GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

GRAINS RESEARCH UPDATE 2026

Streaky Bay, SA
Thursday 30 July

CELEBRATING 30 YEARS

GRAINS RESEARCH UPDATE 2026

Streaky Bay

Thursday 30 July

9.00am to 1.00pm

Streaky Bay Community Complex,
Wells Street

#GRDCUpdates

STREAKY BAY GRDC Grains Research Update
convened by ORM Pty Ltd.

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GRDC Grains Research Update STREAKY BAY

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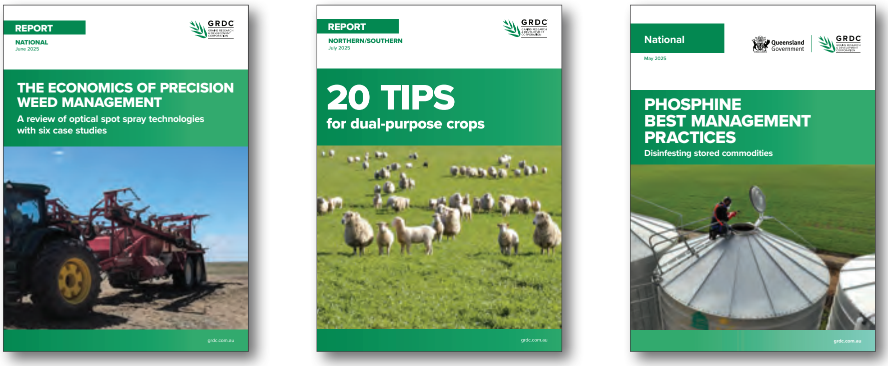

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GRAINS RESEARCH UPDATE 2026

GRDC

Streaky Bay Community Sports Club, Thursday 29 July

PROGRAM

9.00am	Announcements and GRDC welcome	*GRDC representative*
9.15am	Cereal root disease – what are the issues and what are our options	*Blake Gontar, SARDI*
9.55am	Protecting your most perishable asset – latest tips on grain storage	*Ben White, BM White*
10.35am	Morning Tea	
11.05am	Crop flowering calculator, an online tool to optimise sowing date for wheat, barley and canola	*Jeremy Whish, CSIRO*
11.45pm	Cycling and losses of N in the cropping system	*Nigel Wilhelm, SARDI*
12.25pm	Mice, reducing feed supply and improving control	*Ben White, BM White*
1.10pm	Lunch	

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SOUTHERN PANEL

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

2025-27 GRDC SOUTHERN REGIONAL PANEL

ANDREW RUSSELL

PANEL CHAIR

Rutherglen, Victoria

Andrew is the director and a shareholder of Lilliput AG, and managing director of Baker Seed Co, a family owned farming and seed-cleaning business. He has served on GRDC's medium rainfall zone Regional Cropping Solutions Network and has held leadership roles with Riverine Plains Inc, Victorian Farmers Federation and the Rutherglen Group of fire brigades.

PRU COOK

DEPUTY CHAIR

Dimboola, Victoria

Raised on a mixed farm in Victoria's Wimmera region, Pru has spent her professional career working in extension for the grains industry. Starting her career at the DPI, she has worked at GRDC and the Birchip Cropping Group, managing a number of extension projects. In recent years she has managed her own business specialising in extension, project development and project management.

TIM MCCLELLAND

Birchip, Victoria

Tim farms with his wife, father and aunt on a 6500-hectare mixed property in the southern Mallee. After completing his Bachelor of Agriculture and Commerce at the University of Melbourne in 2006, he took on work at Advisor Edge, Birchip Cropping Group (BCG) and RMCG. In 2011, he moved back to Birchip to become formally involved in the family farm and continue his role with BCG.

RUTH SOMMERVILLE

Burra, South Australia

Ruth is an agroecologist who runs a consulting business. She has a Bachelor of Science in Ecology and Master of Applied Science in Wildlife Management from the University of Sydney, and has worked in sustainable agriculture research, development and extension and property management since 2002. Ruth has been the Upper North Farming Systems Group Operations Committee Member in recent years.

ANDREW WARE

Port Lincoln, South Australia

Andrew is a research agronomist who started his career with the South Australian Research and Development Institute (SARDI) and then spent time at CSIRO in Adelaide. This was followed by 10 years away from research, managing the family farm on the Lower Eyre Peninsula, before returning to SARDI. In 2019, he started his own research company, EPAG Research, delivering applied research across the Eyre Peninsula.

DR KATHY OPHEL-KELLER

Adelaide, South Australia

Kathy is a strategic science leader with a strong track record in developing and leading national research programs with industry co-investment, including GRDC. Her own research background is in plant biosecurity and molecular detection of plant pathogens and she has a strong interest in capacity building and succession planning. Kathy is a former acting executive director of SARDI and a research director at Crop Sciences, covering applied research on plant biosecurity, crop improvement, climate risk management, water use efficiency and crop agronomy.

WAYNE BURTON

Halls Gap, Victoria

Dr Wayne Burton has worked as an agricultural scientist and oilseeds breeder with over three decades of leadership across public and private sector research and development. Holding a PhD from the University of Melbourne and a Bachelor of Agricultural Sciences (Honours) from the University of Adelaide, he has played a pivotal role in the advancement of canola and mustard breeding and development in Australia.

MAX YOUNG

Ardrossan, South Australia

Max Young farms at Ardrossan on the Yorke Peninsula. He has more than 40 years' experience growing predominately wheat barley and lentils. Max holds a Roseworthy Diploma in Agriculture and is a graduate of the Australian Institute of Company Directors (GAICD). He has served in leadership roles in both the South Australian No Tillage Association SANTFA and South Australian Grains Industry Trust (SAGIT) and is keenly interested in improving sustainable production through research. Max understands the importance of local grower groups as a conduit between researchers and growers.

ADAM HANCOCK

Naracoorte, South Australia

Adam Hancock is a High Rainfall Zone agronomist with Elders, based in south-east South Australia. He has 15 years of experience advising grain growers to improve productivity and profitability through evidence-based agronomy and precision agriculture. He provides agronomic advice across a wide range of farming systems and environments, supporting clients with both in-season decision-making and long-term planning.

GRETA DUFF

Inverleigh, Victoria

Greta Duff graduated from the University of Melbourne with a Bachelor of Agriculture, spending part of her studies at Dookie College. She began her career in the dairy industry before joining Southern Farming Systems (SFS) in 2020. Since then, Greta has led and contributed to a wide range of projects, particularly with GRDC, and is passionate about supporting the next generation of growers. Through her involvement with the Young Agricultural Professionals Network, she actively works to promote and retain young people in the agricultural industry.

RON OSMOND

General Manager of Strategy & Business Development

Prior to joining GRDC in 2013, after completing a PhD in Agricultural Science, Ron worked in scientific and management roles in Intellectual Property Development and Commercialisation in the private sector. Ron's interest and expertise is in the translation of Research and Development into adoptable outcomes for Australian grain growers.

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Cereal root diseases in South Australia: current risks and management options, with a focus on crown rot

Blake Gontar[1 2] and Rebecca Tonkin[1 2].

[1]South Australian Research and Development Institute; [2]Adelaide University.

GRDC project code: UOA2507-002RTX

Keywords

- barley, integrated disease management, root disease, wheat.

Take home messages

- Crown rot is now the most common soil- or stubble-borne disease on the upper Eyre Peninsula, present at damaging levels in over 70% of paddocks
- Rhizoctonia and take-all remain present at damaging levels in around 20% of paddocks
- New research is being conducted to identify the cost-benefit of management strategies, including new fungicides and approaches to cultural control.

Notes

Notes

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- White grain disorder
- Sclerotinia stem rot
- Eyespot.

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Protecting your most perishable asset – latest understanding on grain storage

Chris Warrick.

Primary Business

GRDC project code: PRB2412-001SAX

Keywords

- fumigant, grain storage, phosphine, silo.

Take home messages

- A storage must be gas-tight sealed to achieve a high enough concentration of fumigant for a long enough period to kill pests at all life cycle stages.
- Pressure test silos, and when buying a new silo, buy a quality, gas-tight sealable silo fitted with aeration and check it meets the Australian Standard.
- Phosphine is a highly toxic gas, so follow all product label statements when applying and venting.
- Phosphine gas concentration needs to reach 550 parts per million (ppm) and remain above this level for 7–10 days. Exposure periods vary with temperature and storage capacity.
- Powered air recirculation systems distribute the phosphine gas to achieve lethal concentration in all areas of the storage - particularly helpful in large silos.
- Fumigation meters are an essential part of best practice use of phosphine for measuring concentration during fumigation and post-venting.

Fumigation fundamentals

Poor fumigation techniques fail to kill pests at all life cycle stages, so while some adults may die, grain will soon be reinfested again as soon as larvae and eggs develop. What's worse, every time a poor fumigation is carried out, insects with some resistance survive, making the chemical less effective in the future.

