

Farm profitability and sustainability are directly linked to the health of the soil, which includes its chemical fertility.

Nutrient levels and balances between nutrients must be maintained for profitable, long-term agricultural production. Deficiencies need to be determined and corrected. Soil pH can influence the availability of many of the essential elements needed for healthy crop production. Certain elements can become deficient or toxic depending on the pH level.

The cropping soils of the Western Catchment are naturally low in nitrogen and phosphorus. These nutrients are often not replaced at the same rate as their removal. The Western Catchment soils have low levels of organic carbon.

Nitrogen

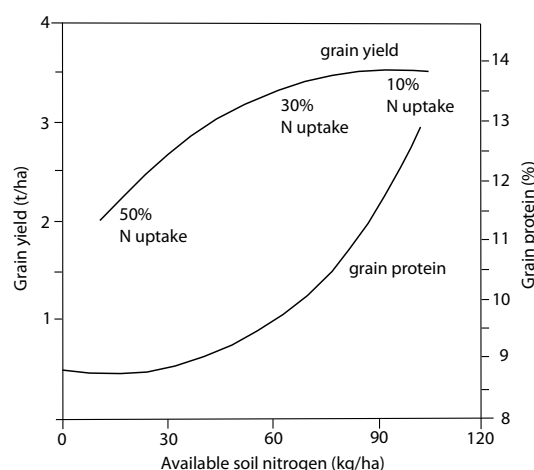
Benefits of nitrogen

Nitrogen (N) is a constituent of all plant cells in plant proteins and hormones, and in chlorophyll. Nitrogen is often the limiting factor to producing high protein grain.

Nitrogen deficiency results in reduced production of the green pigment – chlorophyll. Nitrogen can be mobilised within the plant and moved from old to young leaves. Therefore, nitrogen deficiency usually shows as yellowing of the older leaves.

Nitrogen levels impact on cereal grain yield, grain protein or both. When the soil has a low level of available nitrogen, applied nitrogen fertiliser increases yield but not protein. When nitrogen rates exceed 40–50 kg/ha the subsequent rate of grain yield is lower, nevertheless, grain yield will increase but at a slower rate.

Even though protein levels can be increased using nitrogen fertiliser, a grower needs to decide whether this is economically viable. Sometimes it is economically viable to add nitrogen for extra yield but not extra protein.



Example of response of grain yield and protein to increasing nitrogen supply (Source: SOILpak for dryland farmers on the red soils of Central Western NSW)

How to increase soil nitrogen

To maintain and/or raise soil nitrogen fertility:

- Use a manufactured nitrogen fertiliser
- Use a legume pasture phase
- Use a grain legume crop.



Nitrogen deficiency in wheat (Photo: Yash Dang)

The application of a fertiliser gives immediate benefit to the crop and allows a better control of the amount of nitrogen put into the soil. The use of legume pastures and grain legume crops do not have the same potential as a nitrogen fertiliser to increase soil nitrogen.

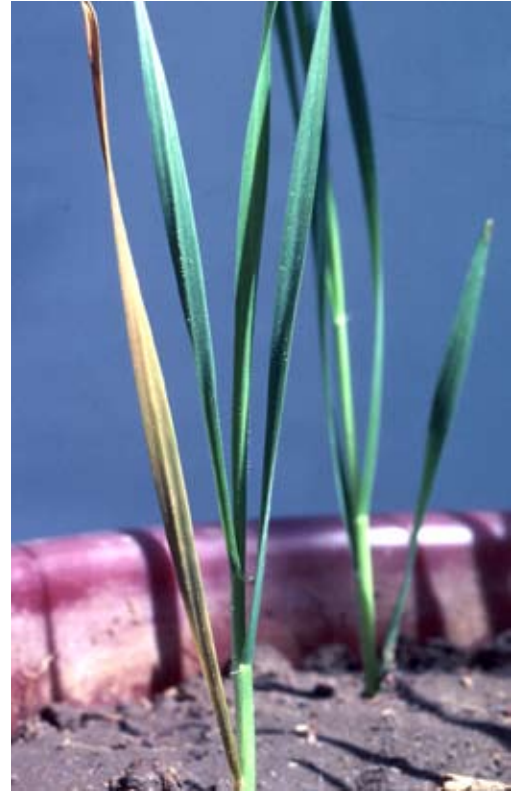
Phosphorus

Benefits of phosphorus

Phosphorus (P) is a constituent of plant cells and is essential for cell division and development of the growing tip of the plant. Without phosphorus, plants are stunted and spindly. Deficiency symptoms also include dull greyish-green leaves with red pigment in leaf bases and dying leaves. If plants are starved of phosphorus as seedlings they may not recover, even when phosphorus is applied later.

