When are you at most risk of losing nitrogen?

By Graeme Schwenke and Guy McMullen, Tamworth Agricultural Institute, NSW DPI

Increasing urea prices are causing many farmers in the northern region to source cheaper nitrogen products for both pre- or post-sowing. In some areas ammonium sulphate (AS) is a lower cost alternative to urea (per unit N) with the added benefit of also supplying sulphur in a plant-available form.

With the increased use of AS have come questions as to its suitability as a surface applied fertiliser. Can the nitrogen be lost through volatilisation like urea? What are the soil and environmental conditions that increase the risk of loss?

The bottom line is that AS can and does volatilise with the degree of loss dependent on soil properties, fertiliser type and environmental conditions. And the losses can be as high as those of urea.

NITROGEN VOLATILISATION

Volatilisation is the loss of nitrogen to the atmosphere as ammonia gas (NH_3) from soils or from fertiliser applied to soil surfaces. In a solution, dissolved NH_3 gas is found in a chemical equilibrium with NH_4^+ (ammonium cation).

$$NH_4^+ \leftrightarrow NH_3 + H^+$$

The ratio of ammonium to ammonia in this equilibrium is highly pH dependent (Figure 1). At low pH (more acidic) the NH_4^+ form dominates, while at high pH (highly alkaline) the NH_3 form is dominant.

The proportions of NH_3 and NH_4^+ are equal at a pH of 9.2. The rate at which the dissolved NH_3 gas is lost from the solution to the atmosphere depends on the difference in partial pressures between the NH_3 gas in the solution and the NH_3 gas present in the air above it – the greater the difference – the faster the rate of loss.

Since the partial pressure of NH_3 in air is usually fairly constant, changes to the NH_4^+ / NH_3 equilibrium in the soil solution largely drive the rate of volatilisation.

But windy conditions are an exception. As wind rapidly replaces air near the surface that has a higher partial NH_3 pressure, with fresh air having a lower partial NH_3 pressure, volatilisation is promoted.

Warmer temperatures also favour the NH_3 gas side of the NH_4^+ / NH_3 equilibrium and lead to greater volatilisation losses.

...ii ▷

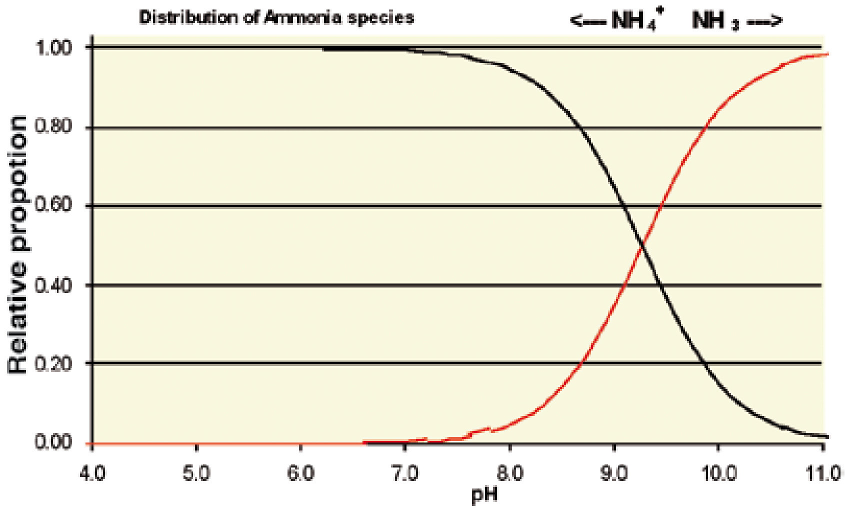
AT A GLANCE

Surface application of ammonium sulphate fertiliser on alkaline cropping soils poses a high risk of volatilisation loss, particularly if there is calcium carbonate (lime) at the surface.

Consultants' Corner

Consultants' Corner is a new initiative by *Australian Grain.* This series of articles will highlight current GRDC-funded research with a particular focus on the commercial implications of adopting cutting-edge research.