The second challenge with fumigating is venting the gas to ensure it is safe and meets the delivery site requirements, with some delivery sites using 0.3 parts per million via a spear test as a clearance limit. New lower worker exposure limits, which come into effect in December 2026, could make venting prior to delivery even more challenging.

Gas-tight

Research shows that fumigating a storage that is anything less than gas-tight sealed doesn't achieve a high enough concentration of fumigant for a long enough period to kill pests at all life cycle stages. Pressure testing a silo ensures it can hold gas concentrations sufficient to kill all insects at all life stages. Just because a silo is sold as a sealed silo does not automatically mean it's suitable for fumigation. Even if a silo is sold as 'sealed', it is not sealed until it is proven gas-tight with a pressure test.

When a pressure test is undertaken, oil levels in the pressure relief valve must take a minimum of five minutes to fall from 25mm to a 12.5mm difference if the silo is sufficiently gas-tight. When buying a new silo, buy a quality, gas-tight sealable silo fitted with aeration and check with the manufacturer that it meets the Australian Standard for sealable silos (AS2628–2010).

Safety

Phosphine is a highly toxic gas with potentially fatal consequences if handled incorrectly. As a minimum requirement, product labels direct the use of elbow-length PVC gloves and a full-face breathing respirator with combined dust and gas cartridge, suitable for inorganic gas. Be aware that cartridges have a limited lifespan as they contain activated carbon. After use, store cartridges in a sealed container and follow manufacturer directions for replacement.

Working with phosphine in an open, well-ventilated area with the wind coming from the side will help carry the gas away from the body. When opening containers, take care and point container lids away from the face and body. When opened, use the entire contents — do not reseal left-over tablets.

Safe Work Australia has announced a change to worker exposure limits for phosphine. Affective from December 2026, the peak exposure limit will be 0.15 Parts per million (ppm) and the Time Weighted Average will be 0.05ppm.

Exposure period

To control pests at all life stages and prevent insect resistance, phosphine gas concentration needs to reach 550 parts per million (ppm) and remain above this level for 7–10 days. At this concentration, an exposure period of seven days is required when grain is above 25°C or 10 days if at 15–25°C. Insect activity and development slow down in cooler grain temperatures, which means a longer exposure time to fumigants is required to deliver a lethal dose to all life stages.

In gas-tight sealed silos larger than 300t capacity that don't have powered recirculation, the exposure period is extended to 20 days regardless of grain temperature. If the silo has powered recirculation, the exposure period can be shortened to 10 days. When grain temperatures fall below 15°C, insect pests become inactive and phosphine fumigation is no longer reliably effective.

Recirculation systems

Some silos are fitted with purpose-built chambers for applying phosphine from the bottom. This method of application carries a safety advantage, as the operator doesn't have to leave the ground to apply the phosphine.

Bottom-application chambers must have a passive or powered air recirculation system to carry the phosphine gas out of the confined space as it evolves. Without air movement, phosphine can reach explosive levels if it's left to evolve in a confined space.

Silos larger than 150t will benefit from a sealed, powered recirculation system to distribute gas throughout the storage and achieve consistent gas concentration sooner. Trials have found that, without powered recirculation, phosphine travels at approximately 6m per day through grain, in any direction.

In silos larger than 300t without powered recirculation, the phosphine label stipulates an extended exposure period of 20 days, referenced as 'surface only application'. Using powered recirculation enables the fumigation period to be shortened to 10 days.

An alternative to a dedicated, powered recirculation box with a phosphine chamber is to connect a small fan between the pluming from the silo headspace to the base and place the phosphine in the headspace and/or aeration ducts at the base. This option has two main advantages – it avoids the risk of explosion if the fans stops as the phosphine can safely continue liberating in the silo, and, being lower cost, there is also the option to buy multiple fans so more than one silo can be fumigated at a time.

Venting

Following fumigation, ventilate silos to allow phosphine gas to escape into the atmosphere, so grain can be delivered free of harmful gas residues. The same PPE required for applying the phosphine is required again to open the silo and remove the phosphine residue. After the removal of tablet residue or bag chains, the labels state that a silo without aeration fans fitted must be left open to ventilate for no less than five days. Silos with aeration fans fitted must be opened to ventilate with fans operating for no less than one day. Larger flat bottom silos, cool grain or extended fumigations are likely to require additional time to vent as the grain desorbs the phosphine.

A low-level phosphine meter is the safest way to ensure the grain is vented to the delivery limit set at the receival point. Grain should be spear tested at least a few hours after fans have been switched off and prior to moving in order to sample the air gaps into which grain may have been desorbing gas. The labels state that grain treated with phosphine should not be used for human consumption or for stock food for a minimum of two days after the ventilation period has finished.

Monitoring gas concentrations

Fumigation meters are an essential part of best practice use of phosphine, especially when fumigating storages that cannot be pressure tested, such as bunkers and bags. Meters are available in high range (0 to 2000ppm) for measuring concentration during fumigation, and low range (0 to 20ppm) for measuring concentration post-venting for clearance and safety.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

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Notes

AIR EP | Ag Innovation & Research
Eyre Peninsula

Agricultural Innovation & Research Eyre Peninsula (AIR EP) is a farmer-led, not-for-profit organisation that aims to advance agricultural research, development and extension (RD&E) adoption in rain-fed, broadacre farming systems across the Eyre Peninsula.

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- **EXTENSION** - AIR EP translates research and development findings into practical changes that improve farm productivity, profitability and resilience.
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Crop Flowering Calculator – an online tool to assist sowing date decisions for wheat, barley and canola

Julianne Lilley, Jeremy Whish, Shannon Dillon, Pengcheng Hu, Bangyou Zheng, Di He, Alex Boyer, Chris Helliwell, Enli Wang and Jessica Hyles.

CSIRO Agriculture and Food, Canberra.

GRDC project code: CSP2206-012RTX

Keywords

- APSIM, cultivar choice, flowering dates, yield potential.

Take home messages

- Targeting crop flowering date to the optimum time maximises yield potential and minimises the risk of yield loss due to frost, heat and water stress.
- Imagine an online tool that can provide growers with the optimum sowing date for new crop cultivars or regions based on the validated genetic controls in the plant.
- This project used genomic analysis of recent and near-release cultivars to build and test APSIM's ability to predict flowering dates observed in National Variety Trials (NVT).
- The resultant Crop Flowering Calculator assists growers, agronomists and breeders to select the most suitable sowing date for specific cultivars to achieve optimal flowering dates to maximise yield across all Australian grain-growing areas.

Introduction

Changing seasonal conditions, better fallow management, improved seeding equipment, and the availability of crop varieties with greater vigour and adaptability have prompted a re-evaluation of sowing date recommendations for wheat and canola. Expanded cropping (particularly canola) into new environments, such as high- and low-rainfall zones, has created the need to identify optimal flowering periods (OFP) and phenological response of new cultivars for these regions.

The OFP is the range of dates when flowering is most likely to maximise yield. Flowering too early risks frost damage or insufficient biomass, while flowering too late increases the chance of heat and water stress. To optimise yield, growers need to match sowing dates and crop varieties to ensure flowering occurs within the OFP for their specific region.

Crop phenology, or the timing of crop development stages, is influenced by temperature, day length, and cold exposure, all controlled by genetic factors. These influences mean sowing date recommendations vary depending on the crop's genetics and the regional climate. However, when new cultivars are released, their phenological response to Australia's diverse environments is not always well understood.

This project aims to provide timely and accurate predictions of flowering periods for new wheat, barley, and canola cultivars, delivered through an online tool. This would allow growers to confidently match sowing dates with new cultivars which will flower in the OFP to minimise stress and maximise yield.

Methods

We identified the OFPs for wheat, barley, and canola at over 3 000 sites in the Australian cropping zone using the APSIM NextGen crop models run over a continuous 66-year period (1957–2022). Climate data were sourced from BOM weather stations, and regional soil profiles were used for each site. Importantly, the analysis incorporated newly developed frost and heat damage functions for APSIM NextGen applied to a range of cultivars from slow winter types to fast spring types in each crop.

APSIM uses phenology parameters to describe how a cultivar responds to temperature, vernalisation (cold exposure), and photoperiod (day length). Traditionally, these parameters are derived from observations in controlled environments and field experiments at various sowing dates and locations.

This project used genomic analysis and machine learning to streamline this parameter development for APSIM. Because phenological responses are ultimately driven by genetic controls, we can correlate the genetics with observed responses. We used machine learning models trained on phenology observations and genetic data for a diverse range of varieties (49 wheat, 26 barley, and 208 canola cultivars).

Material Transfer Agreements with breeding companies enabled genomic analyses of commercial and pre-release cultivars included in National Variety Trials (NVT) for 2022–2024. In 2024, genomic models were used to predict phenology parameters for 30 wheat, 5 barley, and 27 canola cultivars. These were validated by running APSIM simulations at NVT locations with available phenology data. Only cultivars with at least two years of observed data across five locations, and with acceptable prediction accuracy, were included in the Crop Flowering Calculator. Insufficient phenology measurements were collected at NVT sites in 2024 for inclusion in the study.

