NITROGEN - THE FACTS

Nitrogen (N) plays an important role in New Zealand agriculture. Fertiliser nitrogen is used to increase the yield of pasture and crops, helping to fill the feed gaps that invariably arise during the year. When used appropriately, it is an effective addition to the nitrogen provided naturally by clovers and other legumes.

Nitrogen and plants

Nitrogen is needed to build proteins, DNA and enzymes in plants and animals. It has a major effect on plant quality. Nitrogen is also an essential component of chlorophyll, the green pigment in plant leaves that converts sunlight into energy. Therefore, plants with an adequate supply of nitrogen show strong, vigorous, dark green growth.

In crops and pasture, nitrogen supply drives yield in the absence of any other growth constraint.

Nitrogen loss

Nitrogen can be lost from the soil-plant system through three major pathways: dentrification, leaching and volatilisation.

Denitrification is caused by specific bacteria reducing nitrate to two gases (nitrogen gas and nitrous oxide gas), which then escape to the atmosphere.

Leaching is the loss of nitrate as it is carried down through the soil in water and into receiving water bodies. It can be a major source of nitrogen loss, particularly on sandy soils in areas that receive high rainfall (>1000 mm/year). Animal urine is the largest contributor to nitrate leaching, due to its high concentration of nitrogen. Nitrogen fertiliser and nitrogen fixation by legumes also contribute, but to a lesser degree.

Volatilisation is the loss of nitrogen to air as ammonia gas. It occurs in soils when there are high concentrations of ammonia, e.g. in urine patches and when urea fertiliser is used. The rate of volatilisation increases under windy conditions and high soil temperatures. The risk of ammonia loss also rises with increasing use of urea. Volatilisation was traditionally viewed as a concern for warmer conditions and dry soils; however, research has shown that it also occurs in cooler weather and moist soils. As such, there is potential for volatilisation loss year-round.

Implications of nitrogen loss. Losses occur regardless of whether or not nitrogen fertiliser is applied; they are a natural function of fertile soil. However, inappropriate use of nitrogen fertiliser can exacerbate these losses.

Nitrate leaching has the greatest environmental impact, but can be managed to a certain extent.

Denitrification contributes only a small amount to total nitrogen loss (<10 kg N/ha/year). However, nitrous oxide is a greenhouse gas, so loss should be reduced where possible.

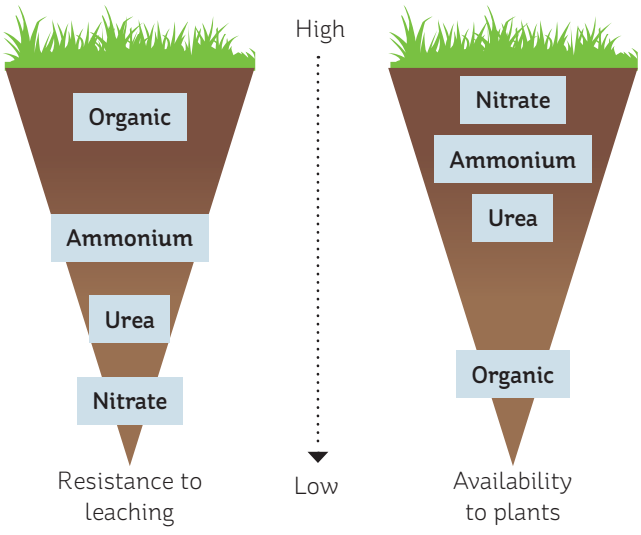

FIGURE 1
The leaching potential of different forms of fertiliser nitrogen and how this affects their uptake by plants

Volatilisation causes economic loss to the farmer but doesn't have any direct, significant environmental effects (although the ammonia will be redeposited - and nitrogen subsequently lost – somewhere else).

Signs of deficiency

Nitrogen affects both the quantity and quality of plants. Nitrogen-deficient plants cannot produce enough chlorophyll. Therefore, the first signs of a deficiency show as yellowing of older leaves, because the plant moves nitrogen reserves from old tissues to new growth.

