NITROGEN FERTILISER MANAGEMENT FACT SHEET

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

WESTERN REGION
SEPTEMBER 2023

Ammonia volatilisation from spreading sulfate of ammonia and lime in close succession

Lime and sulfate of ammonia are being surface-applied to soil in close succession in the western region.

Photo: GRDC

KEY POINTS

- Growers applying lime and sulphate of ammonia in close succession to the soil surface prior to seeding risk losing a significant amount of the nitrogen (N) applied through ammonia volatilisation
- In a glasshouse study, applying lime and sulphate of ammonia in close succession onto two cropping soils prior to sowing canola increased the potential for fertiliser N loss via ammonia volatilisation by up to 20 per cent of fertiliser N applied
- The risk of ammonia volatilisation also persisted (up to 26 per cent of fertiliser N) when sulphate of ammonia was applied to the same two soils containing residual lime on the surface soil after harvesting a canola crop, and prior to planting a second crop (barley) in a glasshouse study
- The greatest ammonia volatilisation occurred when the application of sulphate of ammonia to recently limed soil (or a soil containing residual lime) coincided with a series of one millimetre simulated rainfall events. Ammonia volatilisation from limed soil significantly decreased if simulated rainfall (20mm) occurred immediately after sulphate of ammonia application
- Growers should avoid spreading sulphate of ammonia onto recently limed soils (or when there is residual lime on the soil surface) prior to seeding and when the soil is dry, unless confident that first rainfall events will be sufficient to cause the dissolved sulphate of ammonia to move beyond the soil surface

Background

Western region growers are spreading lime and sulfate of ammonia onto cropping soils in close succession. A survey of agricultural consultants revealed the practice occurs prior to sowing canola (which has a high requirement for both sulfur and fertiliser N) in sandy soils.

Anecdotal evidence suggests that the practice of spreading lime and sulfate of ammonia on dry soil in close succession prior to seeding may be decreasing fertiliser nitrogen (N) use efficiency in Western Australian cropping areas due to loss of fertiliser N via ammonia volatilisation. This not only impacts growers' bottom line but also impacts the environment.

P Level 4, 4 National Circuit, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au

Researchers from the University of Western Australia (UWA) conducted glasshouse studies to investigate the short-term interaction between surface-applied lime and sulfate of ammonia on ammonia volatilisation, crop growth and yield.

Ammonia losses from N fertilisers

Ammonia volatilisation is the loss of surface-applied fertiliser N to the atmosphere as ammonia gas (NH_3). All fertilisers that contain ammonium (NH_4^+) or that generate ammonium – such as urea – are susceptible to ammonia volatilisation when applied to the soil surface. The actual ammonia loss depends on a number of factors:

- type, timing and placement of fertiliser N;
- soil properties, for example soil pH, cation exchange capacity, soil water content;
- environmental conditions, for example air temperature, rainfall, wind speed; and
- interactions with plants, for example crop height.

Emitted ammonia not only represents a loss of fertiliser N, but can impact on air and water quality, and ecosystem biodiversity. Ammonia volatilisation also indirectly contributes to nitrous oxide emissions (N_2O) when the volatilised ammonia is subsequently deposited on the soil surface, and then nitrified or denitrified. The Intergovernmental Panel on Climate Change estimates that about 1 per cent of ammonia deposited to land is subsequently converted to nitrous oxide.

The greatest ammonia volatilisation rates from Australian dryland cropping soils have occurred when fertiliser N was applied to the surface of alkaline soils or to soils with low pH-buffering capacity. For example, 29 per cent of fertiliser N applied was volatilised from an acidic cropping soil with a low pH-buffering capacity in the WA grainbelt, while up to 34 per cent of fertiliser N was volatilised when applied to a bare-fallow cropping soil with more than 10 per cent calcium carbonate content in northern New South Wales.

Applying sulfate of ammonia and lime in close succession

The effect of spreading sulfate of ammonia shortly after liming on ammonia volatilisation does not appear to have been studied.

Australian field-based investigations of ammonia volatilisation following the application of granular sulfate of ammonia to rain-fed cropping soils have reported ammonia volatilisation rates ranging from zero to 34 per cent. The extent of these losses was greatly influenced by the soil pH and the calcium carbonate content of the soil. Where soil pH was 7.5 or greater (measured using a range of methods), 90 per cent of the studies reported some degree of ammonia volatilisation. In addition, laboratory-based studies have demonstrated that the extent to which calcium carbonate enhances ammonia volatilisation from sulfate of ammonia depends on its particle size, with losses increasing as the size of the calcium carbonate particles decreases rather than in response to the total calcium carbonate content of the soil.

