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NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Managing soil amendments and fertilisers for a cleaner environment

Agfact AC.29, October 2004*
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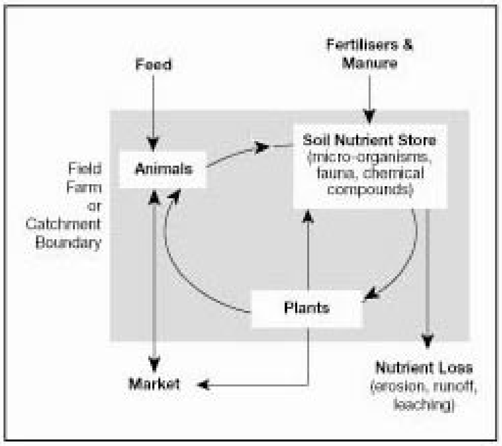
If agricultural plants are to grow well they need a balanced supply of a wide range of major and minor nutrients. Some of these nutrients are provided adequately by the soil for long periods. Others, particularly the major nutrients phosphorus and nitrogen, are often naturally low in New South Wales soils or become so soon after the start of agricultural production. They usually need to be supplied by fertilisers to keep production profitable and sustainable.

These inputs of nutrients to the agricultural system are either stored or transferred. Storage capacity is limited by the nutrient-holding ability of the soil and the amount of plant and animal matter (biomass). Losses to the environment occur when the input is greater than the rate of harvesting (use), so the storage capacity of the system fills up and 'overflows' (see Figure 1).

Soil health also directly affects losses to the environment. A healthy soil will reduce the risk

Maintaining groundcover will reduce the loss of soil and nutrients. Photo by R. Lawrie.

Figure 1. A simplified model of the flow of nutrients in an agricultural production system. Nutrients are 'stored' in the various boxes and move between between the stores or in and out of the system.



of run-off and erosion and hold more nutrients in organic forms and in the soil (on exchange sites). All soils, whether fertilised or unfertilised, contain at least some nutrients and some loss of soil and nutrient occurs naturally—although excessive loss can result from poor management.

Trying to reduce or stop the use of fertilisers and soil amendments for crop and pasture production can be counterproductive. The decrease in plant growth and resulting reduction in surface cover is likely to increase soil erosion and loss of nutrients to waterways. Some soil amendments such as mulch will increase groundcover and thus reduce soil and nutrient loss.

This Agfact suggests guidelines for managing soils, fertilisers and soil amendments to minimise detrimental environmental effects. It also looks at what happens to nutrients when they are applied to the soil and what fertilisers and soil amendments do to the environment if they are used excessively or incorrectly. It examines heavy metal contaminants of fertilisers and soil amendments and their potential environmental impact.

IMPORTANCE OF BEST MANAGEMENT PRACTICE WHEN APPLYING AMENDMENTS AND FERTILISERS

Some agricultural practices— including the use of fertilisers and other soil amendments—have been blamed for contaminating the environment through:

- eutrophication (enrichment with nutrients) of dams and waterways, leading to the development of blue-green algal blooms
- phytotoxicity
- soil contamination.

We should use fertilisers and soil amendments carefully and be aware of their possible effects on the environment. We can ensure that plants use most of the nutrients applied in fertiliser or other soil amendments by following three basic principles:

- Apply fertiliser/ soil amendment at rate recommended after soil and plant tissue testing.
- Match fertiliser/soil amendment application times with time of plant need.
- Minimise run-off, soil erosion and leaching.

Under these circumstances few of the nutrients will be lost and there will be minimal contamination of the environment. Some fertilisers and soil amendments may contain contaminants—in particular, heavy metals—that can have an impact on the environment and on human health, if they are taken up by plants. It is important that we minimise the accumulation of heavy metals in the soil and reduce their uptake by plants.

Following best management practices for the use of phosphorus fertilisers will reduce excessive or inappropriate use of phosphate fertiliser, which can result in:

- eutrophication of dams and waterways, leading to the development of green and blue-green algal blooms, mainly through erosion of soil particles with attached phosphorus
- leaching of phosphorus in very sandy soils, leading to contamination of groundwater or drainage waters and possibly surface waters
- accumulation in the soil, and uptake by plants, of heavy metals, particularly cadmium.