A web-based interface was developed to deliver the Crop Flowering Calculator. APSIM simulations were run for 66 years across all sites and validated cultivars for sowing dates between 1 March and 9 August. The results, including predicted flowering dates, were compiled into a dataset that underpins the tool.

Results

Validation of phenology parameters from the machine learning model showed strong agreement with 2022 NVT data for wheat cultivars, achieving a correlation (r^2) of 0.81 and a root mean square error (RMSE) of 9 days for 19 cultivars. While this is slightly less precise than phenology-focused observational trials such as those in the National Phenology Initiative, which achieved $r^2 = 0.92$, it was acceptable given phenology observations were made every 1–2 weeks at NVT sites rather than 3–4 times a week. For canola, the correlation from machine learning models using 2022 NVT data was $r^2= 0.79$, again slightly less precise than $r^2= 0.90$ achieved from phenology observation experiments. Notably, if more, high-quality phenology observations at 3-4 targeted environments are made available the model predictions (a) can be validated more widely, and (b) are likely to have improved accuracy.

The Crop Flowering Calculator tool allows users to put in their location and crop type, then ask: (see Figure 1)

- which variety should I sow (if I know my sowing date)
- when should I sow (if I know my variety).

Users can apply filters to refine the results, such as selecting up to three varieties or filtering by herbicide group or breeding company. Results are presented as a marker on a timeline (see Figure 2) showing the range of predicted flowering dates relative to the OFP for each site.

Conclusion

This project used long-term APSIM simulations and genomic analysis to define optimal flowering periods for wheat, barley, and canola at more than 3 000 sites across the Australian cropping zone. The results were used to develop the Crop Flowering Calculator, an online tool designed in collaboration with consultants, researchers, and breeders. Crucially, the methods underpinning the tool are scalable, applicable for almost any environment and variety, and can be deployed at a fraction of the cost compared to methods that underpinned crop flowering calculators of the past. The tool provides growers and agronomists with reliable, evidence-based insights to guide sowing decisions for new varieties and regions, helping them to achieve better yields with reduced risk.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the authors would like to thank them for their continued support. This research was also supported through funding from CSIRO (‘National Phenology Initiative - Phase 2’ (NPI2)). Thanks to the APSIM Initiative, which supports APSIM modelling software.

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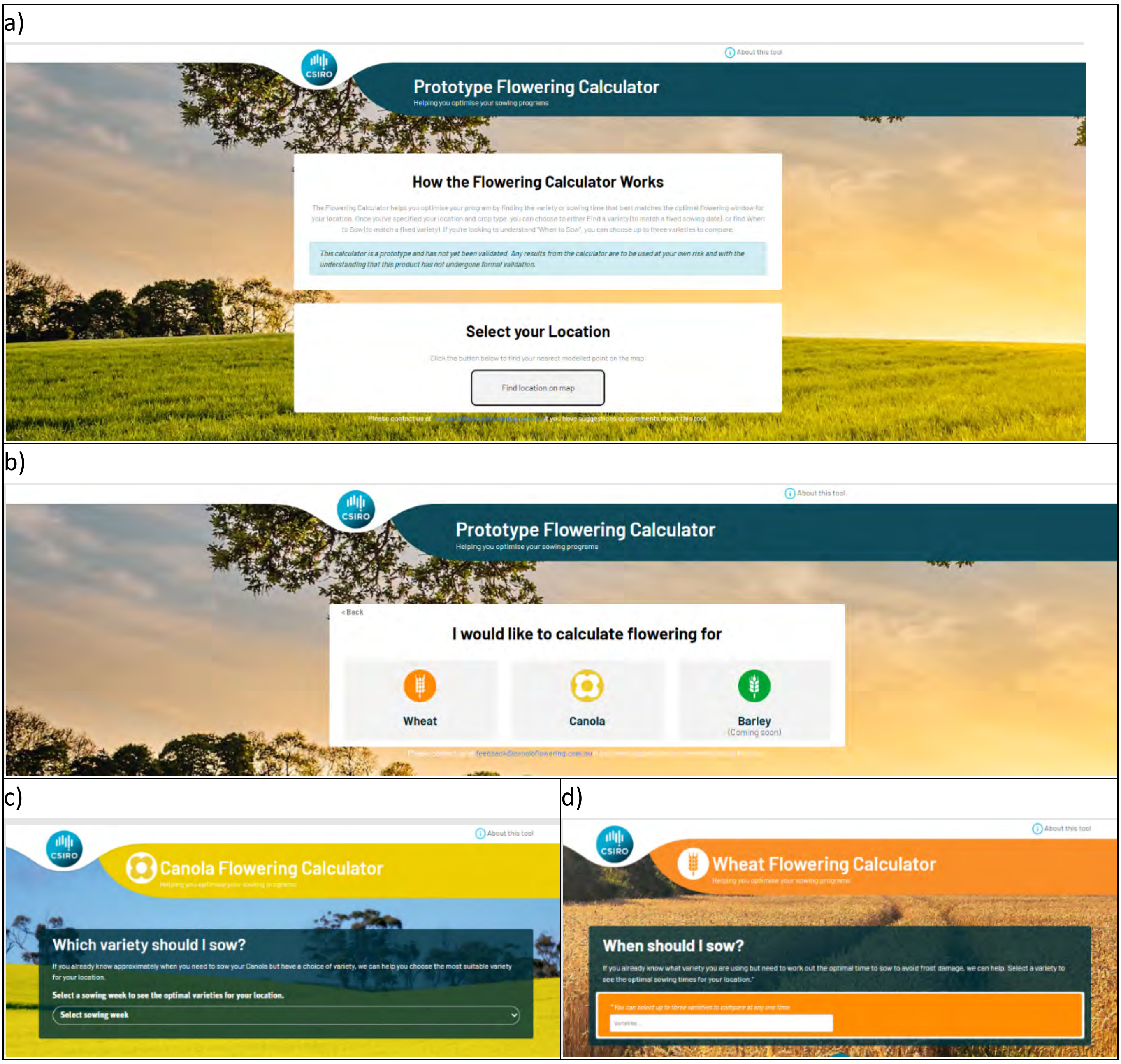

Figure 1. User interface of Crop Flowering Calculator, showing pages for a) location selection, b) crop selection and c) cultivar selection, where sowing week is selected from dropdown menu, or d) sowing date selection, where up to three cultivars are chosen.

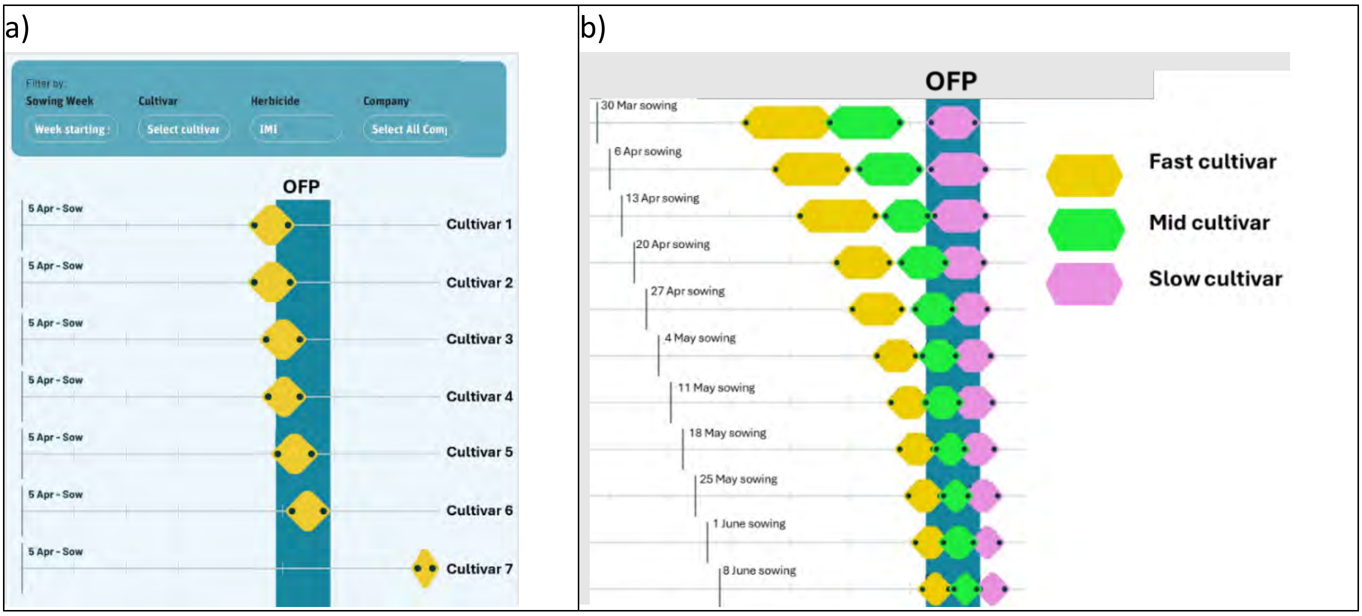

Figure 2. Results page in Crop Flowering Calculator, showing a) cultivar selection output example where filters can be set for categories, such as herbicide group and breeding company, and b) output example where up to three cultivars can be matched with the OFP for a range of sowing dates.