FIGURE 1: Distribution of ammonium / ammonia according to soil solution pH



HOW TO SAVE MONEY ON FERTILISER

Grain growers have an opportunity to compare fertiliser use with other farms on an individual and region-wide basis thanks to GRDC-funded web-based comparison software.

The newly-launched Australian Farming Practices Database (AFPD) can potentially save growers money on what is currently the most expensive cropping cost by showing how to reduce fertiliser inputs.

Importantly, it provides a personalised report to each farmer, showing important data such as nutrient balances for their farm.

Farmers can input data about their farm, and have their farm compared with others as well as industry benchmarks.

Such information can be valuable in analysing the need for fertilisers in 2008, a year when fertiliser prices have never been higher.

Farmers can input data about their farm, and have their farm compared with others and industry benchmarks. The system returns a report to the farmer, showing how their farming inputs and systems compare.

AFPD is a new industry facility aimed at gathering data and information about the levels of use of various farming practices in the grains industry.

The industry has changed dramatically in the past two decades, not least in the use of modern farming systems. But there is a lack of up-to-date information about how these have been adopted, where they have been most beneficial and where further research work is needed.

The database project aims to provide the industry, and specifically grain producers, with better access to data and for use in comparisons that have meaning for an individual farm or the industry as a whole.

The major differences to other data gathering exercises in the past is that this facility returns something of value to farmers who participate – information about how their farm and systems compare with others. This can be most valuable in assisting in planning and reviewing farm performance.

The system operates electronically, using emailed forms and reports, and can be done in less than an hour from your own home.

To access the database facility go to; www.grdc.com.au/farmingpractices or contact Alan Umbers on email: a.umbers@grdc.com.au

◁i...LOSING NITROGEN

Soils and volatilisation

The equalibirium equation shows that a hydrogen (H^+) ion is produced with each NH_3 gas molecule. H^+ ions are what we measure as acidity so in soils with a low capacity to buffer changes in pH, volatilisation will stop after the H^+ released has lowered the pH enough that the equilibrium is again dominated by NH_4^+ (moves the equilibrium to the left in Figure 1).

But soils contain minerals and organic matter that give them varying levels of buffering capacity that resist changes in pH. The alkaline soils of northwest NSW, particularly those with calcium carbonate (lime) present, often have high pH buffering capacities. So the H^+ produced is absorbed (buffered) by the soil and the pH does not become more acidic and volatilisation continues.

In calcareous soils, volatilisation continues until either the soil can buffer no more acidity (for example, when all carbonate has dissolved) or there is no more NH_3 left to volatilise. Acidity may be able to develop in a localised area if the NH_4^+ source is concentrated, say if AS is applied in a granular form as opposed to a fine crystalline form or as a solution.

Generally, NH_3 gas loss is greater from soils containing free lime (calcium carbonate or $CaCO_3$) than those without lime.

NH_3 volatilisation losses can be directly related to the amount of lime present in the soil up to about 10–12.5 per cent.

Previous studies have found an average of 4.1 per cent lime in the top 10 cm of the irrigated cotton growing soils of NW NSW.

Lighter soils will volatilise more than heavier soils with a high cation exchange capacity (CEC). NH_4^+ can also be fixed within the lattice structures of vermiculite and illite clay minerals from where it is only slowly available.

Free NH_4^+ in the soil solution is also subject to bacterial oxidation to form nitrate (NO_3^-). This is the process of nitrification which also depletes the soil solution of NH_4^+.

To maintain the equilibrium level more dissolved NH_3 is converted to NH_4^+ and the total available for loss is again decreased.

The effects of soil moisture content on NH_3 volatilisation are varied and somewhat contradictory, probably because they are interlinked with the effects of moisture content on plant uptake and soil nitrification processes.

NH_3 gas volatilisation loss can occur

without moisture loss from soil, but is likely to increase as soils dry because this increases the concentration of dissolved NH_3 gas in the remaining soil water.

Dry soil also inhibits nitrification. Surface applied AS fertiliser will not dissolve if the soil is air-dry and chemical reactions cannot proceed.