Following best management practices for the use of nitrogen fertilisers will reduce the risk of adverse effects on the environment, including:

- eutrophication of dams and waterways, leading to the development of (mainly) green algal blooms, largely through nitrate leaching, as well as run-off and soil erosion

Blooms of blue-green algae can occur frequently in many NSW waterways. Photo by Roy Lawrie

- contamination of groundwater or drainage waters, and possibly surface waters, from nitrate leaching
- soil acidification, caused by nitrate leaching and the use of highly acidifying nitrogen fertilisers
- contribution to the greenhouse effect by the release of nitrous oxide, formed mainly from nitrate in soil by soil bacteria, to the atmosphere during denitrification.

Following best management practices for the use of soil amendments will reduce the risk of adverse effects on the environment as described for nitrogen and phosphorus fertiliser and will also reduce the risk of:

- phytotoxicity, that is, the uptake of particular metals, such as zinc, by plants to levels that affect plant growth and survival
- contamination of land with heavy metals such as cadmium
- contamination of waterways with heavy metals, phosphorus and nitrogen.

PROTECTING THE ENVIRONMENT WHEN USING FERTILISERS

One way to reduce nutrient losses to the environment is to increase the nutrient storage capacity and the rate of cycling within the system. Management practices that raise soil organic matter levels and maintain good soil structure will increase the nutrient-holding capacity of the soil. This in turn will improve the root environment of crops, resulting in better growth and greater nutrient uptake. Limiting nutrient inputs to the rate of use (harvesting) plus a small amount for minor unavoidable losses will also reduce nutrient loss. This requires careful nutrient budgeting and a reliance on the supply of nutrients already in the system.

Although fertilisers and soil amendments are sometimes washed directly into dams and waterways, the nutrients from them usually reach dams and waterways attached to eroded soil particles (particularly phosphorus) or dissolved in run-off (particularly nitrogen).

Nutrients from fertiliser and soil amendments, particularly nitrogen as nitrate, can also move into groundwater and drainage waters and then possibly into surface water by leaching through the soil. Other components such as heavy metals can become more mobile under acidic conditions and then be transported in water.

The best way to minimise the losses of nutrients and contaminants to your local waterbodies is to prevent erosion and reduce both excess run-off and leaching, manage your soils and apply fertilisers and soil amendments correctly. The advice given in this section will help you minimise the impact of nutrients and contaminants on the environment.

Phosphate fertilisers

Minimising eutrophication and algal blooms

There are three main approaches to minimising the contribution of phosphate fertilisers to eutrophication and the development of algal blooms:

- Minimise soil erosion by wind and water.
- Stop any soil that does erode from reaching dams and waterways.
- Increase the efficiency of fertiliser use, which has the potential added benefit of reducing costs.

These three approaches complement one another, but the first is by far the most important.

No till crops (here it is beans) planted directly into stubble will reduce soil erosion and nutrient run-off.

Controlling soil erosion

The key management factors in controlling soil erosion are surface vegetative cover and surface soil structure. Soil loss begins to increase dramatically as surface vegetative cover falls below about 70 per cent on open sloping grazing land. This critical level of surface cover gradually decreases as the slope decreases, to about 40 per cent on the plains. It is also important to remember that some areas are more prone to soil and nutrient loss than others. Yards, feedpads and laneways can be major sources of eroded sediment and nutrient. Soils that are structurally unstable when wet are also prone to erosion.

On open sloping grazing land, soil erosion increases dramatically when vegetative cover falls below 70% (left); on the flatter plains the critical level of surface cover is 40% (right). Photo by D Lang

To minimise soil erosion you need to maximise surface cover—year round if possible, but most importantly at times of high erosion risk—and to maintain good surface soil structure. Some helpful management techniques are:

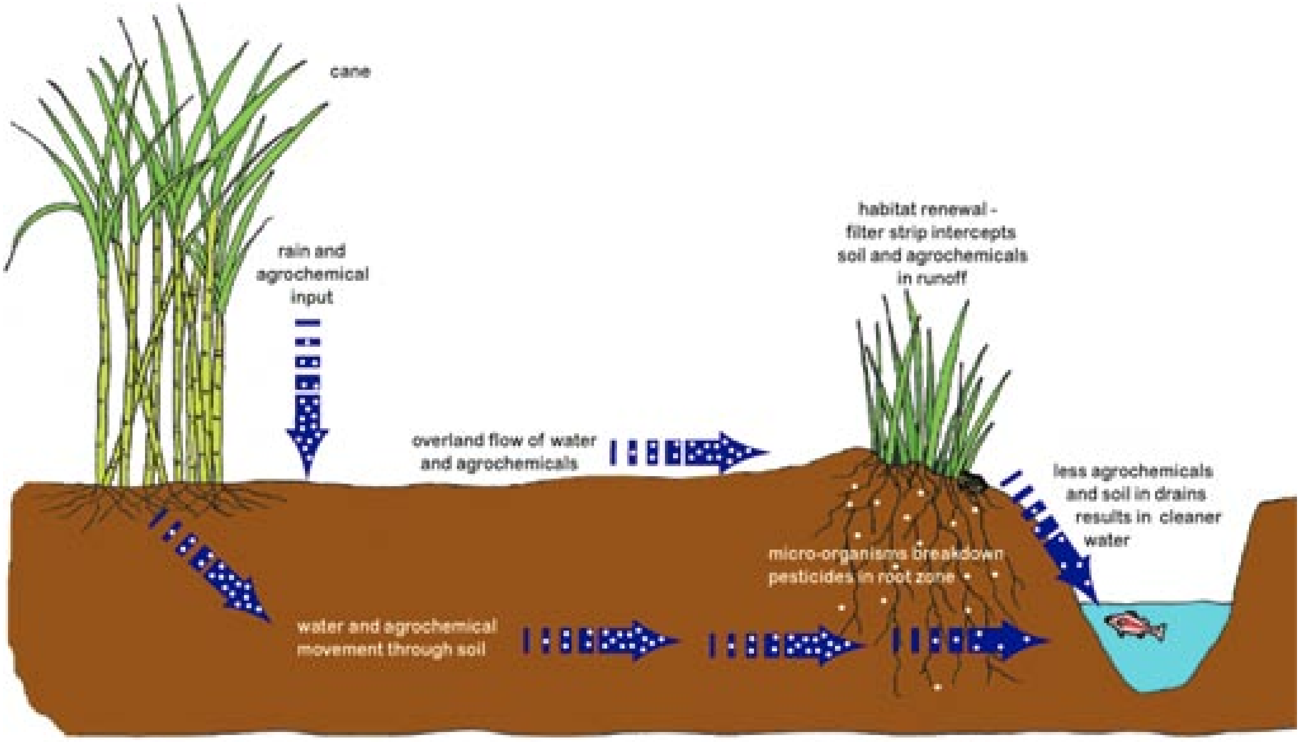
- reducing tillage and using direct drilling
- retaining stubble on the surface for as long as practicable and, if burning is necessary, waiting until the main period of high erosion risk has passed
- using herbicides rather than tillage to control weeds during fallows
- using crop/pasture rotations that include well managed perennial pastures and legumes
- using permanent raised beds and controlled traffic when row cropping
- improving grazing management to minimise compaction and maintain adequate surface cover, particularly during drought
- increasing topsoil organic matter levels by stubble incorporation or mulching and including pastures in crop rotations
- practising cover cropping, sod culture or mulching in orchards and vineyards
- judiciously applying lime or gypsum (or both) to acid soils and gypsum to sodic clay soils

A vegetative filter strip on a cane farm is effective in stopping trash and soil from moving. Four species are shown—from the rear they are vetiver grass, Lomandra (native), Lepironia and Twig rushes (*Baumea* sp.). Photo by M Heesom

- promoting vigorous plant growth generally, through sound soil, crop and water management, including efficient fertiliser use
- controlling rabbit numbers to maintain groundcover.

Sometimes soil conservation earthworks such as contour banks and grassed waterways are also needed to help control soil erosion; seek further advice from your local district adviser and the

Figure 2. A vegetative filter strips trap sediment, nutrients and chemicals above and below the surface, thus improving water quality.



Department of Infrastructure, Planning and Natural Resources.