Notes

How much urea N is being lost as volatilisation

Kamal Adhikari[1], Zhaohan Luo[2,3], Roger Armstrong[1,4], Nigel Wilhelm[2,3] and Graeme Schwenke[5].

[1]Agriculture Victoria; [2]South Australian Research and Development Institute; [3]The University of Adelaide; [4]LaTrobe University; [5]NSW Department of Primary Industries and Regional Development.

GRDC project code: UOQ2204-010RTX

Keywords

ammonia volatilisation, N-use efficiency, rainfall and wind effects, soil type.

Take home messages

- **Most ammonia (NH_3) losses from top-dressed urea occur within the first two weeks** after urea application, making this the critical period for volatilisation losses.
- **Soil type strongly influences losses.** Clay soils, for example, Vertosols, retain ammonium-N and reduce volatilisation, while low-clay Calcarosols, rich in calcium ions (Ca^{2}) and containing free calcium carbonate, are more prone to greater losses.
- **Weather conditions are key.** Light rainfall or moist soil followed by windy periods increase NH_3 losses, whereas timely and enough rainfall after top-dressing helps reduce volatilisation.
- On sandy or low-clay Calcarosols, splitting applications or using urease inhibitors could be beneficial to reduce volatilisation losses.

Background

Current intensive cropping systems have become increasingly reliant on fertiliser nitrogen (N) to maximise yields, maintain grain quality and ensure farm profitability, with urea representing one of the largest variable cost inputs for growers. However, research by Agriculture Victoria in Victorian cropping systems indicate that, on average, approximately 30% of applied urea N is lost (Wallace et al. 2022). In the Southern region, urea is commonly top-dressed in anticipation of rainfall. Growers are increasingly concerned about N losses when expected rainfall does not eventuate. Top-dressing of urea increases the risk of NH_3 volatilisation and can be a major pathway for gaseous N loss from fertiliser in grain cropping systems, resulting in both economic losses through reduced fertiliser N use efficiency and negative environmental impacts. Better understanding how much of the 'unaccounted N' is lost through volatilisation is essential for developing effective strategies to improve N use efficiency. Despite this, field measurements of soil NH_3 volatilisation are scarce, particularly on neutral to alkaline soils in southern grain-growing regions, and seasonal variability remains poorly understood (Turner et al. 2010, Incitec Pivot Fertilisers 2024). To address this knowledge gap, NH_3 volatilisation was measured over two seasons (2024 and 2025) following urea top-dressing at two sites with contrasting soils and environmental conditions in southern Australia grain-growing regions:

- Horsham in the Wimmera region of Victoria (medium rainfall zone) on a Vertosol (cracking clay soil)
- Minnipa on the upper Eyre Peninsula of South Australia (low rainfall zone) on a Calcarosol.

This work is part of a national GRDC project that aims to track the fate of fertiliser N across key soils and cropping systems nationwide, and to quantify the relative contribution of different loss pathways, such as NH_3 volatilisation, denitrification, and leaching, to the N that remains unaccounted for in the soil-plant system.

Methods

Experiments to quantify NH_3 volatilisation following top-dressing of urea were conducted over two winter growing seasons (2024 and 2025) at two field sites. The first site was the Horsham SmartFarm in the Wimmera region of Victoria, a medium rainfall environment (annual average rainfall = 373mm) on a Vertosol (cracking clay soil). The second site was the Minnipa Agricultural Centre on the upper Eyre Peninsula of South Australia, a low rainfall environment (annual average rainfall = 325mm) on a Calcarosol. The physico-chemical properties of the surface soil (0–10cm) at each site are presented in Table 1. Barley was grown at the Minnipa site in both seasons, while at the Horsham site, barley was grown in 2024 and wheat in 2025.

Table 1: The physico-chemical properties of site soils (0–10cm, CEC = cation exchange capacity).

Site	Soil type	Soil pH (H_2O)	Soil total Carbon (%)	Sand (%)	Silt (%)	Clay (%)	CEC (cmol/kg)
Horsham	Vertosol (clay)	7.9	1.7	37.7	17.4	45.0	34.5
Minnipa	Calcarosol (sandy loam)	8.1	1.4	71.7	10.5	17.8	28.5

Across both sites and seasons, commercial prilled urea was top-dressed in anticipation of a substantial rainfall event when crops were at the 2–3 leaf stage. Urea was applied uniformly by hand at Horsham and using a tractor-mounted spreader at Minnipa within two treatment circles at each site. At the Horsham site, urea was applied at a rate of 80kg N/ha (174kg urea/ha) to two circles of 40m diameter, while at the Minnipa site it was applied at 50kg N/ha (109kg Urea/ha) to two circles of 50m diameter. At the Horsham site, two background circles (40m diameter), and at the Minnipa site, one background circle (50m diameter), were established upwind of the urea-treated plots and received no urea application to monitor background atmospheric NH_3 concentrations. All circular plots were separated from each other by at least 60m. ALPHA samplers (passive diffusion samplers, Tang et al. 2001) were mounted on posts at the centre of each circle at least two days prior to urea application to measure pre-treatment NH_3 concentrations. ALPHA samplers were then collected and replaced two to three times per week for approximately one month following urea application. The ALPHA samplers were stored at 4 °C until analysis for ammonium–N concentration. To calculate NH_3 losses from the applied N using the WindTrax model, the amount of NH_3 measured in the untreated background circles was subtracted from the levels measured in the fertilised plots. Soil moisture and mineral nitrogen (ammonium-N and nitrate-N) were monitored throughout the study at both sites to better understand the factors influencing NH_3 volatilisation.

Results and discussion

Figures 1 and 2 show the cumulative NH_3 losses from applied urea over the experimental period, daily rainfall and wind speed at the Horsham and Minnipa sites, respectively. Across both seasons, per cent N emitted as NH_3 of the applied N were significantly greater [Fisher's LSD Test, P = 0.0051 (2024), P = 0.0362 (2025)] at Minnipa than at Horsham, although N application rate was higher at Horsham (80kg N/ha vs 50kg N/ha). At the Horsham site, total NH_3–N losses were 6.5kg N/ha and 7.3kg N/ha in 2024 and 2025, respectively, equivalent to 8.2% and 9.2% of the 80kg N/ha applied (Figure 1). In contrast, at the Minnipa site, NH_3–N losses were higher, 19.6% and 13.7% of the 50kg N/ha applied, amounting to 9.8kg N/ha and 6.9kg N/ha in 2024 and 2025, respectively (Figure 2). The observed losses align with previous studies from the Southern region, which have reported NH_3 volatilisation losses of 9.5–26% from surface-applied urea (Turner et al. 2010, Incitec Pivot Fertilisers 2024). The relatively lower losses recorded at the Horsham site in this study are largely attributable to soil characteristics, particularly the higher clay content (45%) of the Vertosol soil. The corresponding high CEC (34.5cmol/kg) results in greater retention of ammonium-N in the soil (Adhikari et al. 2019). The lower volatilisation rate observed in the Vertosol soil, despite substantial ammonium-N remaining in the surface soil throughout the measurement period (Figures 3 and 4), provides evidence of this effect. In contrast, the sandy loam Calcarosol at Minnipa has a substantially lower surface soil clay content (18%). Although its measured CEC (28.5cmol/kg) was broadly comparable to that of the Vertosol, carbonate-rich Calcarosols are dominated by Ca^{2+}, which strongly compete with ammonium-N for cation exchange sites, resulting in less effective ammonium-N retention in soil. The presence of free calcium carbonate further buffers the soil against pH decline following urea hydrolysis and neutralises acidity generated during nitrification, thereby maintaining alkaline conditions for longer periods that favour NH_3 volatilisation (Fenn and Kissel 1975). Furthermore, the lower water-holding capacity of the Calcarosol promotes rapid surface drying, a condition that likely further enhanced NH_3 losses. Higher wind speeds during the first week after urea application at Minnipa, compared with Horsham in both seasons, may have further contributed to increased losses, as windy conditions promote volatilisation from the soil surface in the absence of a dense crop canopy. Together, these soil properties and higher wind conditions help explain the higher volatilisation losses observed at Minnipa.

