GRAINS RESEARCH UPDATE 2026

Cummins, SA
Wednesday 29 July

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GRAINS RESEARCH UPDATE 2026

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Cummins

Wednesday 29 July

9.00am to 1.00pm

Cummins Community Sports Club,
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#GRDCUpdates

CUMMINS GRDC Grains Research Update
convened by ORM Pty Ltd.

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GRDC Grains Research Update CUMMINS

Contents

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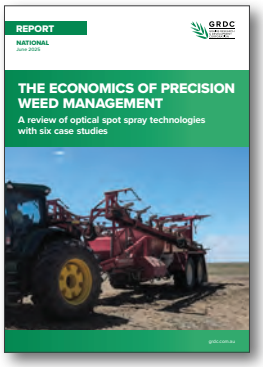

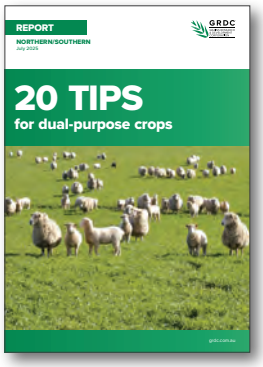

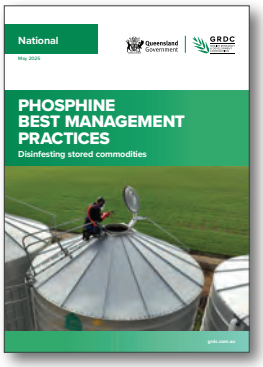

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GRAINS RESEARCH UPDATE 2026

Cummins Community Sports Club, Wednesday 29 July

PROGRAM

9.00am	Announcements and GRDC welcome	*GRDC representative*
9.15am	Pulse 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	Cycling and losses of N in the cropping system	*Nigel Wilhelm, SARDI*
11.45pm	Mice, reducing feed supply and improving control	*Ben White, BM White*
12.25pm	Getting best bang for buck on canola fungicides	*Ang Van de Wouw, University of Melbourne*
1.10pm	Lunch	

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SOUTHERN PANEL

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.

Pulse root disease – what are the issues and what are our options

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

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

GRDC project codes: UOA2206-007RTX, UOA2507-002RTX

Keywords

- integrated disease management, pulses, root disease, soilborne disease.

Take home messages

- Field experiments conducted in South Australia over three years have shown yield losses of up to 77% from Fusarium root rot, 49% from Aphanomyces root rot and 50% from Rhizoctonia root rot in lentil and faba bean, across a range of environments.
- Surveys conducted across southern Australia show multiple soilborne diseases including Aphanomyces, Rhizoctonia, Fusarium, Pythium and Phoma root rots are affecting pulses including lentil, faba bean, chickpea and lupin.
- There are partially effective management options for most soilborne diseases which can be combined into an effective integrated disease management package which complements other objectives, such as good weed control.

Background

Key soilborne diseases such as crown rot, Rhizoctonia root rot and root lesion nematode are estimated to cost Australian grain growers more than $500 million per annum in direct yield losses – an average loss of ~$38 ha over every paddock, every year – in wheat and barley alone. These diseases are quite well known by growers and agronomists and often are identified where they have a clear impact on a crop.

Pulses and canola are also impacted by soilborne diseases. But unlike cereals, these diseases are less well known by industry, and impacts may go unnoticed or be misdiagnosed. Globally, several diseases are considered major constraints to pulse production, including Aphanomyces root rot, which is considered a major issue across the northern USA, Canada, France and the UK. Increasingly, researchers in the USA and Canada are identifying several *Fusarium* species which act in complex to cause Fusarium root rot in a wide range of pulses. Yield losses of up to 84% in dry bean, and typically in the range of 10–30% are reported (Bogdan 2025).

A previous GRDC investment 'Impact of root diseases on pulse crops in Northern and Southern regions' began quantifying the losses in lentil, chickpea, faba bean and lupin in Australian pulse production, while a new investment under the National Soilborne Disease Initiative will focus on epidemiology and integrated disease management. The key aim of the collaborative team, which includes SARDI, NSWDPI, Agriculture Victoria, WA DPIRD, USQ and Queensland DAFF, is to determine economically-viable management options for the key root diseases which reduce pulse yields across a range of environments and seasons.

Causes and distribution of root diseases in lentil and faba beans

A survey of pulse root diseases was conducted nationally from 2019–2020, with additional data collected in South Australia the year prior (2018). Approximately 950 samples were processed, including ~350 from SA. About 70% of SA samples were lentil and faba bean. Briefly, the research team used two molecular methods, qPCR and Next

Generation Sequencing, to identity the potential pathogens that were present in the roots of pulses with root disease symptoms. Visual symptoms were assessed and recorded, and we attempted to isolate causal fungi and oomycetes ('water moulds' like *Pythium* and *Phytophthora* spp.) in the lab. Isolates were then studied on their own to determine if they were the original cause of disease, and what other crops they may impact. Three of the key pathogens identified in the survey and tested in lab assays are discussed below.

Aphanomyces euteiches

This pathogen has an international reputation as a major constraint in pea and lentil, causing very large yield losses. The survey found that it is particularly focused in the faba bean growing regions of SA and NSW. It was previously known to be present in northern NSW and is also known to be an issue in horticultural production of pea in Tasmania, and green bean in Victoria and NSW. Although it was only detected in 6% of SA faba bean samples during the survey, all of these came from the SE or Kangaroo Island. Subsequent surveys and monitoring in these two regions suggests it may be present in closer to 30% of paddocks in these regions.

A growth room assay showed that all isolates collected from SE faba beans and soils caused plant death in both faba bean and lentil, with little variation in virulence (Figure 1).