Intercepting eroded soil

Eroded soil can be intercepted by maintaining streambanks in good condition and minimising their erosion, planting buffer strips along waterways and around dams and other means such as detention basins. Using buffer strips or vegetative filter strips can trap up to 90 per cent of eroded sediment from further upslope (see Fact Sheet 3: *Improving water quality*, LWA). However, buffer strips along waterways are not sufficient by themselves to protect streams from excess soil and nutrient loss. They must be coupled with the management options described above. **Your most important goal should always be to minimise soil erosion in the first place.**

The design and maintenance of buffer strips is important if they are to work effectively and fit in with other farm operations. Width of strips is determined by the amount of water and sediment being transported and the slope of the land: the greater the volume, the wider the strip required. Sometimes purpose-planted strips are not required as natural riparian vegetation can serve the same purpose. Managing strips to ensure complete groundcover and vegetative height of 10 cm or more is also essential. For this reason careful grazing management is required to avoid overgrazing. Information on this can be found in Fact Sheet 3 *Improving water quality*.

Using phosphate fertilisers efficiently

The following guidelines for using phosphate fertiliser efficiently should be followed:

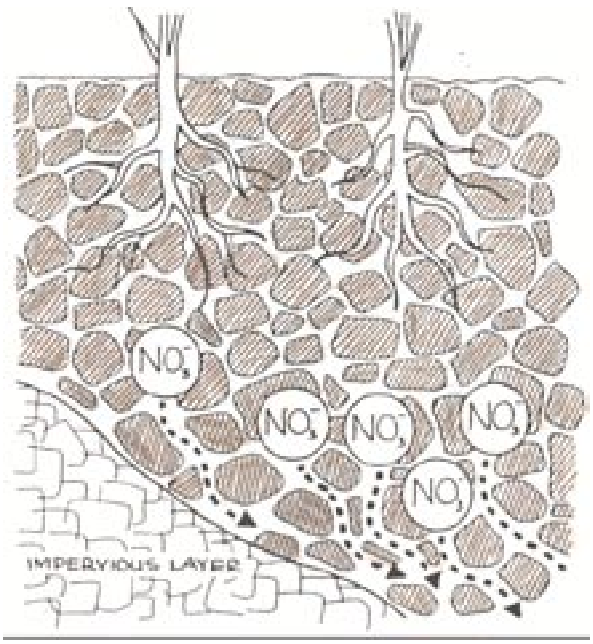
- Match the supply of phosphorus (P) to the needs of the plant, through soil or plant tissue testing and improved timing of fertiliser application (consult your local district extension officer for more detail).
- Incorporate, rather than broadcast, fertiliser wherever possible.
- Avoid fertilising bare areas, especially when storms are likely.
- Don't fertilise close to or across dams and waterways (even semi-permanent waterways).
- Store fertiliser under cover, and away from dams and waterways, on impervious or compacted soil and divert run on from higher ground around fertiliser stockpiles.
- Keep records of fertiliser usage and calibrate spreading equipment to reduce the likelihood of overuse.
- Don't flood irrigate immediately after applying fertiliser. Up to 25 per cent of the P will be lost when flood irrigation follows phosphorus application.

Reducing phosphorus leaching. Avoid heavy single applications of phosphate fertiliser, especially under high rainfall or irrigation on very sandy soils, as these do not retain P well. Under these conditions consider using rock phosphate, or organic or controlled release fertilisers.

Managing phosphate fertiliser contaminants. Guidelines for minimising soil accumulation and plant uptake of heavy metal contaminants, with emphasis on cadmium, are:

- Use only fertilisers that have low or nil levels of cadmium (Cd) and other heavy metals, particularly for high risk crops such as potatoes and on acid, sandy soils. Low levels of cadmium are defined as less than 50 mg Cd per kg of P for fertilisers and less than 1 mg Cd per kg of product for manures and composts. Contact your fertiliser supplier/ manufacturer or the national cadmium management program website

Figure 3. Leaching in the soil.



Leaching occurs when the downward movement of soil water carries nutrients, particularly nitrate (NO_3^-), out of the soil.

SOIL SENSE: SOIL MANAGEMENT FOR NORTH COAST FARMERS (http://www.cadmium-management.org.au) for further advice on heavy metal levels in fertilisers.

- Avoid the use of chloride fertilisers such as potassium chloride (muriate of potash) where cadmium is likely to be a problem.
- Maintain, and preferably increase, soil organic matter levels.

Nitrogen fertilisers

Minimising eutrophication and algal blooms

The main way to minimise the contribution of excess nitrogen (N) to eutrophication and the development of algal blooms is to reduce the leaching of nitrate to groundwater and drainage waters that can end up in surface waters. This is especially important where soils are permeable (e.g., sandy soils), as water moves thorough these soils more easily.