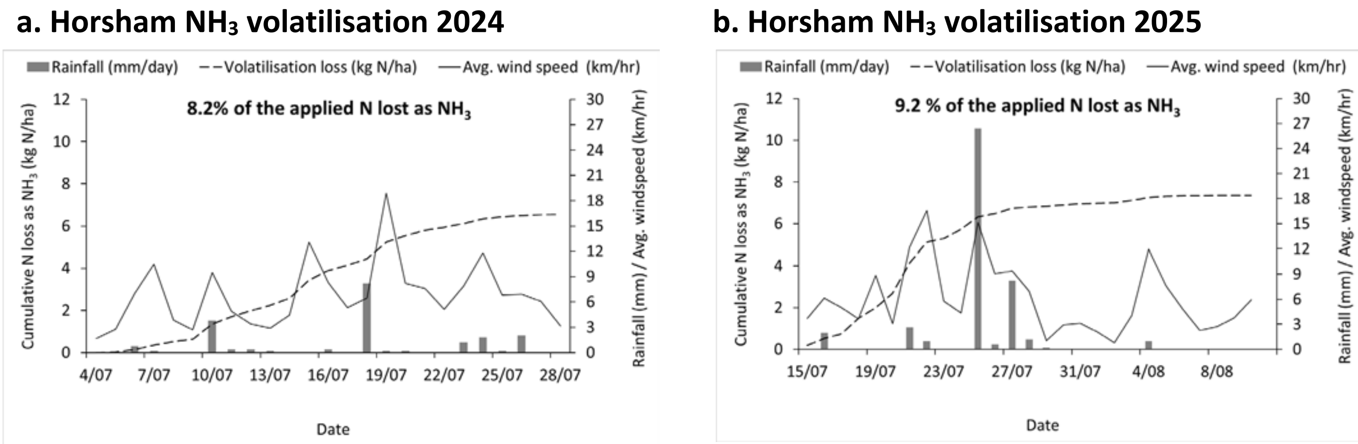

Figure 1. Cumulative NH_3 losses following urea top-dressing over the experimental period, together with daily rainfall and wind speed at the Horsham site during (a) 2024 and (b) 2025.

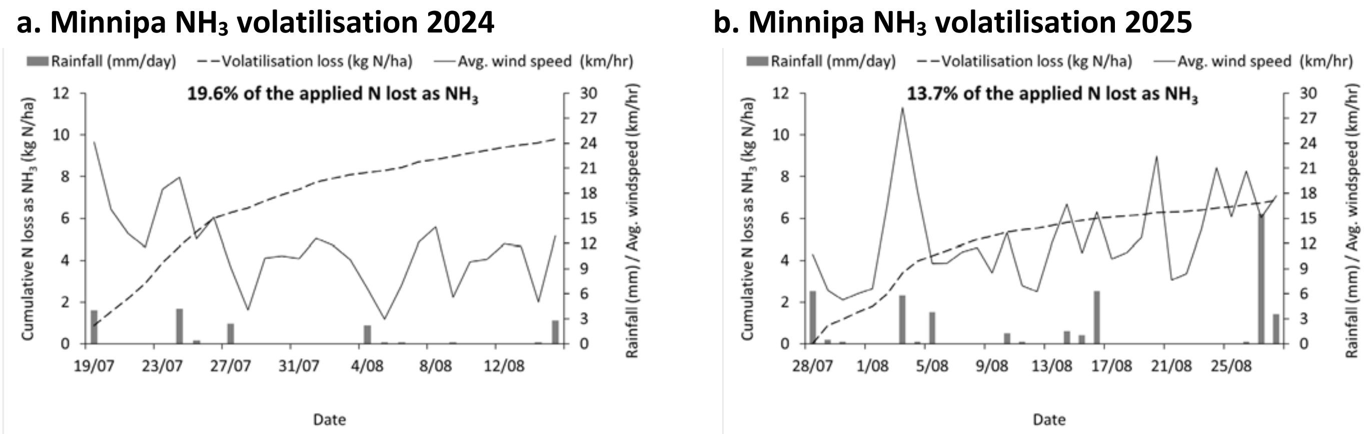

Figure 2. Cumulative NH_3 losses following urea top-dressing over the experimental period, together with daily rainfall and wind speed at the Minnipa site during (a) 2024 and (b) 2025.

The greater (Fisher's LSD Test, P = 0.0316) volatilisation losses observed at the Minnipa site in 2024 compared with 2025 were attributed to differences in rainfall and wind conditions following urea application. In 2024, light rainfall (<4mm) on the day of application, would have been sufficient to initiate urea hydrolysis but insufficient to move urea deeper into the soil profile, where the risk of volatilisation is reduced. Subsequent windy conditions over the following days, while urea remained near the soil surface, likely exacerbated volatilisation losses. In contrast, in 2025, over 6mm of rainfall fell on the day of urea application, followed by generally low wind conditions, with a brief increase in wind speed on day 6 when an additional 6mm of rain occurred. Overall, substantially higher post-fertiliser application rainfall in 2025 compared with 2024 helped maintain adequate surface soil moisture, thereby minimising the extent of volatilisation losses (Figure 2). Although the Horsham site received substantial rainfall (26mm) 10 days after urea application in 2025, total emissions were similar to those in 2024 (Fisher's LSD Test, P = 0.4860), as over 85% of the total volatilisation had already occurred before the rainfall event.

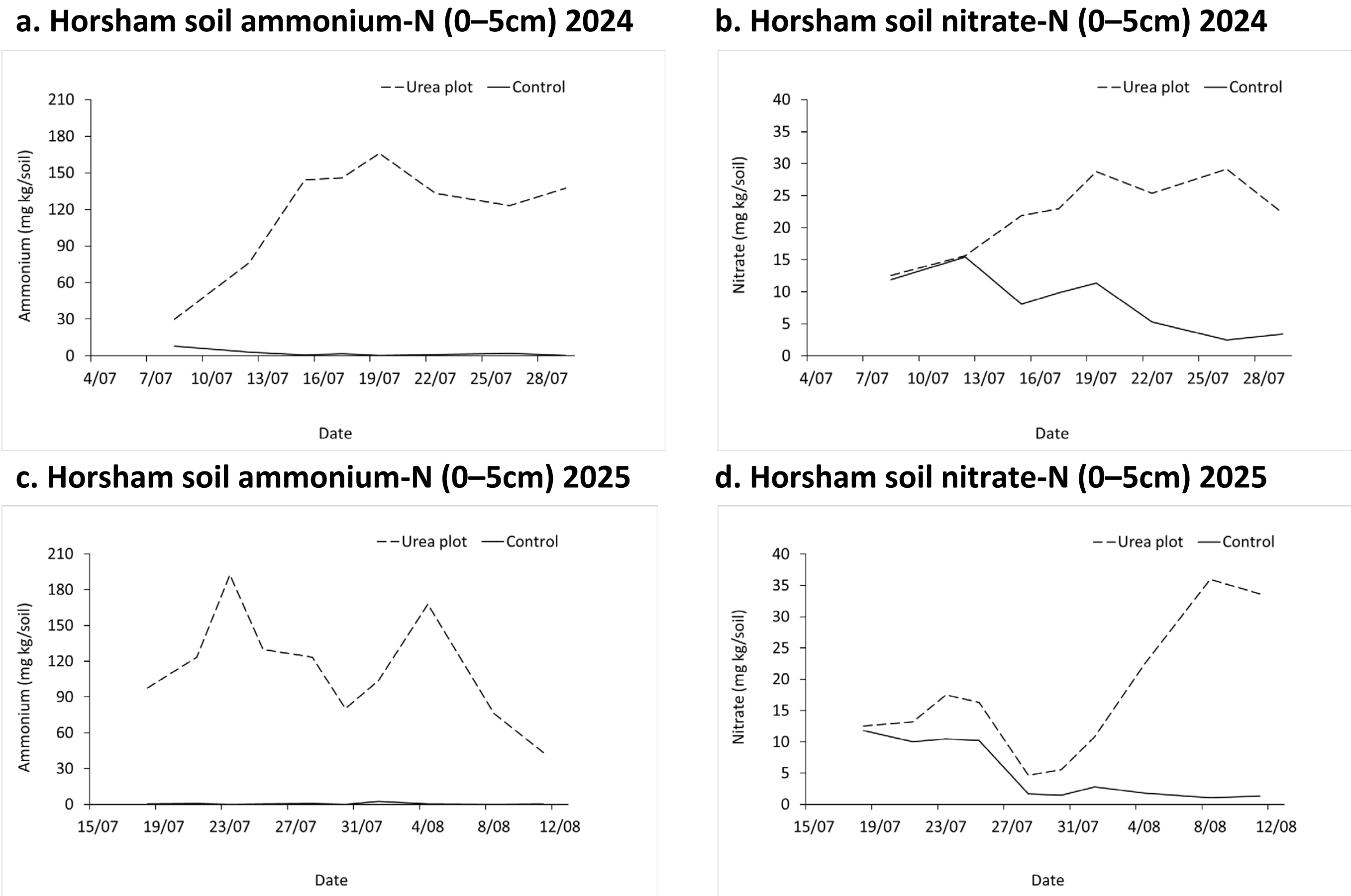

Figure 3. Ammonium-N and nitrate-N levels in surface soil (0–5cm) following urea top-dressing over the experimental period at Horsham. The y-axis scales differ between the ammonium-N and nitrate-N graphs.