Field and laboratory data from these studies suggest that applying sulfate of ammonia to soil that has been recently limed is likely to result in ammonia volatilisation under environmentally conducive conditions, such as sufficient soil moisture to dissolve but retain ammonium sulfate on the soil surface and if the lime particles are adequately fine.

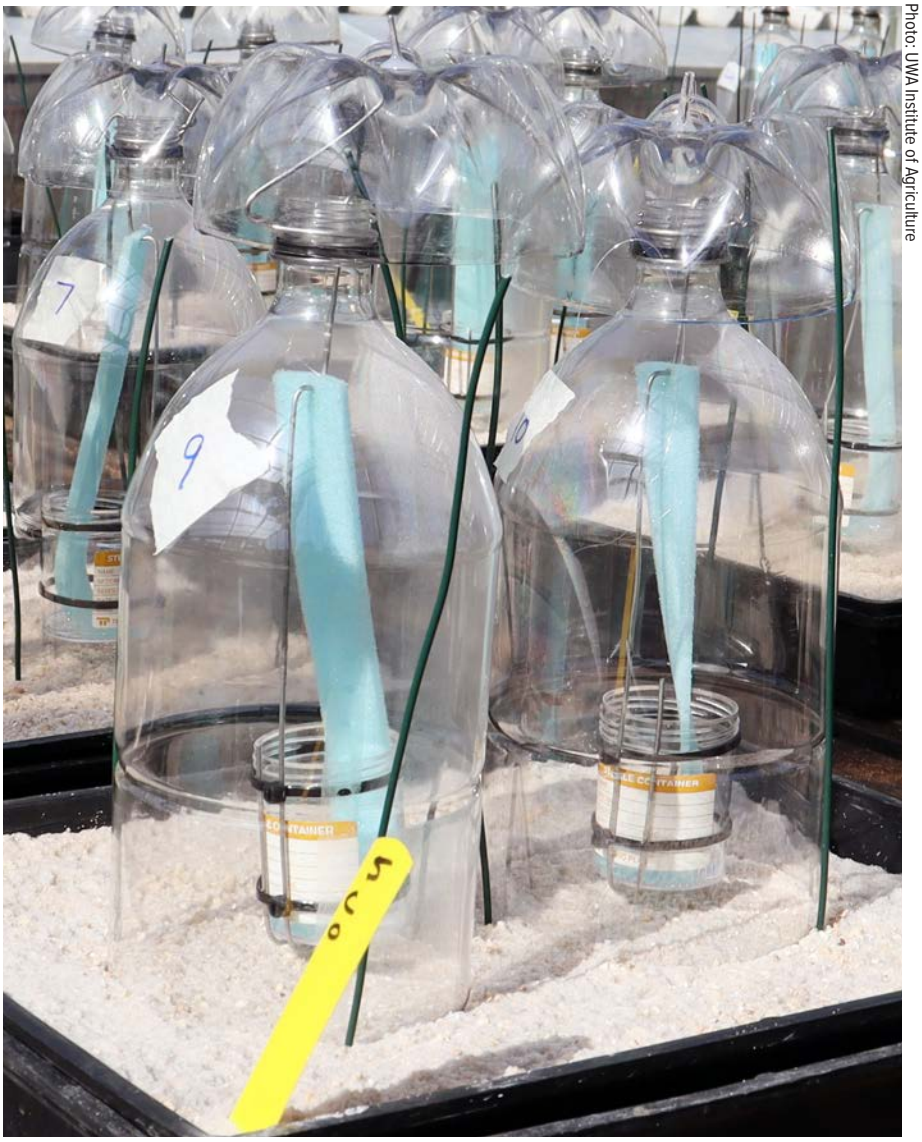


Photo: UWA Institute of Agriculture

Semi-open passive chambers for measuring ammonia volatilisation losses from soil in the glasshouse.

Does applying sulfate of ammonia and lime in close succession increase the risk of ammonia loss?

UWA conducted a glasshouse study to investigate the short-term interaction between surface-applied lime and sulfate of ammonia on ammonia volatilisation, crop growth and yield. In particular, the study investigated two scenarios to see if the potential for ammonia volatilisation increased and therefore decreased crop productivity and N use efficiency. The two scenarios were:

- applying 100 kilograms per hectare (kg/ha) of sulfate of ammonia to limed soils prior to planting canola (ATR Stingray[b]); and
- applying 100kg/ha of sulfate of ammonia to soils containing residual lime following a canola crop and before being planted to barley.

These scenarios were investigated under two different sets of season break circumstances.