A) Faba bean

Isolate	Visual root disease score (0-10)	Root biomass / plant (g)
Control	0.18 a	0.44 c
SBD23/1	6.8 bc	0.17 a
SBD23/4	3.8 ab	0.37 bc
SBD23/5	8.8 c	0.24 ab
SBD23/9	9.2 c	0.12 a
SBD23/10	3.2 a	0.40 bc

B) Lentil

Isolate	Visual root disease score (0-10)	Root biomass / plant (g)
Control	0.1 a	0.05 b
SBD23/1	9.3 b	0.01 a
SBD23/4	9.3 b	0.01 a
SBD23/5	9.9 b	0.01 a
SBD23/9	9.8 b	0.01 a
SBD23/10	7.6 b	0.01 a

Figure 1. Effect of five *Aphanomyces euteiches* isolates from SA on plant growth, root health (root disease score, 0–10) and root biomass of A) faba bean, PBA Bendoc$^{\phi}$ and B) lentil, PBA Hallmark XT$^{\phi}$, tested in a controlled environment assay. Data followed by the same letter in the same column are not significantly different (p=0.05).

Fusarium spp.

Fusarium spp. were some of the most detected and isolated species from diseased survey samples. Among the most common were *Fusarium oxysporum* (actually a species group), *F. acuminatum*, *F. tricinctum*, *F. solani* (actually a species group), *F. avenaceum* and *F. redolens.* These last two were of particular interest, as they are identified in the literature as pathogens in related legume crops, or in pulse crops overseas. *F. avenaceum* was present in ~15% of samples, while *F. redolens* was detected in ~10% of samples. *F. redolens* detections were concentrated around SA and Victoria (Figure 2). Pathogenicity of five *F. avenaceum* and two *F. redolens* isolates were tested in controlled environment room (CER) assays and showed moderate to strong disease effects.

Figure 2. Distribution of *F. avenaceum* (blue dots) and *F. redolens* (red dots) detected by NGS in 2019 and 2020 national survey samples (left) and controlled environment study conducted at the Plant Research Centre, Waite in 2020 with examples of *F. avenaceum* and *F. redolens* in faba bean roots (right).

Rhizoctonia solani (AG8 and AG2.1)

Rhizoctonia solani isolates can be separated by mating type (anastomosis groups, AGs). *R. solani* AG8 is the best known and is associated with the cereal root disease Rhizoctonia root rot. It is very common, especially across drier, sandier soil types found in the SA and Victorian Mallee, YP, upper-SE and upper-EP. It is known to affect pulse crops, but pulse crops are generally considered 'break crops' for Rhizoctonia root rot, since they have been shown to reduce inoculum overall. However, the survey did highlight that pulse root health is often affected by *Rhizoctonia*. The survey found that *R. solani* AG8 was present in approximately 40% of lentil and 27% of faba bean samples. Rhizoctonia alone was occasionally observed as the key root disease in individual pulse crops (Figure 3).

Figure 3. Lentils collected near Kimba in 2020 showing characteristic Rhizoctonia patches in the paddock, and spear tips on roots. Root samples tested with qPCR had 287pg ***Rhizoctonia*** AG8 DNA/g of root, and no substantial level of any other pathogen.

Yield loss

Aphanomyces root rot (ARR)

Two field trials conducted in 2024 and 2025 at Kybybolite in SA demonstrate how damaging this disease can be for SA growers. The non-irrigated faba/broad beans sown into inoculum at Kybybolite in 2024 showed limited disease symptoms, likely due to the very dry season (~decile 2 rainfall). However, there was still an 8% yield loss in inoculated treatments, regardless of variety. No yield impact was observed in lentils at the same site.

More dramatic results were observed in the field experiment conducted at Kybybolite in 2025, (decile 5 rainfall), where ARR reduced faba/broad bean yield by 39% and lentil yield by 12%. There did not appear to be any yield difference between lentil varieties (Figure 4), whereas the impact of ARR was greater in PBA Bendoc$^{\phi}$ and PBA Amberley$^{\phi}$ than in PBA Samira$^{\phi}$ and particularly Aquadulce (Figure 5).

