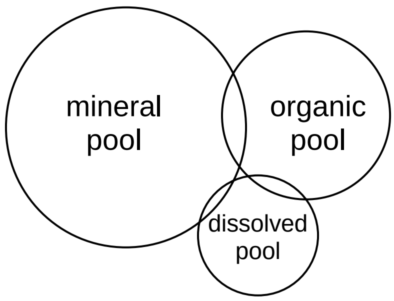
NSW DPI
Soil biology basics
PROFITABLE & SUSTAINABLE PRIMARY INDUSTRIES www.dpi.nsw.gov.au

Microbes and minerals

Plants require many elements from the soil and largely depend on microbes to extract these nutrients and incorporate them into organic molecules. As organic matter breaks down, the nutrients dissolve into the soil water where they can be accessed by plant roots. This means that at any one time the nutrients in the soil can be in one of three places; bound to soil particles, incorporated in organic matter or dissolved in the soil water.



Nutrient pools in the soil

The relative sizes of these nutrient pools vary widely for different elements and different soils.

Metal nutrients

In most soils there is a relatively large mineral pool or reserve of metal nutrients such as iron, calcium and magnesium. Microbes tend to only play a minor role in the extraction of these nutrients, and deficiencies can be corrected easily by the use of lime, gypsum or trace fertilisers, all of which are permitted in organic farming.

There are large reserves of potassium in most clay soils but it only becomes available to plants when it is released into soil water, where it is readily leached away by rainfall.

Non-metal nutrients

Sulfur

Soil minerals in the form of sulfides are common but sulfur is not available to plants in this form. *Thiobacillus* bacteria can covert sulfides into sulfates, a form which plants can use. These bacteria occur naturally in healthy soils. Some sulfides can be slowly oxidised to sulfate by exposure to air. Sulfate can also be added to the soil in the form of gypsum.

Phosphorus

Many Australian soils are phosphorus fixing. This means that phosphorus in the soil is tightly bound to the soil particles and relatively unavailable to plants. Thus the mineral pool of phosphorus in the soil can be relatively large but little of it available to plants.

Phosphorus is exported from the farm every time you send product to market. This loss has to be replaced either as fertiliser or by releasing some of the remaining soil phosphorus.

Certain fungi can assist plants to extract phosphorus from the mineral pool. *Penicillium radicum* and *Penicillium bilaiae* can be inoculated to seeds of wheat, lentils or medic to help the young roots obtain phosphorus from the soil. Other plants rely on vesicular arbuscular mycorrhiza fungi (VAM). VAM fungi can be encouraged by practices such as minimum tillage, short fallows, winter cover crops and crop rotations that avoid brassicas and lupins.

Rock phosphorus contains about 15% phosphorus in an insoluble form. Only when it is applied to acidic soil is the rate of release likely to approach that needed by most plants.

Phosphorus can be added in an organic form. Poultry manure is up to 2% phosphorus and in this form the phosphorus is not fixed by the soil. Another approach is to add rock phosphorus to a compost pile. The composting action helps release the phosphorus in an organic form.

Liming will help reduce phosphorus fixation in acid soils but the amount needed may be considerable. Heavy additions of animal or poultry manure can also reduce phosphorus fixation. In both cases the decrease in fixation is a long-term process.

Practices that build soil organic matter will help to build the organic pool of phosphorus. Fertiliser additions may still be necessary but at rates low enough that rock phosphorus or manures may suffice.