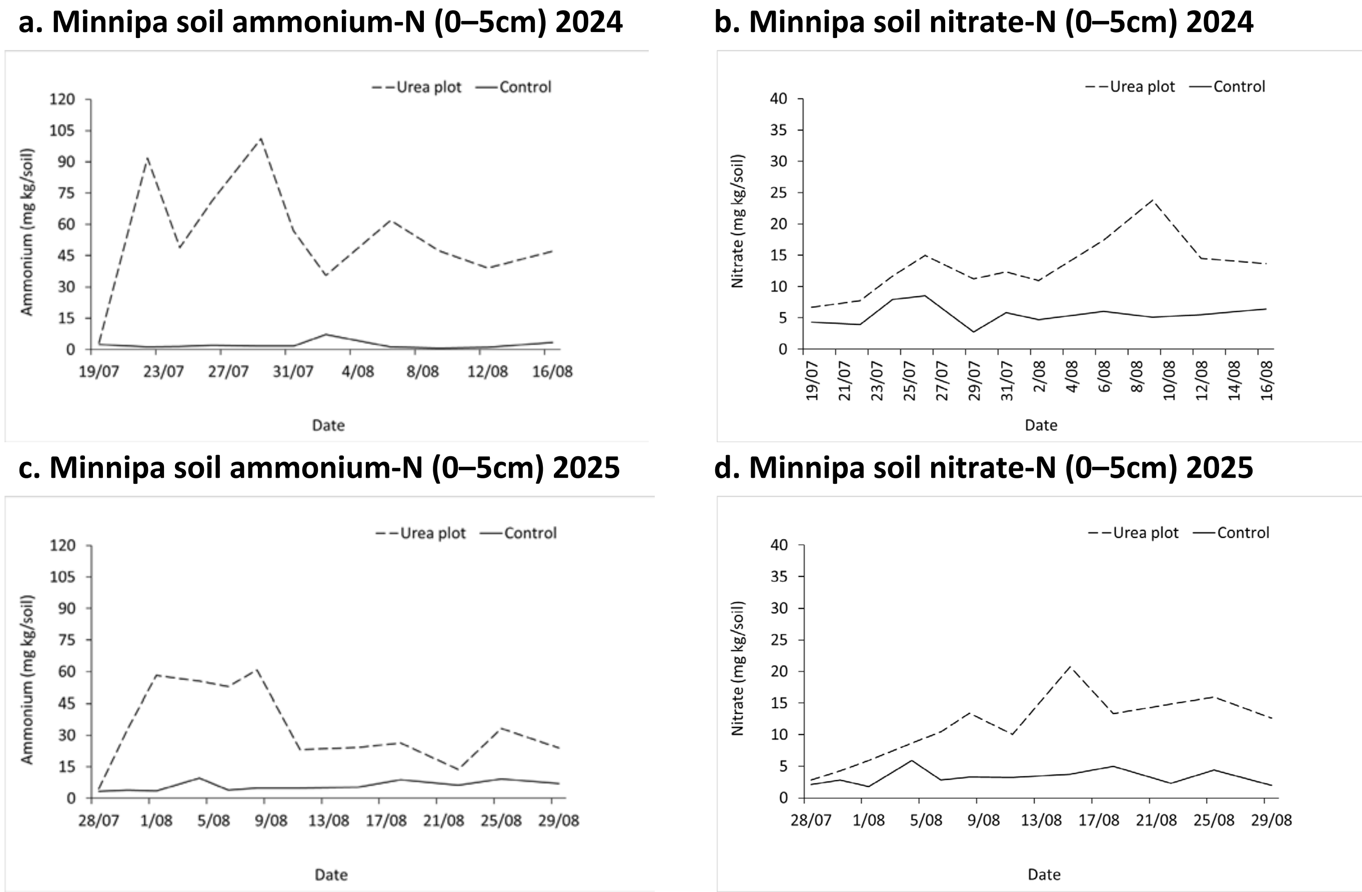

Figure 4. Ammonium-N and nitrate-N levels in surface soil (0–5cm) following urea top-dressing over the experimental period at Minnipa. The y-axis scales differ between the ammonium-N and nitrate-N graphs.

Overall, most NH_3 losses occurred within the first two weeks following urea application, emphasising this as the critical period for volatilisation. Soil ammonium-N levels in the urea-treated plots corresponded with this pattern, peaking between 10 and 15 days after application – indicating that urea hydrolysis was largely complete by this time – before gradually declining with some fluctuations (Figures 3 and 4). Soil nitrate-N levels in the urea plots gradually increased throughout the trial as ammonium-N was converted to nitrate-N, although this accumulation was moderated by crop uptake. At Minnipa, both ammonium-N and nitrate-N concentrations in the background plots remained low and relatively stable throughout the sampling period; however, at Horsham they were comparatively higher during the first half of the monitoring period in both years (Figures 3 and 4).

Conclusion

- Soil characteristics strongly influence NH_3 volatilisation losses from top-dressed urea. Across both seasons, per cent N lost as NH_3 of the applied N were consistently higher on a Calcarosol (Minnipa) compared with a Vertosol (Horsham), despite higher N application rates on the Vertosol (80kg N/ha vs 50kg N/ha). The lower losses on the Vertosol are largely attributed to its high clay content (45%) and greater CEC. In contrast, low clay (18%) Calcarosol, with the dominance of Ca^{2+}, presence of free calcium carbonate, and limited water-holding capacity, was more prone to volatilisation.
- Weather conditions at the time of and following urea application affect volatilisation. Higher wind speeds and light rainfall on the day of urea application at Minnipa in 2024 exacerbated losses by leaving urea near the soil surface and allowing rapid volatilisation. In 2025, greater rainfall on the day of application, coupled with generally lower wind conditions, maintained surface soil moisture and reduced NH_3 losses. At Horsham, even a substantial rainfall event later in the sampling period (26mm on day 10, 2025) did not affect total NH_3 volatilisation compared with 2024, as most volatilisation had already taken place before the rainfall.

- Most NH_3 losses happen quickly. Ammonia losses largely occurred within the first two weeks after urea application, highlighting the critical period for volatilisation.
- The findings reinforce that both soil type and seasonal weather conditions should be considered when planning urea management. On sandy, low-clay Calcarosols under dry and windy conditions, strategies to reduce volatilisation, such as split applications or using urease inhibitors, could be beneficial.

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The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the authors would like to thank them for their continued support. The authors also thank Agriculture Victoria and the South Australian Research and Development Institute (SARDI) for co-funding, as well as the Agriculture Victoria Horsham soil science technical team and SARDI Minnipa Agricultural Centre (MAC) staff for their support throughout the project, which contributed to its successful completion.

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Losses of fertiliser nitrogen via denitrification in Southeastern Australian cropping systems

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GRDC project codes: UOM2310-004RSX, UOQ2204-010RTX

Keywords

- denitrification, nitrogen loss, soil type, waterlogging.

Take home messages

- Marked differences in N loss were measured between contrasting cropping soil types, with cumulative N loss ranging from 4.6–31.7% of applied N during a two-week waterlogging event.
- Emissions of nitrous oxide (N_2O) increased with increasing rate of fertiliser N at Horsham (MRZ) and Hamilton (HRZ) field trial sites, whereas dinitrogen (N_2) emissions were unaffected by N rates.
- Acidic – neutral soils had larger proportions of total denitrification gaseous N emissions (N_2O + N_2) released as N_2O compared to the alkaline soils investigated.

Background

Denitrification is suspected to be a major nitrogen (N) loss pathway (Equation 1) that contributes to poor fertiliser N use efficiency in southeastern Australian (SEA) cropping systems (Wallace et al. 2022). Denitrification presents both economic and environmental penalties to the grains industry as wasted fertiliser-N inputs and as the main soil-based process releasing greenhouse gas product N_2O.

Equation 1. $NO_3^- \rightarrow NO_x \rightarrow N_2O \rightarrow N_2$

Nitrogen loss via denitrification increases when soil moisture is high and soil oxygen (O_2) becomes scarce leading to microbes utilising soil nitrate (NO_3^-) as an alternative electron acceptor to O_2 to continue respiration under anaerobic conditions. The winter dominant rainfall and low evaporation rates in the SEA cropping region contributes to periods of high surface soil moisture – conditions conducive for denitrification. Previous studies in the region tracing the fate of fertiliser N in cropping systems have measured up to 54% of applied N being unaccounted for at crop maturity (Harris et al., 2016a, 2016b; Wallace et al., 2018, 2022). In these studies, N loss via leaching was highly unlikely with limited movement of surface applied ^{15}N-labelled urea detected at depth in the heavy clay soil profiles. Consequentially, this 'unaccounted for N' was attributed to either losses via ammonia volatilisation or denitrification, with the latter occurring in seasons with periods of high soil moisture content. Although measurements of total denitrification (N_2O+N_2) are not available for this region, several studies have measured the intermediate denitrification gas product N_2O (Harris et al. 2016b, Wallace et al. 2018, 2022). These studies demonstrated that the magnitude of N_2O emissions is altered by soil type, changes in seasonal rainfall and N management decisions, such as varying the rate and timing of N application.