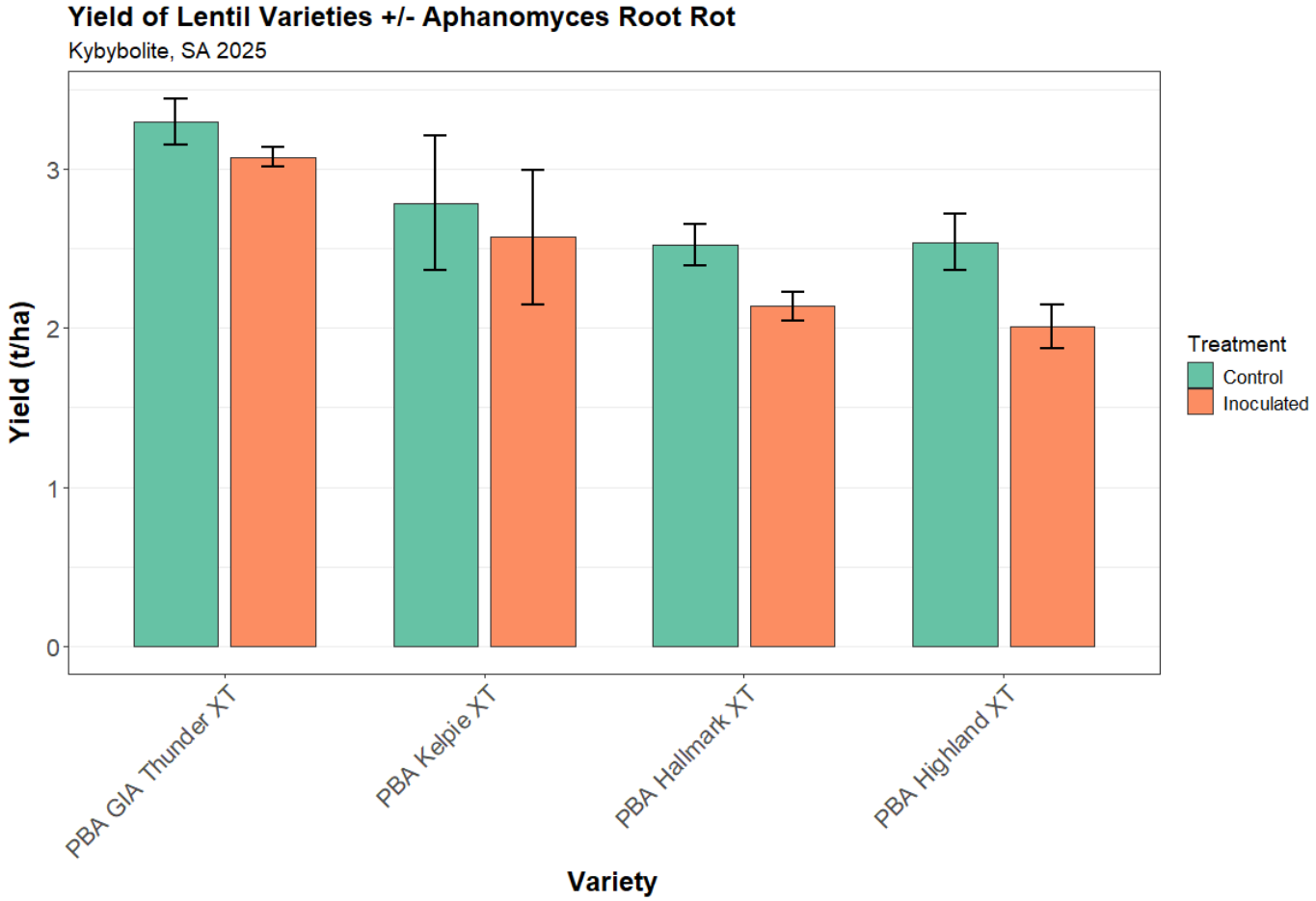

Figure 4. Yield (t/ha) of lentil varieties sown non-inoculated (Control) or sown into *A. euteiches* inoculum (Inoculated) at Kybybolite in 2025.

The results from Kybybolite in 2025 indicate that current varieties vary in their resistance to ARR, and choosing a more ARR-resistant variety is likely to be profitable in the presence of ARR. These results reflect similar work undertaken at Liverpool Plains, NSW in 2023 under irrigated conditions, where diseases symptoms were much greater, and resulted in up to 60% yield loss in the most susceptible variety, PBA Amberley(ϕ). PBA Samira(ϕ) appeared most resistant, and no significant yield loss was measured (P = 0.023).

Furthermore, the results show that *A. euteiches* isolates obtained from faba bean roots/soil in SA are capable of reducing yield in lentil varieties too.

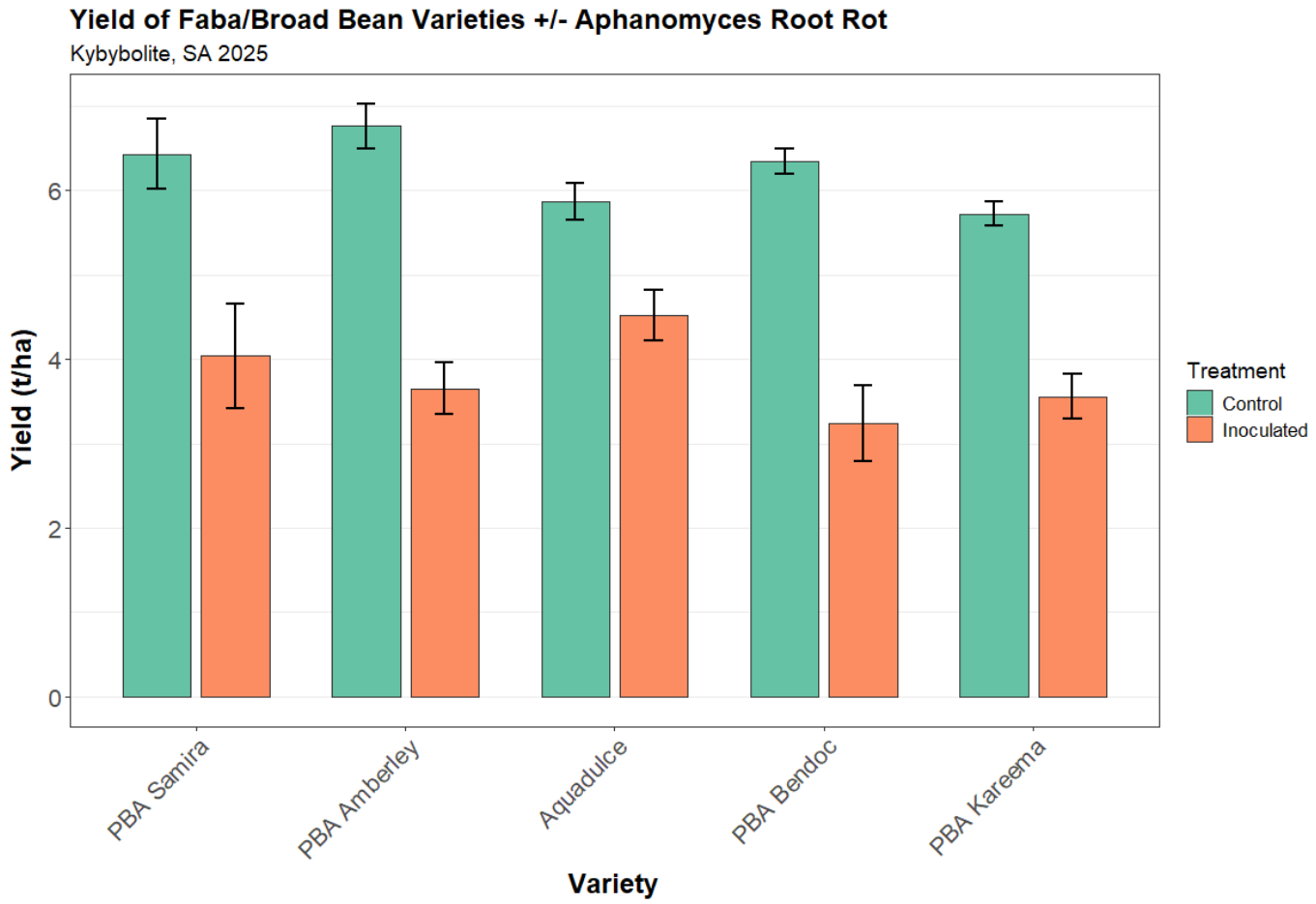

Figure 5. Yield (t/ha) of faba bean varieties sown non-inoculated (Control) or sown into *A. euteiches* inoculum (Inoculated) at Kybybolite in 2025.