Plants lacking in nitrogen are typically stunted and lack vigour because they cannot capture enough energy from sunlight to support their growth. As they also contain less protein, they have less value as a food source for humans (e.g. cereal crops) and animals (e.g. pasture).

Soil tests

Soil tests for nitrogen include:
Mineral N: measures the ammonium and nitrate in the soil that is immediately available for plant uptake.

Available N: measures Mineral N plus the nitrogen that will become available during the growing season.

Deep Soil Mineral N: Performed at a depth of 600 mm and used for deep-rooting crops such as maize. This allows you to determine how much nitrogen the crop will be able to get from the soil, which in turn enables nitrogen applications to be tailored to the conditions – the more nitrogen present in the soil, the less fertiliser is needed.

Nitrogen inputs

Nitrogen fixation by legumes

One way to add nitrogen to the farming system is to include legumes in the pasture. This is an important part of the New Zealand farming landscape. Legumes are able to associate with bacteria that capture (fix) nitrogen in the air and turn it into a form that can be used by plants. In return, the plant provides bacteria with carbohydrates they need for growth.

Clovers make a big contribution, but they also demand higher soil fertility in order to grow well. New Zealand's climate is extremely favourable for the growth of clovers. However, pasture management practices can impact clover growth, e.g. the use of herbicides and nitrogen fertlisers. Excessive use of nitrogen fertiliser (above the usual levels of 50-200 kg N/ha/year) will reduce the amount of nitrogen fixed by legumes.

Leguminous crops such as lucerne also fix nitrogen. The nitrogen is released to the soil when the plants die and decay, or when plants are eaten and a portion of the nitrogen is returned to the soil in dung and urine.

Nitrogen fertilisers

Nitrogen fertilisers help increase the productivity of the land. They are used almost universally on farms and can be applied as:

- Urea – the most commonly used and a highly concentrated source of nitrogen (46% N)
- Nitrate – e.g. potassium nitrate, sodium nitrate, ammonium nitrate
- Ammonium (in solid or liquid forms) – e.g. sulphate of ammonia, ammonium nitrate, anydrous ammonia, hydrous ammonia
- Organic sources - composts, blood and bone, industrial waste

Once in soil, urea and ammonium both get converted to nitrate by the actions of soil bacteria. Plants can take up urea, ammonium and nitrate.

The choice of nitrogen fertiliser to use depends on several factors:

- The most suitable form of nitrogen
- Method of application
- Possible effects on soil
- Cost
- Farming principles

Nitrogen deficiency in maize; note older leaves are affected first

Maximising benefits from fertiliser nitrogen

To maintain clover nitrogen fixation and ensure best pasture response and the most profitable outcomes, apply these principles:

- Maximum amount to be applied annually is 200 kg N/ha
- Maximum single application is 50 kg N/ha
- Do not apply to waterlogged soils or when heavy rain is due. However, if using urea, 5-10 mm rain within 8 hours of application is required to minimise volatilisation loss
- On dairy farms, apply nitrogen after cows have grazed the paddock
- On sheep and beef farms, use nitrogen strategically to boost pasture growth and grow feed for specific purposes, e.g. feeding lambs
- Nitrogen applied at set times of crop growth cycles boosts yields – soil tests can be done to determine how much nitrogen fertiliser is needed (if any)

Nitrogen and animal health

Under some conditions, plants can accumulate high levels of nitrate, which can be toxic to animals. This generally happens after a prolonged dry spell is followed by rain. The moisture stimulates microbial activity, which releases a flush of nitrogen from the soil organic matter. This is taken up by plants as they respond to the favourable growing conditions. This is most likely in autumn, but also occurs in spring. High concentrations of nitrate can also develop in fast-growing winter forages and crops.

At high-risk times, plant testing can be used to determine the risk to animals. If nitrate levels are excessive, limit the time that stock are on high-nitrate feed. Feeding low-nitrogen material, such as supplemental hay, will also help to reduce the risk. Nitrate concentrations are also highest in the base of the plant compared to the leaves, so grazing less intensively will also reduce the risk.