Placement of fertiliser below the soil surface diminishes NH_3 losses to the atmosphere as gas exchange is reduced and soil absorbs NH_4^+.

NEW RESEARCH

The factors and processes that contribute to the risk of nitrogen loss through volatilisation are mostly well known.

What is not known for much of the northern grains region are the levels and interactions of some of these factors, such as free lime content and pH buffer capacity, and the potential volatilisation losses that may result from different levels of these factors. This is the aim of our new research activity.

We are currently testing a range of surface soil samples from across the region. We will then assess the volatilisation loss potential at a selection of these soils to gauge the potential for losses in typical cropping situations.

If the potential proves to be significantly high, the lab results will need to be verified in the field at pre and post-sowing application stages.

What to look out for

While we don't yet know the actual magnitude of volatilisation losses occuring where N fertilisers are surface applied pre or post-sowing, the risk factors are well-enough known to predict that losses will occur where soils are alkaline, are light to medium textured, and especially where they have free lime at the surface.

Incorporation of N fertilisers in such circumstances will reduce the risk of NH_3 gas loss considerably.

Acknowledgements: NSW DPI, NGA and GRDC fund the current Eastern Farming Systems Project in northern NSW. The soil samples being reanalysed in this study have come from several previous research and extension projects funded by GRDC, ACIAR and NHT. We acknowledge the efforts of those who collected the samples for these projects and to Ian Daniells who kindly allowed us use of the other soil data collected at the time.

For more information:
Graeme Schwenke Ph: 02 6763 1137
E: graeme.schwenke@dpi.nsw.gov.au

Guy McMullen Ph: 02 6763 1155
E: guy.mcmullen@dpi.nsw.gov.au ■

Some surface applied nitrogen will be lost to volatilisation on alkaline, light to medium soils, particularly where lime is present near the surface.

'Plastic' soil capacity

By Chris Dowling, Nutrient Management Systems

Crop nutrition based on national, state or regional recipes are increasingly recipes for disaster. According to Land and Water Australia, our climate presents a challenge to agriculture as it seeks to become more profitable, competitive and sustainable.

In an environment where 80 per cent of farm profit may be made in 30 per cent of years, and where inflexible management can lead to land degradation, hardship and poverty, the uncertainty of a variable climate presents both risk and opportunity.

In thinking about this challenge, for the most part, recent approaches have been to try to manage crop nutrition based on better weather and climate forecasting.

Clearly there have been significant advances in this technology recently with climate tools such as SOI and MJO, and crop management tools such as *Whopper Cropper* and *Yield Prophet*. But for many, focusing on weather and climate falls well short of what is desired.

Soils with 'plastic' capacity

An alternate approach could be to continue to use the climate tools but to also work on the soil 'plastic' capacity. More than ever we need to have soils in a condition that allows them to respond automatically to short-term change in production potential rather than always needing quick management intervention.

As part of the broadly acknowledged rundown in soil fertility of the northern cropping belt, there has been a loss of nutrient supply plasticity. Nutrient supply plasticity is the soils' inherent capacity to automatically respond to changes in production potential.

In a nutritional sense plasticity is mostly based in the organic matter for the majority of nutrients. But for some it means maintaining the soil nutrient concentration close to a point where responses to fertiliser application are rarely seen.

In the northern cropping belt there are fewer nutrient management options than in other areas due to variability and low probability of rainfall during some nutritionally important crop development windows.

So it is more important to have the soil in a state where it is able to adjust where management options are limited.

How capable is your soil in responding to short term change; how do you know whether your soils will be able to help you?

The following steps are a guide to an emerging process for managing the soil resource, including nutrients:

- Conduct Soil Function Assessment – a. Identify management responsive and unresponsive soil properties, processes. b. Audit current soil practices.
- Reassess realistic production goals based on ability to manage limitations and/or manipulate properties and processes.
- Develop and implement a mid to long-term nutrient management strategy (3–5 years) aligned to manageable soil properties and processes.

Develop and implement smart seasonal nutrient management tactics.

For more information contact Chris Dowling on 07 3821 3577. ■