Fusarium root rot

Field experiments have been conducted in SA and Victoria from 2023–24, and recorded yield loss from *F. avenaceum* up to 77% in lentil and 56% in faba bean at Roseworthy in 2023. A further experiment was conducted at Pinery in 2024, which investigated yield impacts of *F. avenaceum* at two sowing dates and at different levels of soil inoculum (Figure 6). This experiment also included an off-label seed treatment, which the research team considered may be effective on this *Fusarium*. There was a somewhat linear response to inoculum level in both lentil and faba bean, with low-rate inoculum reducing bean yield by 14% in the earlier sown treatment but no impact on yield in the later sown crop. At the higher rate of inoculum, *F. avenaceum* reduced bean yield by 43% (early sown, 'TOS1') and 32% (later sown, 'TOS2'). The seed treatment improved yield when applied with the medium rate of inoculum, although not quite to the level of non-diseased plots.

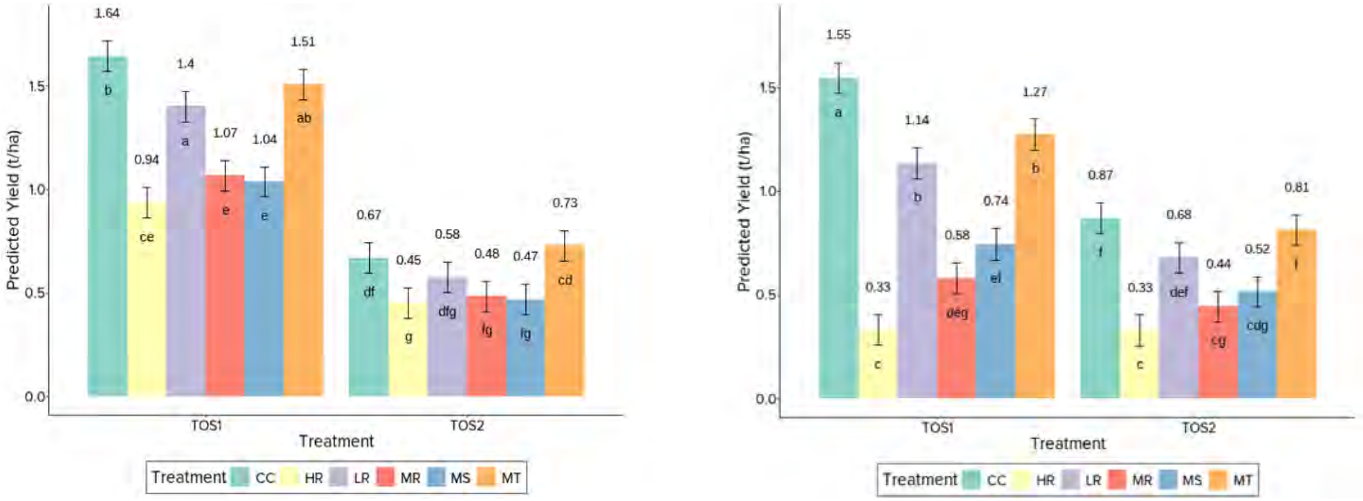

Figure 6. Yield of faba bean (left) and lentil (right) sown non-inoculated (control: CC) or sown into *F. avenaceum* inoculum (LR = low rate, MR = medium rate, HR = high rate, MS = medium rate + seed spore suspension), or sown into a medium rate of inoculum but with a seed treatment (MT) at Pinery in 2024.

Rhizoctonia root rot

A single field experiment conducted at Loxton in 2023 found that Rhizoctonia root rot caused yield loss at high rates of inoculum of 50% ($P < 0.001$), however no significant yield loss was recorded at lower rates of inoculum.

Developing control options

The yield-loss studies presented above generally evaluated a couple of management strategies. Firstly, the Fusarium, Aphanomyces, Phoma and Rhizoctonia experiments all demonstrated that soilborne inoculum level impacts disease development and yield loss. This is an important implication because it tells us that if inoculum levels are kept low, mainly through rotations with non-hosts, then yield loss will be reduced. All of these pathogens can be tested for using qPCR to confirm their presence in the paddock to estimate inoculum levels.

Furthermore, seed treatments were shown to have impact for disease control of Fusarium root rot and Phoma root rot. A seed treatment applied in the Rhizoctonia trial also looked effective at establishment and is currently being considered for registration. These experiments show there are active ingredients which could be registered in pulses to improve yield.

Finally, ongoing research into Aphanomyces root rot in faba bean indicates that variety resistance already exists in Australian faba bean varieties. Where the pathogen is identified, growing a resistant faba bean will improve yield. Further work is being conducted to confirm varietal impacts, including in lentil.

If you observe root disease in pulses or are unsure what is causing poor growth in a pulse crop, contact Blake Gontar on 0430 597 811 to discuss sampling and diagnostic options.

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. We would like to acknowledge the contribution of many staff from DPIRD (WA), NSWDPI, UQ, QDAF, Agriculture Victoria and SARDI in supporting previous research including surveys referred to in this paper. We would also like to acknowledge the many agronomists and growers have either provided samples or supported us in locating crops to collect samples from, or hosted field experiments referred to in this paper.

References

Bogdan J (2025*)* Fusarium root rot in pulse crops. Saskatchewan Pulse Growers. https://saskpulse.com/resources/fusarium-root-rot-in-pulse-crops/?download-pdf

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Contact - Southern region

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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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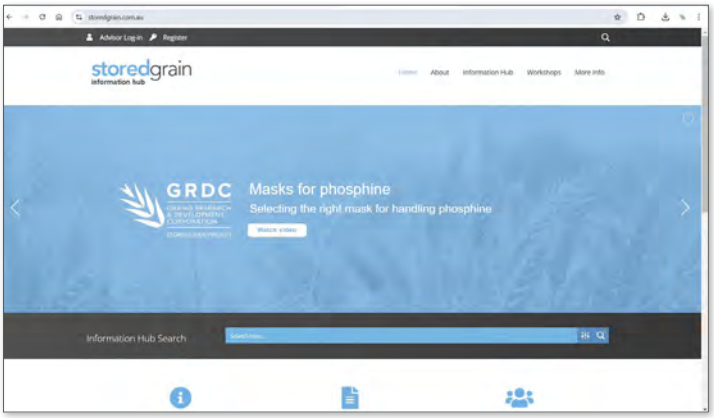