- Low-rainfall: 1mm (110mL/pot) on day zero, 1mm (110mL/pot) on day three or four depending on soil, 20mm (2.20 L/pot) on days 7, 14 and 21.
- High-rainfall: 20mm on day zero, 1mm on day 7, 1mm on day 10, and then 20mm on days 14 and 21.

Acidic soils were used in the study, including a brown sodosol from Goomalling and a yellow tenosol from Wongan Hills (Table 1).

Applying lime and sulfate of ammonia in close succession onto both cropping soils prior to seeding increased the potential for fertiliser N loss via ammonia volatilisation. Cumulative ammonia volatilisation losses after 21 days ranged from below one per cent to 20 per cent of fertiliser N applied, depending on soil and treatment (Figure 1).

The greatest losses from both soil types occurred when sulfate of ammonia application on a recently limed soil coincided with a series of 1mm simulated rainfall events. The risk of ammonia volatilisation (up to 26 per cent of fertiliser N) also persisted when sulfate of ammonia was applied to the same two soils containing residual lime that remained on the surface soil after harvesting a canola crop, and prior to planting barley (Figure 2).

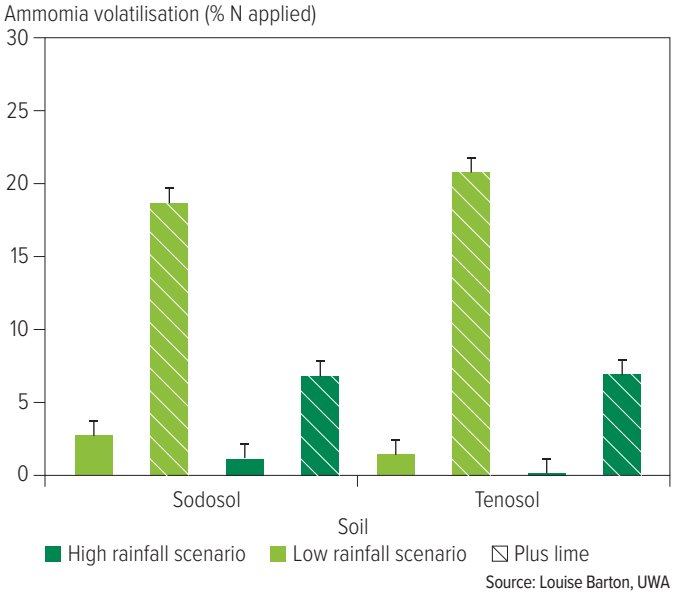
The extent of ammonia volatilisation from the limed soil significantly decreased (below seven per cent if

TABLE 1: Selected soil characteristics of the sodosol and tenosol soils. Values represent means (and standard error) of three replicates.

Soil	Depth (mm)	Soil texture	pH H_2O	Standard error	pH 0.01 $CaCl_2$	Standard error	Cation exchange capacity (cmol(+)/kg dry soils)	Standard error	Total carbon (%)	Standard error
Sodosol	0–100	Sand	5.86	0.02	5.45	0.01	2.22	0.47	1.17	0.02
Sodosol	100–200	Sand	5.59	0.01	5.03	0.02	1.66	0.05	0.67	0.01
Tenosol	0–100	Sand	5.84	0.00	5.17	0.00	5.54	0.07	3.39	0.11
Tenosol	100–200	Loamy sand	6.27	0.02	5.35	0.01	1.45	0.10	0.22	0.01

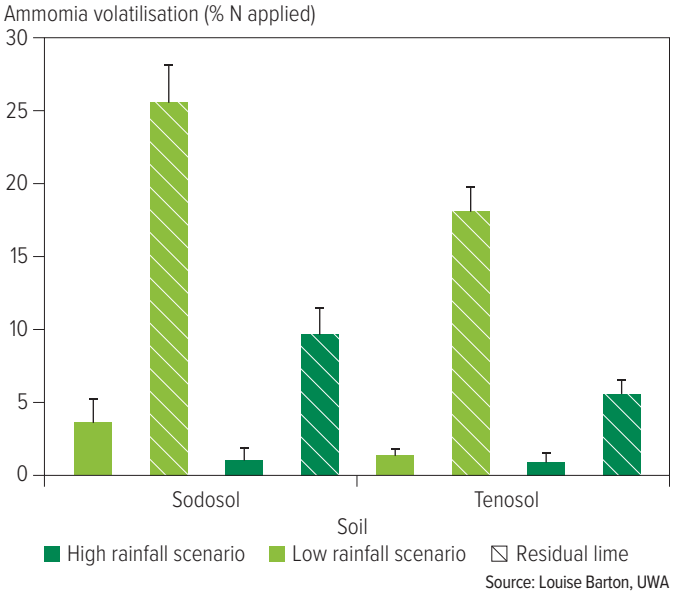
Source: Louise Barton, UWA

Figure 1: The total amount of ammonia-N volatilisation after 21 days in response to a combination of liming (0, 2.5t/ha) and rainfall scenarios (low, high) for a Sodosol soil and a Tenosol soil.