Fertiliser phosphorus does not move far from where it is applied. Because phosphorus is easily fixed in the soil, crops and pastures take up only 5–20% of phosphorus applied in fertiliser. Fixed phosphate can become remobilised but this is often over several years. On the cropping red soils of the Western Catchment soil phosphorus levels did increase with increasing phosphorus fertiliser applications, however, phosphorus was generally still below the optimum level of 30 mg/kg for crop production.

The dry conditions often experienced in the Western Catchment can result in low yielding or failed crops. On the basis of evidence that the fertiliser applied to



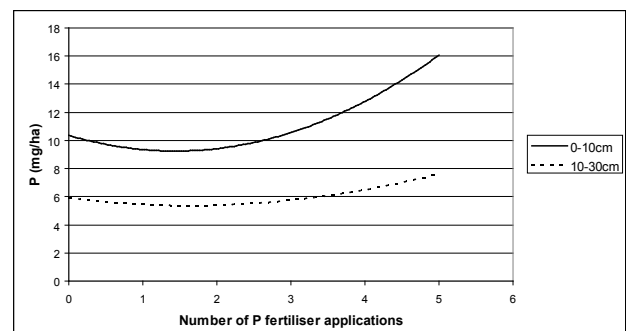
Phosphorus deficiency in wheat (Photo: Yash Dang)

the failed crop may carry over to the following season, there is opportunity to reduce phosphorus fertiliser inputs on the new season crop.

'Rules of thumb' following drought

- Halve the normal phosphorus rate in the year following failed crops
- Use two-thirds the normal rate following drought crops yielding approximately 0.5 t/ha
- Apply the normal rate of phosphorus on fallow paddocks, i.e. no crop sown and no phosphorus applied in the drought year.

It is difficult to make clear recommendations on how much phosphorus inputs can be reduced. The 'rules of thumb' should only be used as a guide.



Available soil phosphorus (Colwell) in the cropped red soils of the Western Catchment in 2008 (Source: The effects of cropping on the Western CMA red soils)

In soil with low phosphorus availability, place the fertiliser close to the seed when sowing as this halves the rate of phosphorus required compared with broadcast fertiliser.

pH

Effect of soil pH on crop production

Soil pH is a measure of the acidity or alkalinity of the soil. Whether a soil is acid, alkaline or neutral is principally determined by its parent material and climate but management practices can also be influential. pH has a major influence on the availability of nutrients to plants.

In the Western Catchment the red soils have slightly acidic topsoils (pH 5.4 CaCl₂) with neutral subsoil (pH 7.5 CaCl₂). The pH has increased with years of cropping, which is different from many other cropping regions' soils (*The effects of cropping on the Western Catchment red soils, 2008*).

The Western Catchment grey soils have neutral topsoils (pH 7.7 CaCl₂) with alkaline subsoils (pH 8.1 CaCl₂) (*The effects of cropping on the Western Catchment grey soils, 2008*).

Most plants grow best when soil pH (CaCl₂) is between 5 and 7. In acidic (low pH) conditions, aluminium and manganese become more soluble and may reach concentrations that are toxic to plants while other nutrients such as phosphorus and molybdenum may become less available.

Nutrients that may be deficient in alkaline (high pH) soils include phosphorus, zinc, iron and manganese.

How to improve/manage pH in soils

Managing acidic soils

The application of lime will reduce soil pH, but it is not always economically viable.

Managing alkaline soils

Monitor crops grown on highly alkaline soils to identify deficiencies (or toxicities). Soil testing does not accurately measure micronutrients such as zinc, copper, manganese and iron, so micronutrient imbalances are best diagnosed using leaf analysis. Contact an agronomist to ascertain which plant parts and at which growth stage samples should be taken for accurate diagnosis.

Once a nutrient imbalance associated with high pH has been identified, managing the problem depends on correcting that imbalance, sowing tolerant crops and/or avoiding sensitive crops.

Soil organic matter and organisms

Soil organic matter (SOM) is any living or dead animal or plant material, including plant roots, decomposing residues of plants, animals and microbes (for example, earthworms, bacteria and fungi) and their excretions.

Soil organisms are either:

- Macrofauna (for example, earthworms, termites, ants, dung beetles)
- Mesofauna (for example, mites, collembolan)
- Microfauna (for example, nematodes, protozoa)
- Microflora (for example, bacteria, mycorrhizae, fungi).

Organic matter contains many nutrients essential to the growth of plants, however, for plants to take up nutrients these need to be broken down into more easily absorbed forms. Soil provides the environment to process organic matter so that the nutrients within it are available for plant uptake. Soil biota also help in this process.