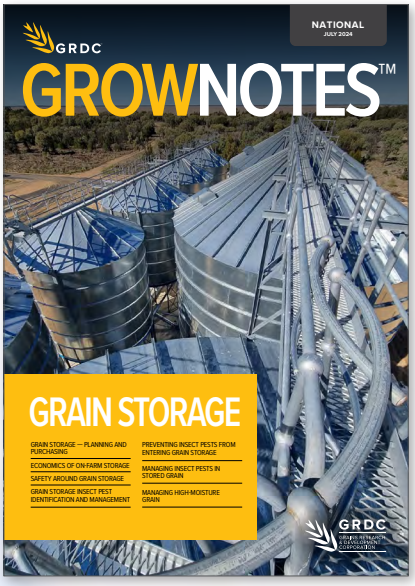

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How much urea N is being lost as volatilisation

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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.

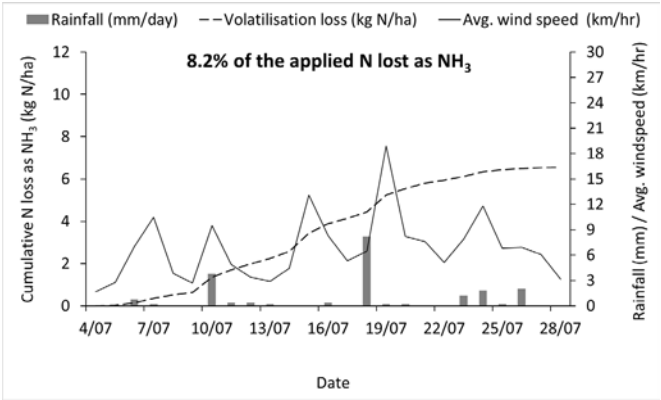
Results and discussion

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.

a. Horsham NH_3 volatilisation 2024



b. Horsham NH_3 volatilisation 2025

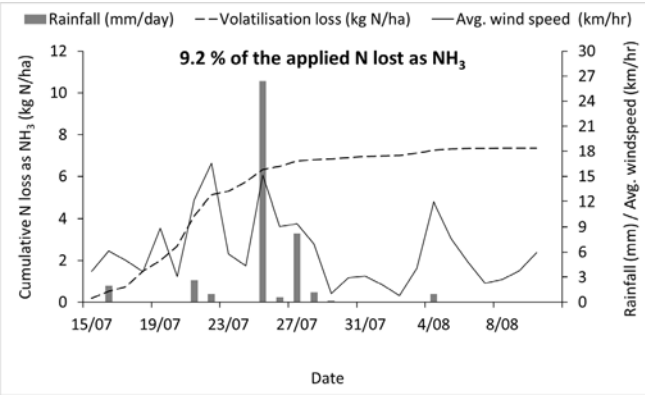
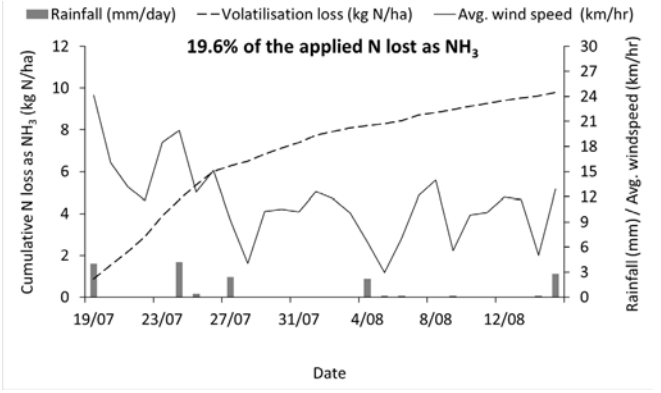


Figure 1. Cumulative NH_3 losses following urea top-dressing over the experimental period, together with daily rainfall and wind speed at the Horsham site during (a) 2024 and (b) 2025.

a. Minnipa NH_3 volatilisation 2024



b. Minnipa NH_3 volatilisation 2025

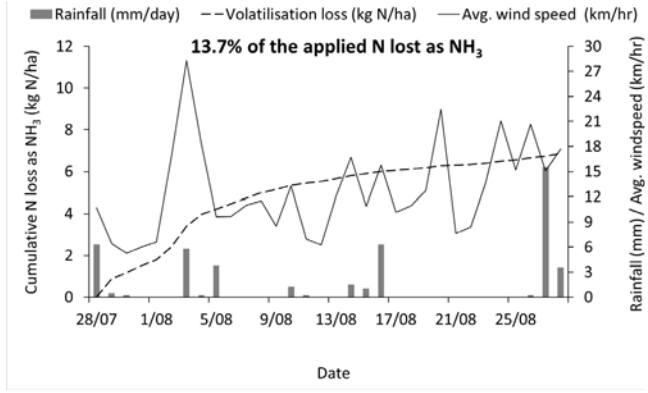


Figure 2. Cumulative NH_3 losses following urea top-dressing over the experimental period, together with daily rainfall and wind speed at the Minnipa site during (a) 2024 and (b) 2025.

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.