Source: Louise Barton, UWA

Figure 2: The total amount of ammonia-N volatilisation after 21 days in response to a combination of residual liming (0, residual lime) and rainfall scenarios (low, high) for a Sodosol soil and a Tenosol soil.



Source: Louise Barton, UWA

20mm of simulated rainfall occurred immediately after sulfate of ammonia application). Ammonia volatilisation following the application of sulfate of ammonia to non-limed soils represented less than four per cent of the fertiliser N applied. The growth and grain yield of the canola and barley were not negatively impacted by the loss of N via ammonia volatilisation as there was sufficient plant-available N to maintain plant growth.

Further field-based research is required to confirm if the extent of ammonia volatilisation measured in the glasshouse study is representative of the losses that occur under current land management and environmental scenarios in the western region, and if these losses impact on grain yield and fertiliser N use efficiency.

Implications and recommendations for growers

Growers applying lime and sulfate of ammonia in close succession to the soil surface prior to seeding risk losing a significant amount of the N applied via ammonia volatilisation. This glasshouse study and published research investigating ammonia volatilisation losses following the application of sulfate of ammonia to calcareous soils, indicates that the extent of losses may be as high as 34 per cent depending on the prevailing weather conditions.

While the practice of applying lime and sulfate of ammonia in close succession prior to planting canola is not extensive, growers and agronomists need to be aware that this practice can potentially result in significant N losses from the cropping system.

To minimise the risk of ammonia volatilisation, it is recommended that growers avoid spreading sulfate of ammonia onto the surface of soil containing lime or residual lime from a previous application prior to seeding and when the soil is dry. This is unless the grower is confident that first rainfall events (20mm or more) will be sufficient to cause the dissolved sulfate of ammonia to move beyond the soil surface.

Further field-based research is required to confirm if the extent of ammonia volatilisation measured in the glasshouse study is representative of the losses that occur under current land management and environmental scenarios in the western region, and if these losses impact on grain yield and fertiliser N use efficiency.

REFERENCES

- Barton, L., Hoyle, F. C., Grace, P. R., Schwenke, G. D., Scanlan, C. A., Armstrong, R. D., Bell, M. J. 2022. Soil nitrogen supply and N fertilizer losses from Australian dryland grain cropping systems. Advances in Agronomy 7, 1-52.
- Fillery, I. R. P., Khimashia, N. 2016. Procedure to estimate ammonia loss after N fertiliser application to moist soil. Soil Research 54, 1-10.
- Schwenke, G. D., Manning, W., Haigh, B. M. 2014. Ammonia volatilisation from nitrogen fertilisers surface-applied to bare fallows, wheat crops and perennial-grass-based pastures on Vertosols. Soil Research 52, 805-821.

MORE INFORMATION

Louise Barton,
The University of Western Australia
Phone: 08 6488 2543;
louise.barton@uwa.edu.au

Paul Damon,
The University of Western Australia
paul.damon@uwa.edu.au

Zed Rengel,
The University of Western Australia
zed.rengel@uwa.edu.au

ACKNOWLEDGEMENTS

Evonne Walker (UWA) and **Yoshi Sawada** (UWA) are thanked for technical assistance in the glasshouse and laboratory. **Shabab Pathan (DPIRD)** is thanked for classifying the soils used in the glasshouse study. **Summit Fertilizers** are thanked for providing sulfate of ammonia.

GRDC PROJECT CODE

UWA2202-001RTX

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Any recommendations, suggestions or opinions contained in this publication do not necessarily represent the policy or views of the Grains Research and Development Corporation. No person should act on the basis of the contents of this publication without first obtaining specific, independent, professional advice. The Corporation and contributors to this Fact Sheet may identify products by proprietary or trade names to help readers identify particular types of products. We do not endorse or recommend the products of any manufacturer referred to. Other products may perform as well as or better than those specifically referred to. GRDC will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

CAUTION: RESEARCH ON UNREGISTERED AGRICULTURAL CHEMICAL USE
Any research with unregistered agricultural chemicals or of unregistered products reported in this document does not constitute a recommendation for that particular use by the authors or the authors' organisations.
All agricultural chemical applications must accord with the currently registered label for that particular agricultural chemical, crop, pest and region.
Copyright © All material published in this Fact Sheet is copyright protected and may not be reproduced in any form without written permission from GRDC.

Produced by www.coretext.com.au