Dinitrogen (N_2) is the major N loss product of denitrification (N_2O+N_2) (Scheer et al. 2020), with average fluxes of N_2 emissions from terrestrial systems >10 fold larger than N_2O emissions. Measuring total denitrification in the field is extremely challenging due to difficulty detecting relatively small N_2 emissions against the large atmospheric N_2 concentration (~78%). The product ratio (N_2O:N_2) of denitrification emissions is rarely stable, responding to changes in NO_3^- levels, soil moisture conditions and soil physicochemical properties. Therefore, predicting N_2 emissions from N_2O emissions alone is not possible. We present the first denitrification (N_2O+N_2) measurements in the SEA cropping region, investigating:

- contrasting soil types under persisting waterlogging conditions
- contrasting N rates under field conditions in the high and medium rainfall zones.

Methods

The two investigations used the ^{15}N gas flux method detailed by Friedl et al. (2020) to estimate daily denitrification emissions (N_2O + N_2). This technique utilises 60 atom% enriched ^{15}N labelled fertiliser and emission chambers to determine the magnitude of daily denitrification emissions from the soil surface.

Contrasting soil types

Denitrification emissions from four contrasting soil types used for cropping from the western region of Victoria were investigated in a glasshouse experiment. Intact soil cores (15cm diameter and 30cm deep) collected from the field were returned to the glasshouse and waterlogging was imposed using an artificial water table maintained 10cm below the soil surface for two weeks. The soil types used were a Vertosol (Horsham), a Calcarosol (Walpeup), a Sodosol (Wonwondah) and a Chromosol (Hamilton). Soil properties varied in pH (5–7.1), organic carbon (0.47–2.7 %) and surface soil texture (loamy sand – clay) (Table 1). Surface gas emissions were taken on days 1, 2, 3, 5, 7 and 14 after 50kg N/ha was surface applied (as KNO_3 in solution), with gas emissions on non-measurement days determined by via linear interpolation between measurement days.

Contrasting nitrogen rates

The magnitude of denitrification was investigated with contrasting N rates in the 2024 cropping season at both Hamilton (Chromosol) and Horsham (alkaline Vertosol) field sites (Table 1). Urea-N was applied following crop emergence. At Hamilton, N was split applied (50:50) at GS23 and GS31, with treatment total rates of 120kg N/ha and 240kg N/ha. At Horsham, N was applied as an upfront application at GS23 of 50kg N/ha and 100kg N/ha. Measurements using semi-auto emission chamber sampling systems were taken following fertiliser application until anthesis.

Table 1. Victorian cropping soil profile physicochemical characteristics and site details. (g) = glasshouse experiment, (f) = field trial experiment.

Soil sites	Walpeup (g)	Horsham (g, f)	Wonwondah (g)	Hamilton (g)	Hamilton (f)
Annual rainfall (mm)	332	446	380	686	686
Soil classification	Calcarosol	Vertosol	Sodosol	Chromosol	Chromosol
Surface soil texture (0–10cm)	Loamy sand	Clay	Sandy clay loam	Clay loam	Silty Loam
pH ($CaCl_2$)	6.9	7.1	6.1	5.0	5.1
DOC (mg C/kg soil)	38	123	250	202	300
SOC (%)	0.47	0.78	1.6	2.7	3.0
Bulk density (g/cm^3)	1.64	1.20	1.35	1.17	1.12
Sand (%)	84.4	32.9	69.2	51.7	27.5
Silt (%)	1.9	27.1	7.2	24.2	24.7
Clay (%)	13.7	40.0	23.6	24.1	15.4
Gravel (%)	0	0	0	0	32.4

Results and discussion

Denitrification emissions from contrasting cropping soil types

Marked differences in the magnitude of denitrification emissions were observed between the contrasting cropping soil types during the two-week waterlogging event following fertiliser application. Both the magnitude of total denitrification emissions and the product ratio (N_2O:N_2) was impacted by the soil physicochemical properties. Cumulative mean N loss measured as surface emissions ranged from 2.3–15.9kg N/ha (equivalent to 4.6–31.7%) of applied N (Figure 1). Daily emissions were found to increase in the soils with higher levels of soil organic carbon (SOC). For example, the Hamilton Chromosol with the largest measured denitrification emissions had a SOC content of 2.7% compared to the other soil types investigated with SOC ≤1.6% (Table 1). The soils with the largest proportion of N loss released as N_2O were acidic – neutral soils (Hamilton Chromosol and Wonwondah Sodosol) (Figure 1). The complete reduction reaction of NO_3^- to N_2 (Equation 1) requires the enzyme N_2O reductase to convert N_2O to N_2. Acidity inhibits this reaction driving greater N loss released as N_2O (Bakken et al. 2012, Liu et al. 2014).

The range in denitrification emissions between soil types highlights that optimising N management is soil type specific. Management strategies that reduce the severity of waterlogging, such as improved soil structure and drainage infrastructure, may alleviate the risk of N loss and plant available N becoming limiting in seasons with high rainfall events and/or periods of waterlogging.

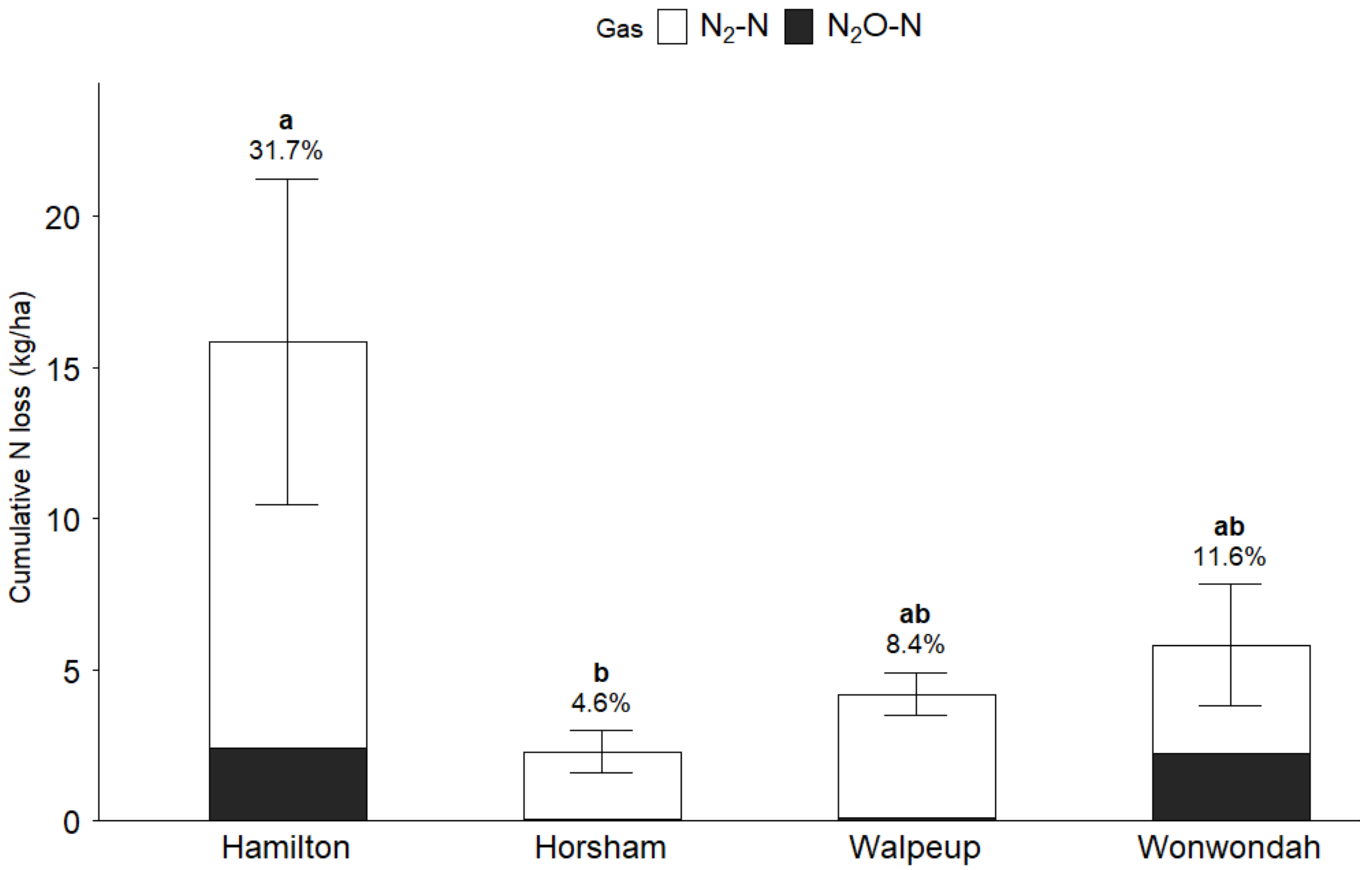

Figure 1. Cumulative denitrification N loss (N_2O +N_2) presented as means with standard error (SE) bars following two weeks of waterlogging, black = N_2O loss, and white = N_2 loss, the percentage below the SE bar letters describes the proportion of 50kg N/ha applied fertiliser lost via denitrification. Significant differences (p-value<0.05) in cumulative N loss between sites is indicated by changes in letters above the SE bars.