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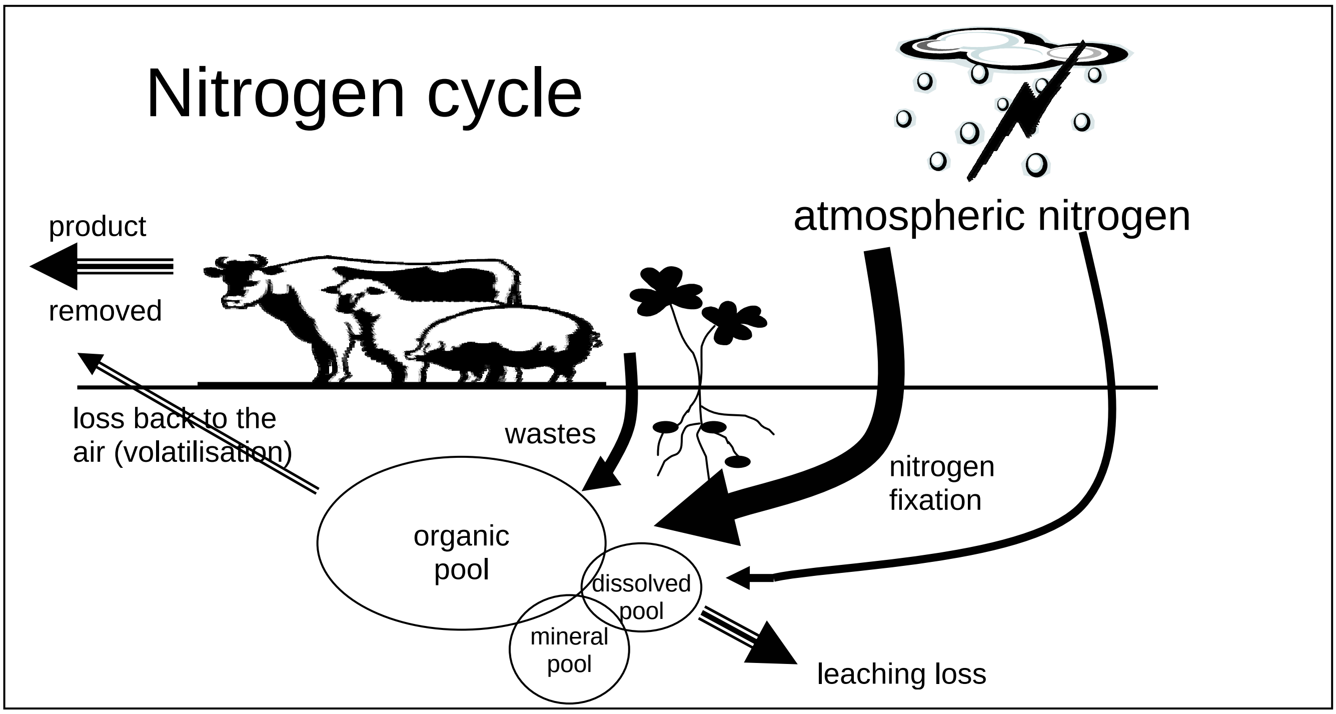

Nitrogen

Over three quarters of the air we breathe is nitrogen. Unfortunately plants cannot use this form of nitrogen and instead require it as nitrate or ammonia. Though a small amount of nitrogen is converted by lightning, plants generally depend on microbes to fix nitrogen into useable forms.

From the point of view of a plant, phosphorus fixation is bad news because the phosphorus becomes unavailable, but nitrogen fixation is good because it makes more nitrogen available. Legumes such as clover and beans have root nodules of *Rhizobium* bacteria which fix nitrogen. Such bacteria can fix 100kg of nitrogen per hectare per year.

Some free living soil microbes can also fix nitrogen but their contribution is relatively small. Examples of these microbes include *Azotobacter chroococcum, Azospirillum brasilense, Agrobacter radiobacter, Gluconobacter diazotrophicus, Bacillus polymyxa, Flavobacterium* and *Herbaspirillum*. Attempts to inoculate soil with these microbes to improve nitrogen fixation have not proven very effective.

Without using nitrate or ammonium fertilisers the best way to maintain nitrogen is to encourage nitrogen fixation with legumes or legume rotations. Acid soils discourage fixation so acidity may need to be remedied by liming.

Organic fertilisers contain only small amounts of nitrogen. To match nitrogen fixation from legumes these fertilisers would have to be added at rates measured in tons per hectare. As a result the transport and spreading costs are considerable. As well, spreading manure in large quantities can lead to soil and water pollution.

Nitrate is readily leached from the soil by rainfall, and ammonia is lost by volatilisation back into the air. Building soil organic matter helps reduce these losses by encouraging nitrogen storage in the organic pool.

Key points

- Building soil organic matter helps store soil minerals in the organic pool.
- Encourage nitrogen fixation by using legume rotations.

More information

Soil biology basics is an information series describing basic concepts in soil biology. For more detailed information we recommend the Australian book *Soil biological fertility:A key to sustainable land use in agriculture* (2003), edited by Lyn Abbott & Daniel Murphy.

NSWDPI has online soil biology information at http://www.agric.nsw.gov.au/reader/soil-biology.

The University of WA has online soil biology information at http://ice.agric.uwa.edu.au/soils/soilhealth.

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