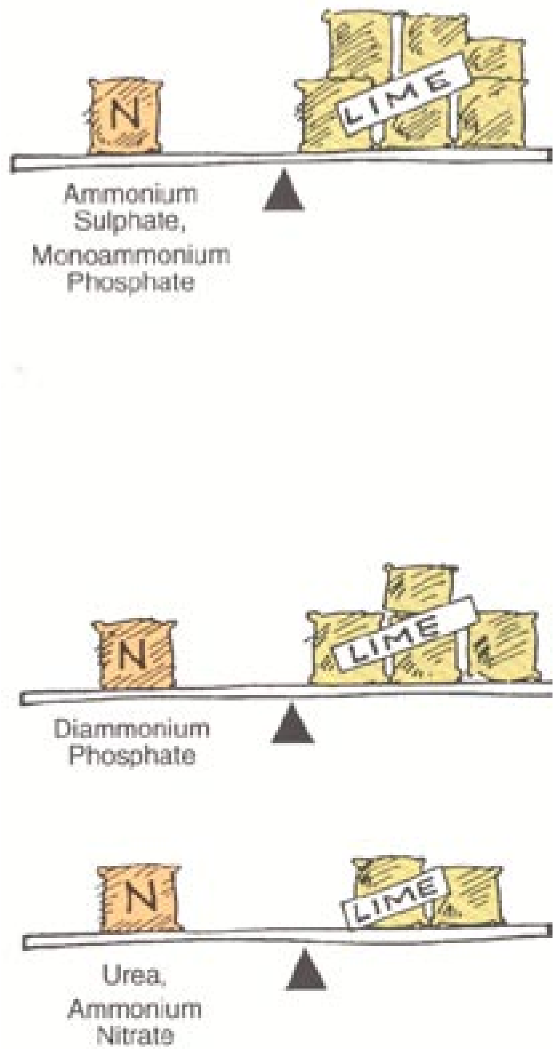
A second, complementary approach is to reduce run-off and soil erosion. Recommended management techniques to achieve this were outlined under 'Phosphate fertilisers'.

Reducing nitrate leaching

Guidelines for reducing nitrate leaching are:

- Apply N fertiliser in small amounts frequently, rather than all at once, and use only recommended rates. Soil or plant nitrate testing, or both, can help detect high levels. Check with your district agronomist or horticulturist.
- Apply N fertiliser as close to sowing as practicable and, again, only when needed by the crop.
- Incorporate crop residues and avoid cultivation in long summer fallows especially in summer rainfall areas.
- Sow winter cereals as early as possible to utilise as much of the nitrate in the soil as possible.
- Sow summer-growing perennial pastures to take up nitrate as it is formed.
- Use organic or controlled release N fertiliser on sandy soils, particularly when subject to high rainfall or irrigation.
- Avoid over-irrigation, which will carry nitrates through soil and into waterways.

Figure 4. Balancing nitrogen fertilisers.



If you use a highly acidifying fertiliser such as ammonium sulfate you will need to add more lime to the soil than if you are using a low acidifying one such as urea.

- Avoid overstocking, which can add to the nitrogen load by producing more manure and urine.

Slowing soil acidification

Soil acidification is a natural process, often accelerated by agriculture. One of the main processes of soil acidification is the leaching of nitrate. Use low acidifying N fertilisers such as urea, ammonium nitrate, aqua ammonia and anhydrous ammonia. Highly acidifying types, particularly ammonium sulfate and monoammonium phosphate (MAP), should be avoided, especially on soils that are already acidic.

Applying lime will help neutralise the acidifying effect of nitrogen fertilisers. More lime is needed to balance the soil acidification caused by highly acidifying fertilisers such as ammonium sulfate than that caused by low acidifying fertilisers such as urea.

Contrary to popular belief, superphosphate application has virtually no direct effect on soil pH. However, it may increase soil acidification indirectly by promoting the growth of legumes, which add N to the soil that can be lost by leaching as nitrate. Utilising as much of your soil water and nitrate as possible with subsequent crops/pasture is the best way to reduce this risk.

Waterlogging can also enhance nitrogen losses.

For more information on soil acidity refer to Agfact AC.19 *Soil acidity and liming* and Acid Soil Action No 4 (1999) *Planning on liming*.

Potassium fertilisers

To minimise leaching of potassium (K) in very sandy soils apply K fertiliser in small amounts frequently, rather than all at once, using only recommended rates.