Denitrification under contrasting nitrogen rates

During field denitrification measurements at Horsham and Hamilton, increasing the N rate applied at each site caused significant increases ($p<0.05$) in the intensity of N_2O emissions released on some of the sampling days. However, N_2 emissions remained closely coupled between N rate treatments throughout the entire investigation period at both sites ($p>0.05$). Average N_2 emissions ranged from 0–173 g N_2-N/ha/day across the cropping season at Hamilton and from 0–59 g N_2-N/ha/day at Horsham (Figure 2). The intensity of emissions responded rapidly to changes in surface soil moisture and mineral N availability, with peak fluxes following rainfall (for example, mid-august and late November for Horsham, and July and August in Hamilton) and immediately following fertiliser addition (arrows in Figure 2). Daily N_2 emissions were >100 fold greater than N_2O emissions at both Hamilton and Horsham. With only one season and two rates of N per site considered, further work across different seasonal conditions and N rates is needed. Using simulation modelling to estimate total seasonal denitrification N losses remains a research focus in the wider GRDC N cycling and losses project (UOQ2204-010RTX).

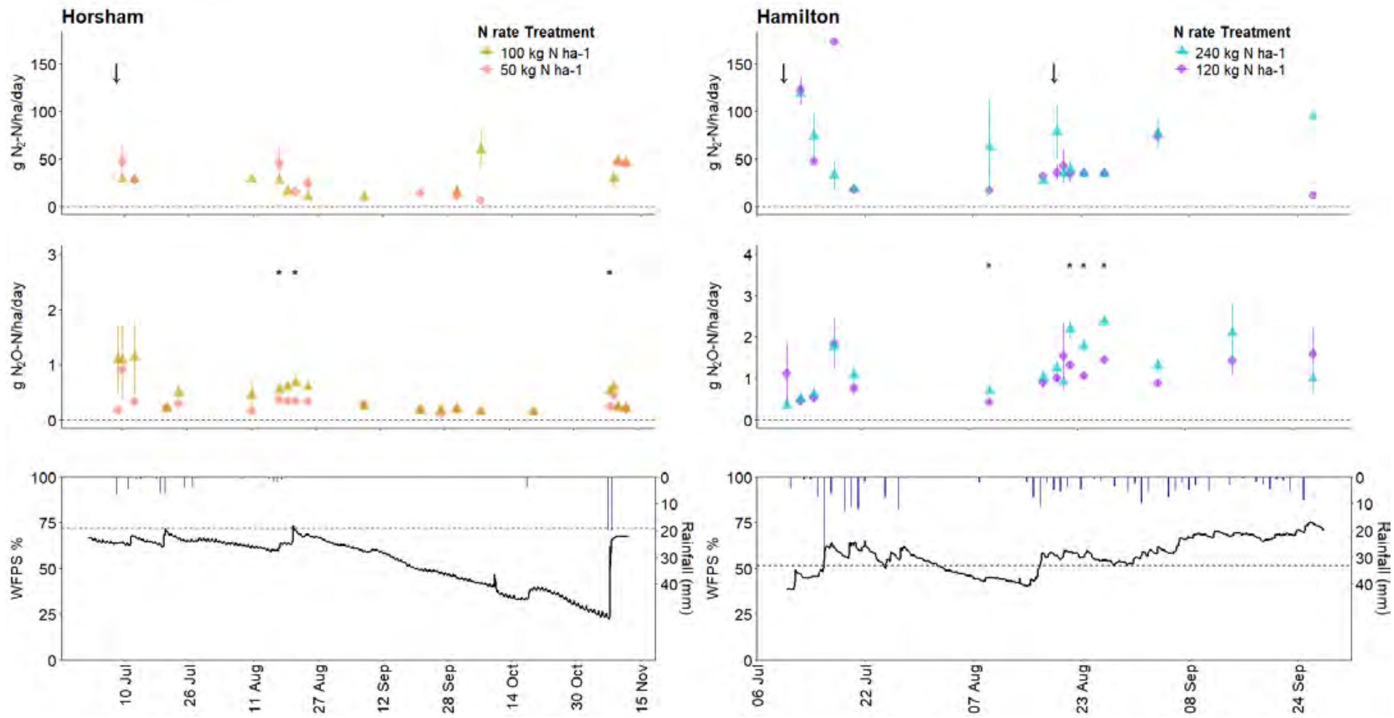

Figure 2. Winter 2024 cropping season denitrification gaseous losses (N_2O and N_2 g N/ha/day) presented as means with SE bars, with soil water filled pore space (WFPS) and rainfall (inverted on the secondary y axis). Treatment N rates are indicated by shape: Horsham 50 kg N/ha = circle and 100 kg N/ha = triangle, Hamilton: 120 kg N/ha = circle and 240 kg N/ha = triangle. Arrows indicate the timing of urea application. Horizontal dotted lines represent surface soil field capacity in the soil moisture and rainfall graphs. Significant differences (p-value<0.05) between N rates are indicated by *.

Conclusion

The SEA cropping region encompasses a large diversity of soil types and climates. These markedly different soil properties can alter the intensity of both total denitrification N loss and the product ratio N_2O:N_2 released under temporary waterlogging conditions. Increasing the rate of N applied increased the magnitude of daily N_2O emissions but not N_2 at both sites investigated. We highlight the importance of matching N supply with crop N demand, with surplus N contributing to heightened N_2O emissions.

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Mouse baiting for grain growers

Ben White, *BM White*

GRDC project code: BVW2302-001SAX

Keywords

- Mice, baiting, harvest losses, integrated pest management

Take home messages

- Minimise grain losses at harvest to reduce feed availability and lower risk of mouse population explosions.
- Monitor mouse activity and act early – baiting is most effective when mice have limited alternative food sources and before significant crop damage occurs.
- Invest in equipment that delivers accurate, even bait coverage, because successful mouse control depends as much on bait placement as bait choice.

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Acknowledgements

We would like to thank those who have contributed to the successful staging of the Streaky Bay GRDC Grains Research Update:

- The local GRDC Grains Research Update planning committee that includes growers, advisers and GRDC representatives.

- Partnering organisation: AIR EP

- Trade display supported by: Polytex

WE'D LOVE TO GET YOUR FEEDBACK

Prefer to leave your feedback online? Scan the QR with your phone camera.

OR use the form on the next page – tear it out and drop at the registration desk as you leave. Thank you!

2026 Streaky Bay GRDC Grains Research Update Feedback

1. **How would you describe your main role?** *(choose one only)*

- ❑ Grower
- ❑ Agronomic adviser
- ❑ Farm business adviser
- ❑ Financial adviser
- ❑ Communications/extension
- ❑ Grain marketing
- ❑ Farm input/service provider
- ❑ Banking
- ❑ Accountant
- ❑ Researcher
- ❑ Student
- ❑ Other* (please specify)

Your feedback on the presentations

For each presentation you attended, please rate the content relevance and presentation quality on a scale of 0 to 10 by placing a number in the box (**10 = totally satisfactory, 0 = totally unsatisfactory**).

2. **Cereal root disease - what are the issues and what are our options**
   Blake Gontar, SARDI

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

3. **Protecting your most perishable asset - latest tips on grain storage**
   Ben White, BM White

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

4. **Crop flowering calculator, an online tool to optimise sowing date for wheat, barley and canola**
   Jeremy Whish, CSIRO

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

5. Cycling and losses of N in the cropping system
Nigel Wilhelm, SARDI

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

6. Mice, reducing feed supply and improving control
Ben White, BM White

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

Your next steps

7. Please describe at least one new strategy you will undertake as a result of attending this Update event

8. What are the first steps you will take?
e.g. seek further information from a presenter, consider a new resource, talk to my network, start a trial in my business

Your feedback on the Update

9. This Update has increased my awareness and knowledge of the latest in grains research

Strongly agree	Agree	Neither agree nor Disagree	Disagree	Strongly disagree
❑	❑	❑	❑	❑

10. Do you have any comments or suggestions to improve the GRDC Update events?

Thank you for your feedback.

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