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NITROGEN—QUEENSLAND

Chemistry

Key points

- Nitrogen (N) is needed for crop growth in larger quantities than any other nutrient.
- Nitrate (NO_3^-) is the highly mobile form of inorganic nitrogen in both the soil and the plant.
- Soil testing and nitrogen models will help determine seasonal nitrogen requirements.

Background

Over 98% of all nitrogen (N) present in the soil is in an organic form. This organic N is converted (mineralised), by microbes into inorganic forms such as nitrate and ammonia, which are then available for crop use. Mineralisation can occur throughout the growing season providing a steady, continuous supply of nitrogen to the crop.

The positively charged ammonium ion (NH_4^+) is immobile in soil, does not leach, and is an intermediary in the conversion of organic-N to nitrate (NO_3^-). Nitrate on the other hand has a negative charge and is highly mobile in the soil. This mobility provides a nitrogen source that moves readily towards plant roots, but can also be leached out of reach of the plant root system. Nitrate is used by the plant to make precursors to plant proteins.

Deficiency symptoms

As proteins make up much of the content of cells, nitrogen is needed in greater quantity than any other mineral nutrient. Nitrogen plays an essential role in the production of chlorophyll, and any deficiency is displayed as yellowing leaves and reduced tillering (figure 1). This ultimately leads to reduced crop yields.

Nitrogen is highly mobile within the growing plant allowing it to re-mobilise and move to tissues that can use it more effectively. As a result, older leaves tend to exhibit nitrogen deficiency symptoms first.

Figure 1: *Nitrogen deficiency symptoms in wheat plants (source: Grundon, 1987).*

Yield potential and nitrogen requirement

Nitrogen requirement of cereal crops is driven by yield potential, where every tonne of grain produced requires 40–50 kg N/ha. Cereal crops access nitrogen from three major pools:

Stable Organic Nitrogen (SON) is released slowly throughout the season, and is by far the largest nitrogen source in the soil. A proportion of SON becomes available to crops during the growing season. Potentially mineralisable N is a measure of the amount of SON that can become available to crops over the growing season.

Residue Organic Nitrogen (RON) is mineralised rapidly into NH_4^+ and NO_3^-, and is highest following legume crops.

Fertiliser Nitrogen is applied to a crop by growers where the above sources cannot meet the needs of the crop.

Due to the number of different nitrogen sources accessible to the crop, it is best to use models to gauge nitrogen status in the soil. Most current models measure the following soil and crop attributes to determine soil nitrogen status/requirement:

- Yield potential—determines nitrogen demand of the crop.
- Total organic carbon (%)—gives indication of potential SON contribution.
- Rotation—characteristic of the last legume crop (RON).
- Soil type—gives indication of the potential for leaching.
- Rainfall—determines RON breakdown and contribution to leaching.

Both the WhopperCropper program and 'The Nitrogen Book for Central Queensland or Southern Queensland' are useful tools available to Queensland growers to help determine nitrogen requirements.

Protein and maximum yield

A simple method to determine whether the correct nitrogen regime was used is to measure grain protein following harvest. The optimum protein percentage in wheat grain varies between cultivars, however it is a useful tool for auditing nitrogen budgets. In general, a wheat grain protein content less than 11.5% indicates that nitrogen was deficient and that the use of N fertiliser would have increased grain yield. Where values are between 11.5 and 12.5%, the nitrogen levels were probably sufficient to