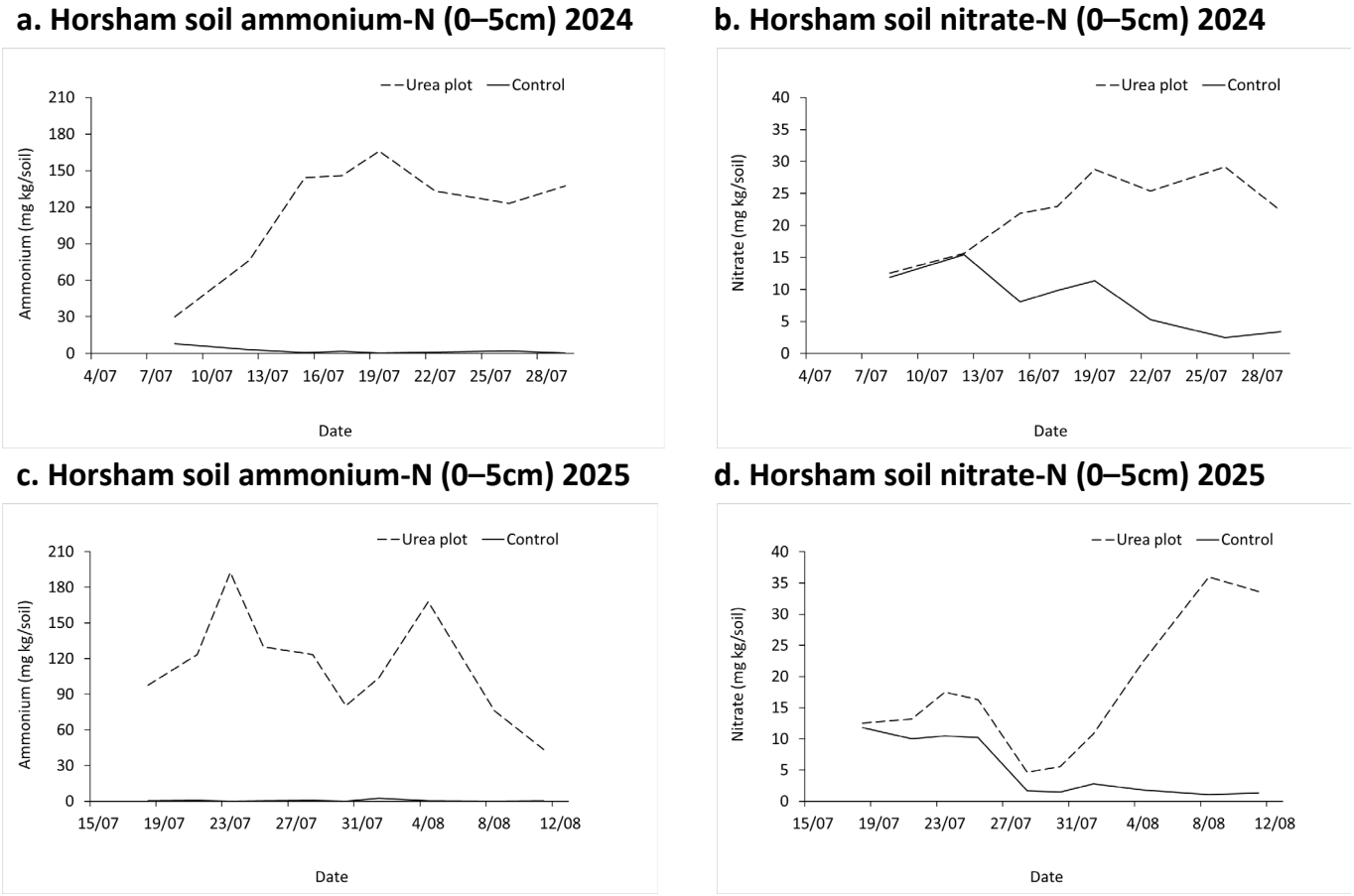


Figure 3. Ammonium-N and nitrate-N levels in surface soil (0–5cm) following urea top-dressing over the experimental period at Horsham. The y-axis scales differ between the ammonium-N and nitrate-N graphs.

