that is:

$$\rightarrow \frac{100 \times 0.76 \times 12}{9} = 101 \text{ kg single super/ha}$$

Soil acidification and lime

Soil acidification is a gradual decline in soil pH, which eventually reduces plant production and persistence. All agriculture makes the soil more acid. Firstly, farms become more acid because the removal of farm products (such as hay, grain, milk and meat) transfers alkalinity off the farm. Secondly, leaching of nitrogen leaves the topsoil more acid. In areas receiving over 500 mm of rain annually, loss of nitrogen is highly likely in most years. About 100–300 kg lime/ha.year must be added to land in a grazing enterprise to neutralise the increased acidity. Much larger amounts of lime than this are required for hay enterprises where the product is sold off farm.

In addition to adding lime to balance acidification, changes in management can also reduce the rate of acidification. Deep-rooted perennial plants can use the nitrogen in the soil before it moves past the root zone.

As soils become more acid the aluminium and manganese components become more soluble. In high concentrations these elements are toxic to plants. High aluminium levels restrict root growth, which limits the plant's ability to take up the nutrients and water required for good growth. It also limits a perennial plant's ability to persist. At pH in calcium chloride (pH_c) below 4.0, the clay minerals, which perform many important functions in the soil, gradually dissolve, releasing even more aluminium.

Situations where acidity problems are likely to appear first are naturally acid light textured soils with low organic matter content, in regions with dry summers, where annual legumes are a major component of the pasture, and on sheep camps (Table 5.7).

Narrow highly acidic layers can severely reduce the vigour of acid-sensitive plants such as lucerne. On a gravelly crest on a basalt-derived soil near Hamilton, the soil pH_c of the 0–10 cm layer was



4.9 and would not raise concern, but sampling in 5 cm increments down the profile revealed a highly acid layer between 5–10 cm. This type of pH profile is common on sheep camps because dung transfers alkalinity to the top 5 cm, but urine causes acidification at the 5–10 cm depth.

Table 5.7 Soil pH from a sheep camp, where the standard 0–10 cm sampling interval ‘averages out’ the sharp difference in pH within the sampling layer

Depth (cm)	pH in calcium chloride	EC 1:5 dS/m	Aluminium % of ECEC
0–10	4.9	0.21	11
0–5	5.9	0.34	1
5–10	3.9	0.08	22
10–15	4.1	<0.05	18
15–20	4.9	<0.05	5

Liming pasture soils

Lime is the most cost-effective soil ameliorant to neutralise soil acidity. There have, however, been few well-documented cases of responses to lime in south west Victoria, even on soils well below the pH levels suggested in Table 5.2. This is because a low pH affects plant growth primarily by mobilising aluminium. If the pH_c is below 4.8, an aluminium test should also be sought. A lime response in pasture would only be expected if aluminium levels are high.

Lime needs to be worked into the soil for maximum effect on improving soil pH, therefore consider liming when the soil is being cultivated, eg growing a fodder or cereal crop or resowing a new pasture. Surface-applied lime can be effective but it will take at least a year to neutralise acidic layers of the topsoil. A typical lime application rate is 2.5 t/ha, but it is better to calculate the required rate from the difference between the current soil pH and that required for the target pasture or crop species (see Table 5.2). Surface and subsoil pH, aluminium levels, soil type, pastures species, cost of lime, farm commodity prices and the results of local lime trials all influence whether lime is recommended in a given situation.

Worked into the top 10 cm of soil, 1 t/ha of lime can be expected to increase the pH of clay soils by 0.26 units, clay loams by 0.37 units, sandy clay loams by 0.47 units, and sandy soils by 0.57 units. It is anticipated that the benefits of one application of lime will last for 5–10 years.

Further reading

Best Management Practices for Nitrogen in Dairy
www.nitrogen.unimelb.edu.au/

Phosphorus for sheep and beef pastures
by J Cayley and P Quigley (2005)
Department of Primary Industries, Hamilton

Making informed decisions on phosphorus fertilisers

by P Quigley, C Gloag, J Cayley, M McCaskill and F Cameron (2003)
Department of Primary Industries, Hamilton