Excessive use of potassium chloride (muriate of potash) is likely to increase chloride levels in the soil. This may reduce plant growth and yields and may also lead to increased plant uptake of cadmium from the soil. Other K fertilisers, such as potassium sulfate, should be used where large amounts of K are needed or where cadmium is likely to be a problem.

Organic fertilisers

There are many organic and organic-based fertilisers on the market. All are derived largely from plant or animal materials, either solely (organic) or substantially (organic based). The collective term for products made from food, organic matter, municipal wastes and biosolids is recycled organics. In addition to this there are organic products such as animal manures (fowl, cattle and swine), fish preparations and blood and bone. Several of these are often composted to increase their stability.

An important feature of organic fertilisers is that their nutrients are mostly in organic forms, which must be broken down to inorganic forms before becoming available to plants, although sometimes the nutrient content may be boosted by the addition of inorganic fertilisers. The other nutrients in organic fertilisers are available more slowly, over a longer period, than those in most manufactured fertilisers. This may be a disadvantage when plants have an immediate need for nutrients, but it can be an advantage under high leaching conditions, in that nutrient loss from the soil is reduced.

However, once organic nutrients are converted to inorganic forms in the soil there is no longer any distinction between sources of supply. Thus, in the long term the excessive or inappropriate application of organic fertilisers can be just as harmful to the environment as the unsound use of manufactured fertilisers.

Table 1. NPK levels (%) in soil amendments.

Product	Nitrogen % (of dry matter)	Phosphorus % (of dry matter)	Potassium % (of dry matter)
Chicken manure	3–6	1–2	1–2
Poultry litter (manure, bedding and water) [1]	1.4–8.4	1.2–2.8	0.9–2.0
Dewatered biosolids [2]	3.9	3.0	0.2
Blood and bone[3]	4.7	4.5	5.0
Compost[4]	0.8–1.3	0.2–1.3	0.2–0.4
Dairy cow manure	2–4	0.3–0.7	1–3
Fish emulsions/ fertilisers [5]	2.1–6.55*	0.54–0.76*	0.57–1.21*

1 Agnote DPI-212: *Best practice guidelines for using poultry litter on pastures*, NSW DPI

2. Biosoil newsletter 8 Jan 1996

3. representative NPK analysis of a blood and bone product sold in Australia

4. TS Gibson, pers. comm.

5. Nutri-Tech solutions product information

* % by wet weight

Organic fertilisers generally have a variable and sometimes low content of the major nutrients nitrogen (N), phosphorus (P) and potassium (K). Unless boosted with manufactured fertiliser, they usually need to be used in large quantities to meet the requirements of agricultural crops. This factor, along with their bulky nature, makes them costly to transport and spread. Because of the generally limited supply and frequently higher cost per unit of the major nutrients, it is usually not feasible to fully replace manufactured fertilisers with organic fertilisers in most broadacre farming operations. However, partial replacement may be possible and is often suitable for the home garden and intensive agricultural industries such as market gardens, orchards, vineyards, dairy farms and turf farms.

Some organic fertiliser or soil amendments can contain heavy metals such as cadmium, zinc, and copper. These will not pose a risk to health or the environment if products used meet the requirements of standards such as the Australian standard for compost, soil conditioners and mulches, best practice guidelines for using poultry manure and the NSW biosolids guidelines. Using low application rates can diminish the risk of contamination.

Some potential benefits of organic fertilisers are:

- There is a reduced likelihood of 'burn' damage to salt sensitive plants and seedlings.
- They can supply trace or minor nutrients, although some manufactured fertilisers also supply these.
- Their organic matter content can help improve soil biology and structure and increase water and nutrient retention for plants, especially in sandy soils, although large quantities are required to have much long-term effect.
- They generally have lower levels of heavy metal contaminants than manufactured fertilisers, although some organic fertilisers contain appreciable amounts.
- They can be used to improve degraded areas and improve their soil health.

A good compromise that is becoming increasingly popular with farmers is to use a combination of manufactured and organic fertilisers, to gain the benefits offered by both types. For example, an application of organic fertiliser such as poultry manure can be supplemented later with dressings of manufactured nitrogen (N) fertiliser. This not only provides some nitrogen (N) in a quick release form, but also means that lower rates of organic fertiliser can be used.