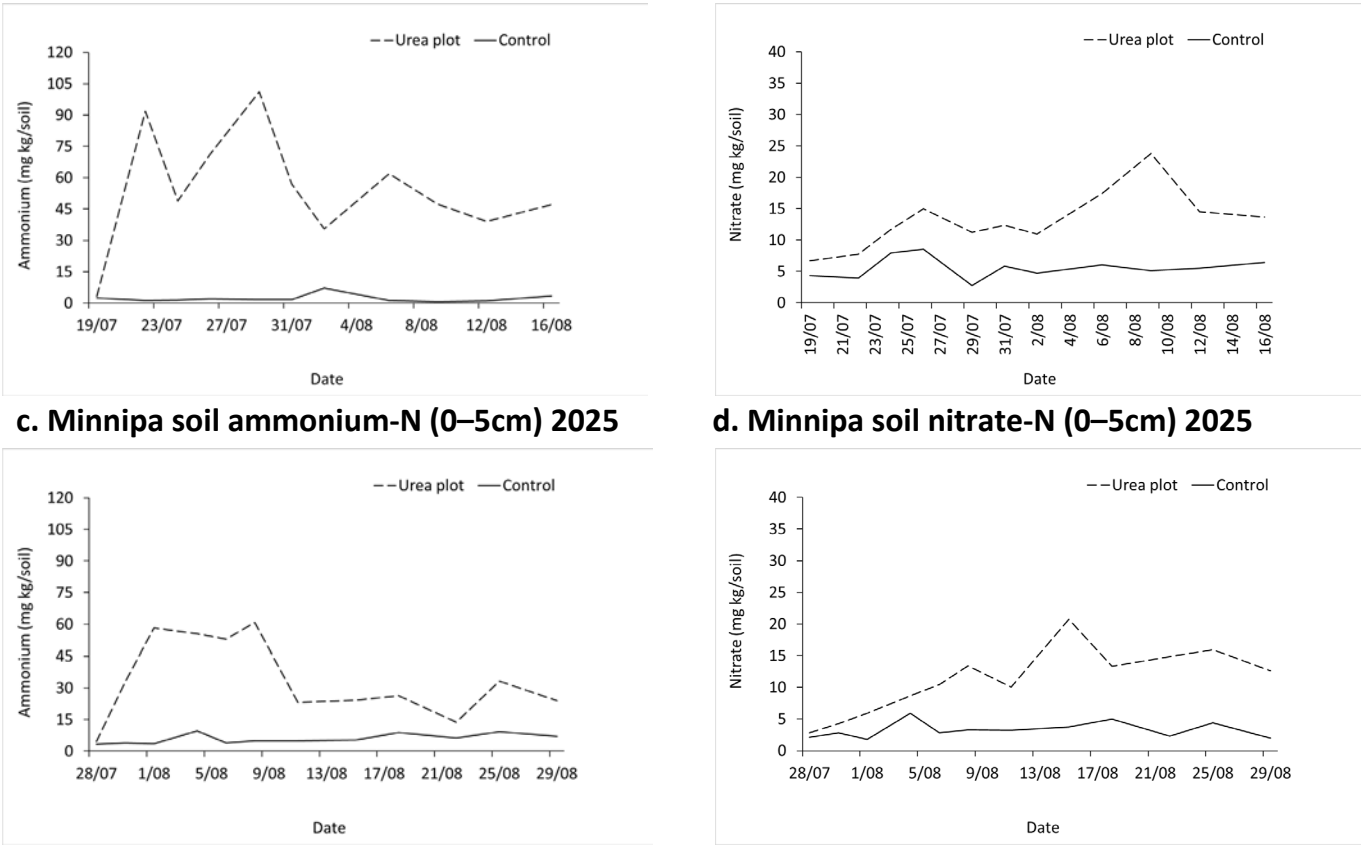


Figure 4. Ammonium-N and nitrate-N levels in surface soil (0–5cm) following urea top-dressing over the experimental period at Minnipa. The y-axis scales differ between the ammonium-N and nitrate-N graphs.

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.

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. 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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Notes

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.

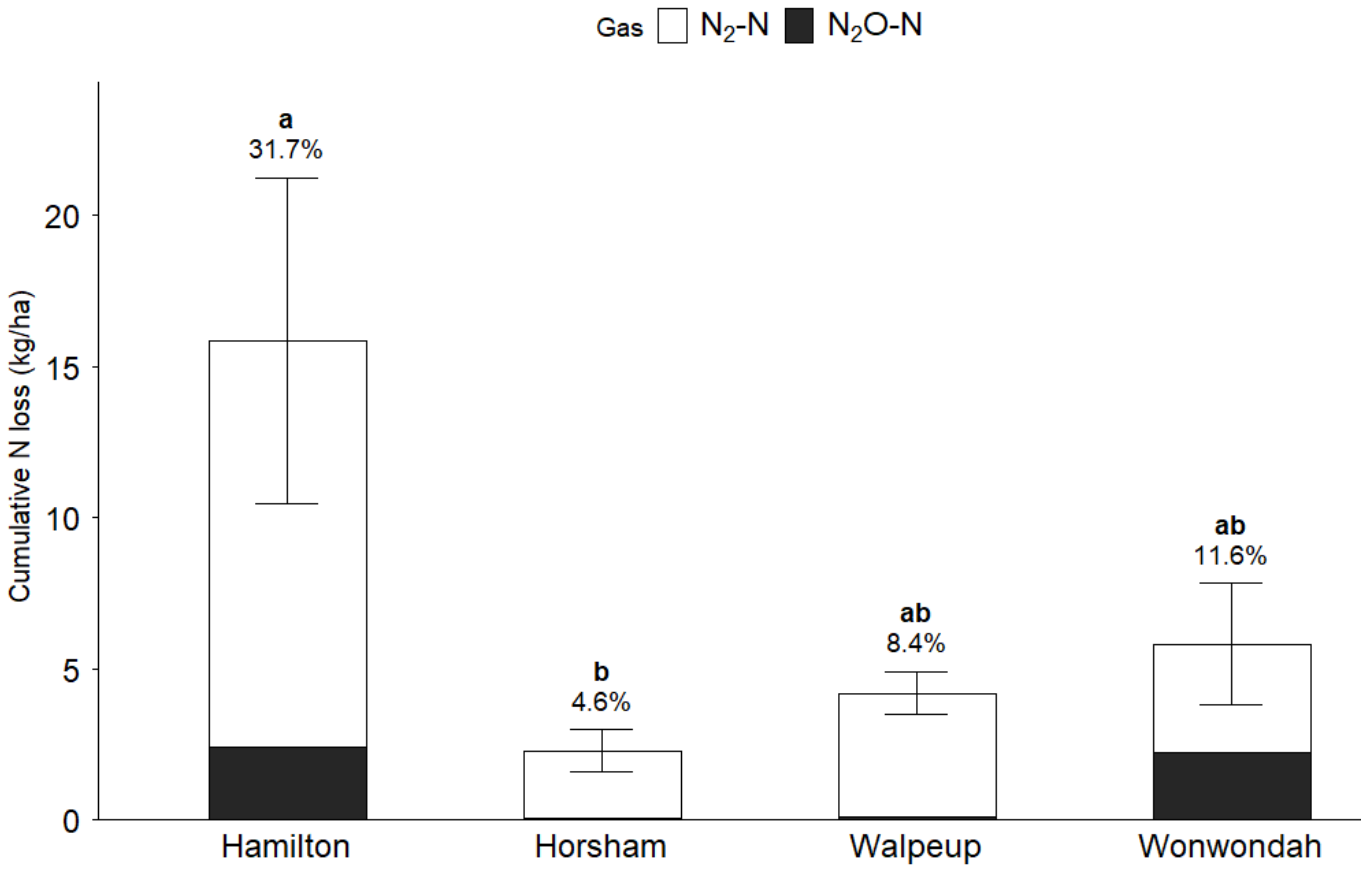

Figure 1. Cumulative denitrification N loss (N_2O +N_2) presented as means with standard error (SE) bars following two weeks of waterlogging, black = N_2O loss, and white = N_2 loss, the percentage below the SE bar letters describes the proportion of 50kg N/ha applied fertiliser lost via denitrification. 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).