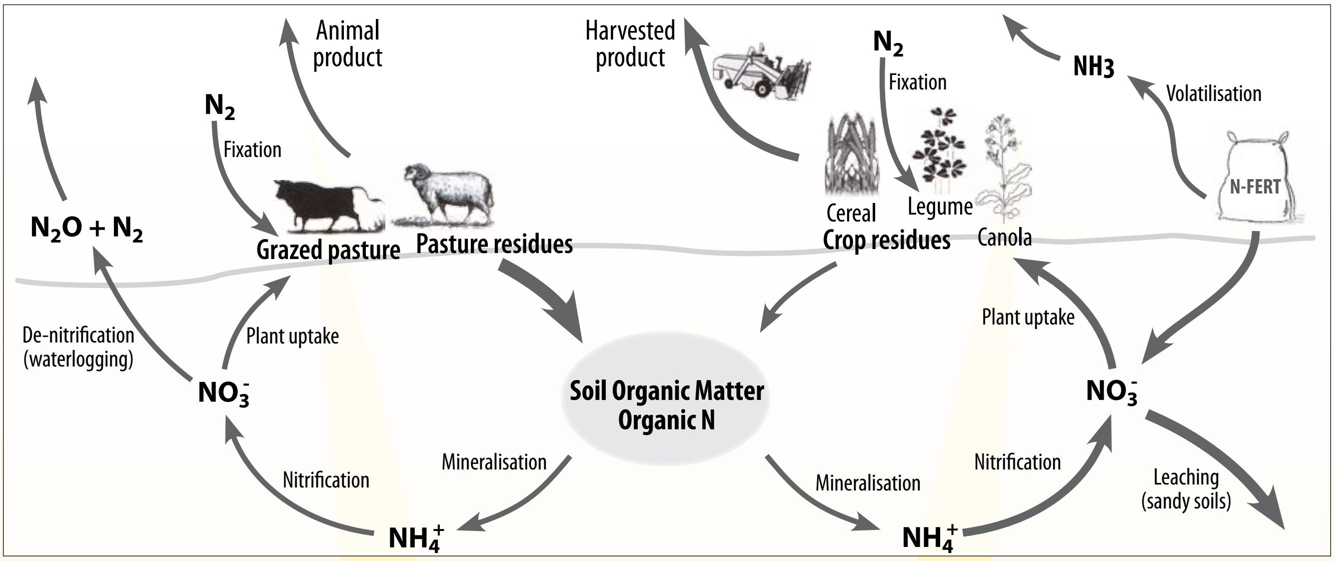

Figure 2: *Principle nitrogen cycling pathways in a mixed cropping/pasture system (adaped from Peverill et al. 1995)*

achieve season grain yield, but additional nitrogen may have increased grain protein. Values greater than 12.5% indicate that nitrogen was not deficient.

Increasing N rates to achieve protein levels above these thresholds results in lower economic responses, as protein payments and yield do not offset the extra cost of nitrogen. Conversely, if crops consistently achieve protein levels below these levels, they are forgoing optimum yield potential.

Soil testing

In Queensland, variable rainfall can mean that nitrogen demands may vary widely from year to year. In order to better manage nitrogen application, it is recommended that testing to estimate soil water and nitrogen levels be conducted close to planting. Deep soil testing (to at least 60 cm) is the best method for determination of nitrate nitrogen, and ideally a number of cores should be taken across the paddock. This information can then be used in conjunction with models such as the WhopperCropper program to view the full range of possible yield outcomes.

Leaching and denitrification

Once organic-N is converted to nitrate it is prone to leaching, particularly on lighter textured soils (such as sands or loams) and during fallow periods when there is no crop uptake of N (figure 2). Where subsoil constraints, such as soil acidity or salinity, limit root growth, these may also reduce the efficiency of uptake of NO_3^- during crop growth (see the 'Subsoil Constraints—Queensland' factsheet).

Soil waterlogging, particularly during the later part of the fallow or early cropping period, can also result in the loss of mineral N if soil nitrate is converted by microorganisms into gaseous N (denitrification), and lost to the atmosphere. The longer soils are waterlogged, the greater the N loss that can occur, especially if there are large quantities of crop residues that can supply an energy source for the micro-organisms that undertake denitrification.

Where practicable, planting early in the fallow to ensure more rapid utlisation of available nitrogen, split application of nitrogen fertilisers and/or incorporating deep rooted perennial species into crop rotations to take up nitrogen that has leached deeper in the profile may help to reduce N loss via leaching and denitrification.

Further reading and references

Cook RJ and Veseth RJ (1991) *Wheat health management*, The American Phytopathological Society Press.

Cox H and Strong W (2009) *The nitrogen books*, Queensland Government, Brisbane.

Cox H Hammer GL, McLean GB, Cowlrick TH, King CA *National WhopperCropper – risk management discussion support software* (factsheet), Agricultural Production Support Research Unit (online).

Department of Natural Resources and Water (2007) *Constraints to cropping soils in the northern grains region: a decision tree*, Queensland Government Department of Natural Resources and Water. (online).

Grundon NJ (1987) *Hungry crops: A guide to nutrient deficiencies in field crops*. Queensland Department of Primary Industries, Brisbane.

Peverill KI, Sparrow LA and Reuter DJ (1995) *Soil analysis an interpretation manual*, CSIRO publishing.

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