Benefits of soil organic matter

Soil organic matter plays a number of roles in the soil. Soil organic matter:

- is a major source of plant nutrients (such as nitrogen, phosphorus and sulphur) which are released slowly for plant use. It also influences the availability of many micronutrients, such as copper, zinc, iron, boron and manganese.
- is responsible for some or all (depending on the soil type) of a soil's cation exchange capacity (CEC), which is the ability to hold on to nutrients such as calcium, magnesium, and potassium. A soil's CEC also helps buffer it against natural or man-made changes in soil pH.
- is a source of energy for soil fauna and micro-organisms. Many of the physical and chemical benefits listed above are facilitated by the breakdown of plant and animal residues by microbes. Microbes are also important in the breakdown of herbicides and pesticides.
- plays an important role in soil structural stability and water-holding capacity. Organic compounds are central to the stability of the soil and influence aggregate stability, water holding capacity, aeration and plant root exploration.
- is an important 'storage area' for carbon in the environment (surface organic matter contains approximately 58% carbon).

How to increase soil organic matter

Soil organic matter can be increased in cropping systems by adding a pasture phase or maintained by retaining crop residues after harvest.

- Pasture encourages soil organisms by providing a food source and eliminating soil disturbance. The addition of a legume component is ideal, because legumes supply their own nitrogen. Perennial species provide a sustained supply of soil organic matter.
- Retaining stubble after harvest increases soil organic matter.

Practices that decrease soil organic matter

Decreases in surface soil organic matter occur with cropping and may be caused by:

- less organic material being returned to the soil from cultivated crops compared with native vegetation
- faster breakdown of plant residues from crops that are 'high quality' compared with native species residues that are 'low quality'. Quality is determined by the concentrations of nutrients, especially nitrogen, and complex organic compounds such as lignin
- erosion of organic matter-rich topsoil
- changes in soil condition such as temperature and moisture
- breakdown of soil aggregates by cultivation
- mixing/redistribution of the soil organic matter-rich surface soil with the sub-soil by cultivation.
- because of the high temperatures and low rainfall in the Western Catchment, these factors are most critical for managing soil organic matter.

Practices which alter SOM levels

Maintain / increase SOM	Loss of SOM
Stubble retention	Cultivation
Adoption of minimum or zero-tillage	Repeated wetting and drying of soils
Pastures in rotation	Stubble burning
Avoiding long bare fallow periods	Bare fallow in summer
	High temperatures

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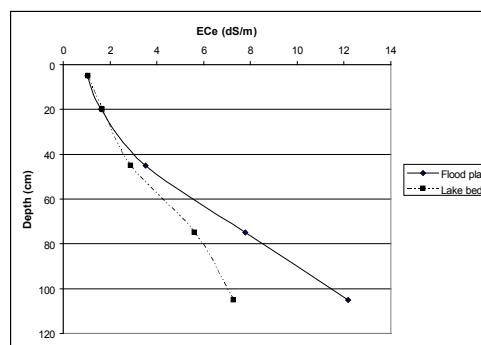
Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (February 2009). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up-to-date and to check currency of the information with the appropriate officer of New South Wales Department of Primary Industries or the user's independent adviser.

Considerations

EC/Sub-soil constraints

Electrical conductivity (EC) of the soil is a measure of the concentration of salts in the 'soil water solution'. The soil water solution is made up of positive and negative ions dissolved in soil water (for example calcium, magnesium, carbonate, chloride). A low level of EC (e.g. 0.5–1 dS/m) is desirable.

The grey soils in the Western Catchment subsoils have a high EC, especially on the floodplains.



Average electrical conductivity of the soil water extract (EC) of the grey flood plain soils and lake bed cropping paddocks in the Western Catchment (Source: *The effects of cropping on the Western CMA grey soils*)

There are limited options available to ameliorate subsoil constraints. These include stubble retention, no tillage and crop rotations which include perennial legume crops, pastures and canola. Characterisation and identification of crops and cultivars adapted to adverse subsoil conditions may provide a long-lasting solution to overcoming subsoil constraints.

References and further reading

The effects of cropping on the Western CMA red soils

The effects of cropping on the Western CMA grey soils

SOILpak for dryland farmers on the red soil of Central Western NSW

Northern Wheat-Belt SOILpak

Dryland Cropping Guidelines for the Western Farming Systems Zone

Further information

Agfact P1.4. *Phosphorus Nutrition for Winter Crops*

PRIMEFACT 735, *Increasing soil organic carbon of agricultural land*

www.western.cma.nsw.gov.au or www.dpi.nsw.gov.au

Acknowledgements

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