For more information on organic fertilisers refer to the NSW DPI Agnotes: DPI-475 *Using compost on farm*, DPI-212 *Best practice guidelines for using poultry litter on pastures* and DPI-462 *Recycled organics*.

WHAT HAPPENS TO FERTILISER NUTRIENTS APPLIED TO SOILS?

Phosphorus

Phosphate is the main type of fertiliser used in Australia. We use about 400 000 tonnes of P each year, mainly as superphosphates.

Sources of soil phosphorus

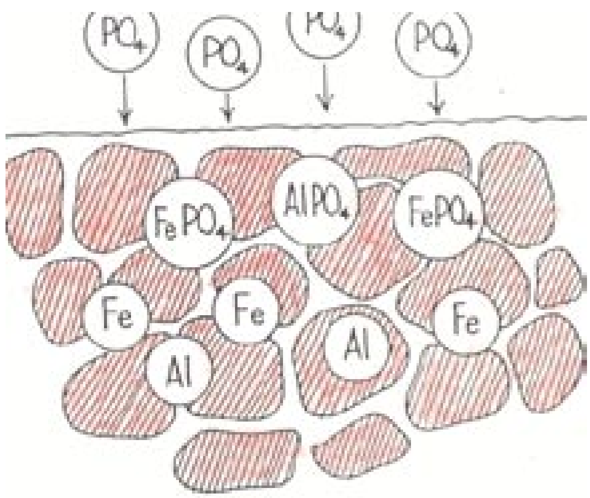
In their natural state, most Australian soils are deficient in P for intensive agricultural production and most Australian plants are adapted to low P environments. There are some important exceptions, mainly the black earths and cracking clays of northern New South Wales and south-eastern Queensland, but even these soils may become deficient in P after many years under agriculture. The top 15 cm of soil frequently contains 500 to 10 000 kg total P/ha, but most of this is fixed and unavailable to plants.

The widespread occurrence of soil P deficiency in Australia results from our dependence on introduced species for agricultural production, the great age of most of our soils, their exposure to prolonged periods of weathering and the low natural P content of the parent rocks. This has led to the development of many strongly leached, highly weathered soils of low fertility, together with younger soils that have formed from parent rocks affected by earlier phosphorus-depleting weathering cycles.

How phosphorus reacts and moves in the soil

Small amounts of P are held in organic matter. Inorganic P and other nutrients that plants can use are released when the organic matter is broken down by microbial activity. However, generally this is inadequate for agricultural

Figure 3. Phosphorus, as phosphate (PO_4) binds rapidly with iron and aluminium in acid soils and becomes unavailable to plants. *F ROM SOIL SENSE – SOIL MANAGEMENT FOR NORTH COAST FARMERS*



production and P in the form of fertiliser must be added to most soils to meet plant requirements where factors such as moisture or other nutrients are not limiting growth.

The reactions of fertiliser P in soils are very complex. P forms compounds of extremely low solubility with iron and aluminium in acid soils, and with calcium in alkaline soils, so that little applied P is immediately available to plants. Recovery of phosphorus P top-dressed on a pasture may be as low as 10% in the year of application, with phosphorus P residues becoming less available with time. In the long term, 30–50% may be recovered.

P fixes (binds) strongly to clay. In clay the aluminium content is much higher than the iron or calcium content, so added soluble P is most likely fixed as aluminium phosphate in the initial stage of the reaction. As time passes, the phosphates change to the less soluble iron phosphate. The mobility of phosphate ions in soil is restricted, so the rate of change is slow, but increases with increasing moisture content and temperature.

In most soils P does not move far from where it was placed because of the normally rapid reaction with the soil and the insolubility of the newly formed P compounds.

In all except very sandy soils it moves only 1 to 5 mm from the phosphate source, whether manufactured or organic. Thus surface-applied P is usually available to plant roots only at the surface and when soil is moist.

This low mobility, combined with the insolubility of the P compounds formed in the soil, means that in most soils very little fertiliser derived P is leached or dissolved in run-off unless there is heavy rain immediately following fertiliser application. In most cases the P that is lost, both fertiliser derived and naturally occurring, is lost as P attached to eroded soil particles. As such the P is not readily soluble in water, although in the long term it can be released from dam and waterway sediments back into solution under low oxygen conditions. However, in well-managed pasture there is less erosion and excess P can move in the dissolved form. This can be derived from fertilisers, manures and or leaf litter in the pasture.

Only on very sandy non calcareous soils is fertiliser P normally leached into groundwater or drainage waters (up to 30% in some studies). Leaching is less likely in calcareous sands.

Nitrogen

Plants need substantially more nitrogen (N) than phosphorus. In agricultural systems N comes from the mineralisation of organic matter, the fixing of nitrogen from the air by legumes, and the application of fertilisers. Fertiliser N interacts with soil components through biological and chemical processes, so that soon after their application most N compounds (apart from nitrate) cannot be found in the soil in the form in which they were applied.

Sources of soil nitrogen

On farmed land most soil N is in organic matter. The top 15 cm of soil frequently contains 500 to 5000 kg N/ha in highly complex, organic compounds. In this form the N is not normally available to plants.

The soil inorganic N is the N immediately available to plants and consists of ammonium (NH_4^+) and nitrate (NO_3^-). The amount of inorganic N varies greatly depending on seasonal conditions, past fertiliser treatment, history of growing legumes and soil properties, but it is seldom greater than about 100 kg N/ha. In a soil that has not received any N fertiliser nor grown any legumes it is usually less than 50 kg N/ha.

How nitrogen reacts and moves in the soil

N undergoes several reactions in the soil:

- **mineralisation.** Microorganisms convert the N from organic matter or urea fertiliser to inorganic forms (ammonium and nitrate) that plants can use.
- **immobilisation.** Plants and microorganisms take up inorganic forms of N (mainly nitrate from fertilisers and other sources) and convert them to organic matter, which can be recovered after breakdown of plant residues. This is the reverse process to mineralisation.
- **nitrification.** Microorganisms use oxygen to convert ammonium from fertilisers and other sources to nitrite and nitrate.
- **denitrification.** Bacteria convert nitrite or nitrate to nitrous oxide (N_2O) and elemental nitrogen (N_2), which can be lost to the atmosphere.
- **nitrogen fixation.** Microorganisms associated with the nodules on legume root systems convert N gas from the atmosphere to ammonium and organic N, which is stored in nodules.

In contrast to P, N as nitrate is very mobile in soils. It is readily leached to groundwater and drainage waters that may end up in surface waters. It is also easily dissolved in run-off.

Potassium

Except in horticultural industries, where very high rates (up to 600 kg/ha) are applied, potassium (K) applied to soils is not normally a hazard to the environment. It is held by all but very sandy soils in a form which readily attaches to particles of clay and organic matter (an exchangeable cation). As such it is relatively immobile and is taken up by plant roots fairly quickly.

Only in very sandy soils is K likely to leach. If this does happen, K does not present the same problems in the environment as do N and P, but leaching still needs to be minimised.

GLOSSARY

Buffer strips or vegetative filter strips: Strips of vegetation, usually grasses, planted adjacent to waterbodies to intercept water movement into the waterbody and trap soil and nutrients.

Cation Exchange capacity (CEC): A measure of the soil to hold cations (positively charged elements) by electrical attraction.

Denitrification: The breakdown of nitrate into nitrogen gases which are lost to the atmosphere.

Exchange sites: Places (sites) on which cations (and sometimes anions) are held in the soil.

Eutrophication: enrichment with nutrients usually pertaining to waterbodies such as rivers, lakes, dams and so on.

Phytotoxicity: Toxicity to plants.

Soil amendment: Any product that may be added to the soil to improve its quality in some way.

Soil health: As defined by Doran and Zeiss, 2000 (USDA), 'Soil health is the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health.'

Soil structure: The arrangement of the soil particles into clumps (peds) and the spaces in between these.

FURTHER INFORMATION

For more information consult your nearest NSW Department of Primary Industries district agronomist or horticulturist. Joining your local Landcare group will also help you learn more about minimising the environmental impact of activities on your farm.

ACKNOWLEDGMENTS

R. Lawrie, T. Wells, L. van Zweiten, A. Senn and L. Rogers made valuable contributions to the text.

* Revised from Agfact AC.21 *Fertilisers and the environment*, I Vimpany and T Abbott, 1995

DISCLAIMER

The information contained in this publication is based on knowledge and understanding at the time of writing in October 2004. However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up-to-date and to check the currency of the information with the appropriate officer of NSW Department of Primary Industries or the user's independent adviser.

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