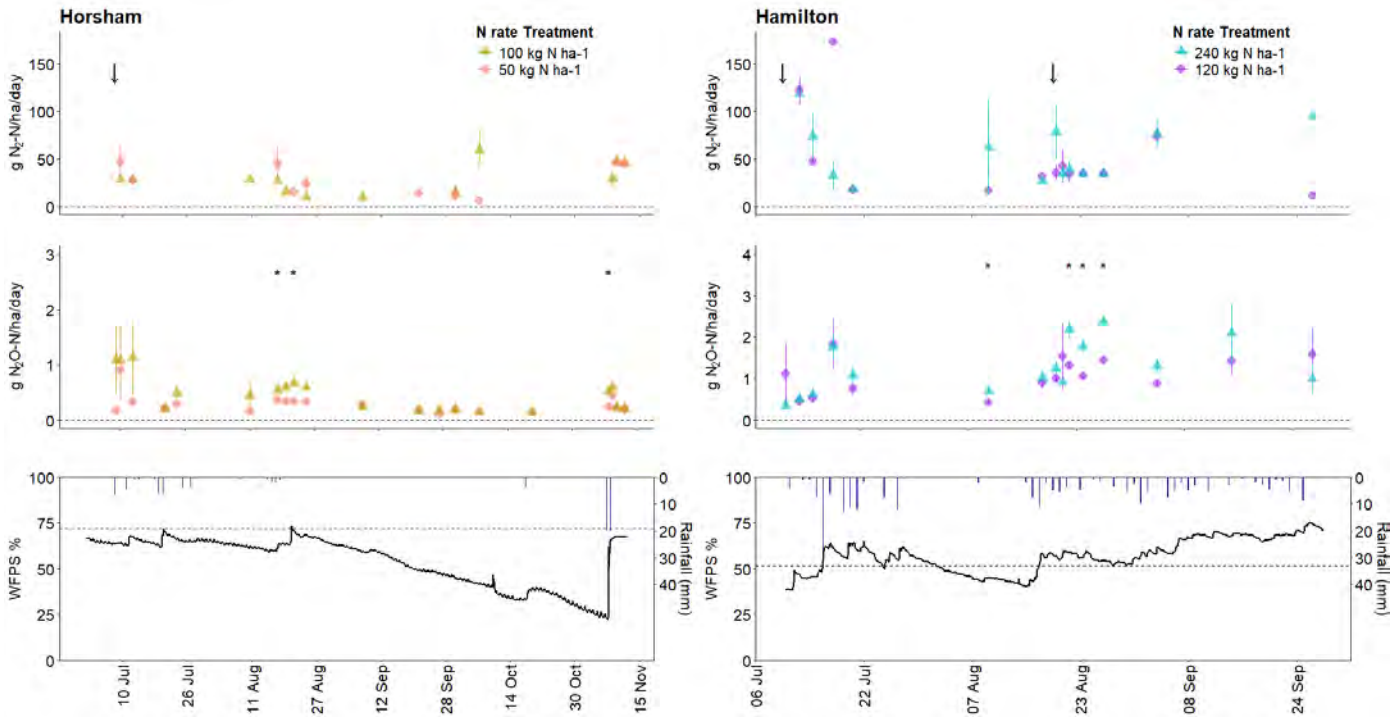

Figure 2. Winter 2024 cropping season denitrification gaseous losses (N_2O and N_2 g N/ha/day) presented as means with SE bars, with soil water filled pore space (WFPS) and rainfall (inverted on the secondary y axis). Treatment N rates are indicated by shape: Horsham 50 kg N/ha = circle and 100 kg N/ha = 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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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. We thank Agriculture Victoria for funding. We are particularly grateful to the Agriculture Victoria technical staff who assisted in maintaining the trial sites. Gas and solid isotope analysis was conducted by Central Analytical Research Facility (CARF) at the Queensland University of Technology.

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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.

Notes

Notes

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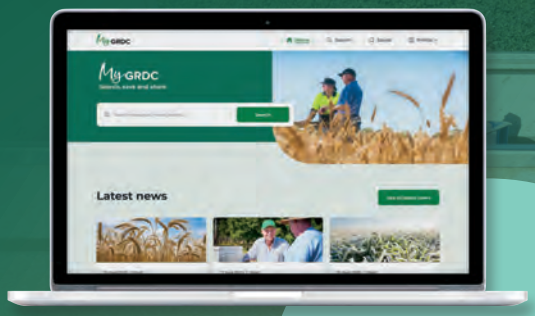

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GRDC

Getting the best bang for buck on canola fungicides

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GRDC project codes: MGP2504-002RTX, MGP2504-0022RTX

Keywords

- blackleg, canola, disease management, fungicides.

Take home messages

- Increased canola intensity will result in higher disease levels.
- Use non-fungicide disease control strategies where possible.
- Applications at 30% bloom are likely needed in 2026 to control upper canopy infection.
- Blackleg can be successfully managed but it requires a combination of crop management, cultivar resistance and strategic use of fungicides.
- Resistance to DMI fungicides (Group 3) has been detected across all canola growing regions in Australia whilst resistance to the SDHI fungicides (Group 7) has been detected only on the Eyre Peninsula to date. No resistance has been detected to the QoI fungicides (Group 11).

Background

Blackleg disease is controlled through a combination of cultural practices, genetic resistance and fungicides. The main cultural practice is isolation from previous years' canola stubble by at least 500m to reduce inoculum and disease pressure, but infections will still occur outside of this distance.

Good genetic cultivar resistance (high blackleg rating) is the most effective way of controlling blackleg disease. However, blackleg populations overcome genetic cultivar resistance and blackleg populations are different in different regions and on individual farms. Simply put, blackleg populations will evolve in response to the resistance of the cultivar growing on your farm. If you sow a new cultivar, its blackleg rating will likely be as reported in the blackleg management guide. If you have sown the same cultivar for more than three years, then the rating of your cultivar may be reduced, that is, if the cultivar was MR when first grown, three years later it may behave as a MRMS on your farm. This blackleg evolution is highly driven by disease pressure. Regions that grow two crops of canola over three years with high rainfall will result in blackleg populations evolving quickly. Moderate rainfall regions with less intensive canola tend to maintain their genetic resistance ratings for longer.

Reliance on fungicides to control blackleg disease has increased substantially over the past five years, with an average of 2.5 applications a season in 2024 compared to only 1.5 applications in 2018. Fungicides are used at three different growth stages to control the various forms of blackleg disease (Figure 1). Seed-dressing and fungicide-amended fertiliser are used to control crown canker, as infection at the seedling stage leads to the development of crown canker. Foliar applications at the 4–8 leaf stage are also aimed at controlling crown canker. Lastly, 30% bloom foliar applications are used to control upper canopy infection (UCI).

Increased use of fungicides increases the probability of the pathogen evolving causing fungicide resistance. When fungicide resistance evolves in the field, it can lead to either reduced or complete loss of efficacy of the corresponding fungicide actives. From 2018 to present, we have monitored the frequency of fungicide resistance across Australian blackleg populations. We have also investigated which specific on-farm practices may be potentially driving selection of fungicide resistance.

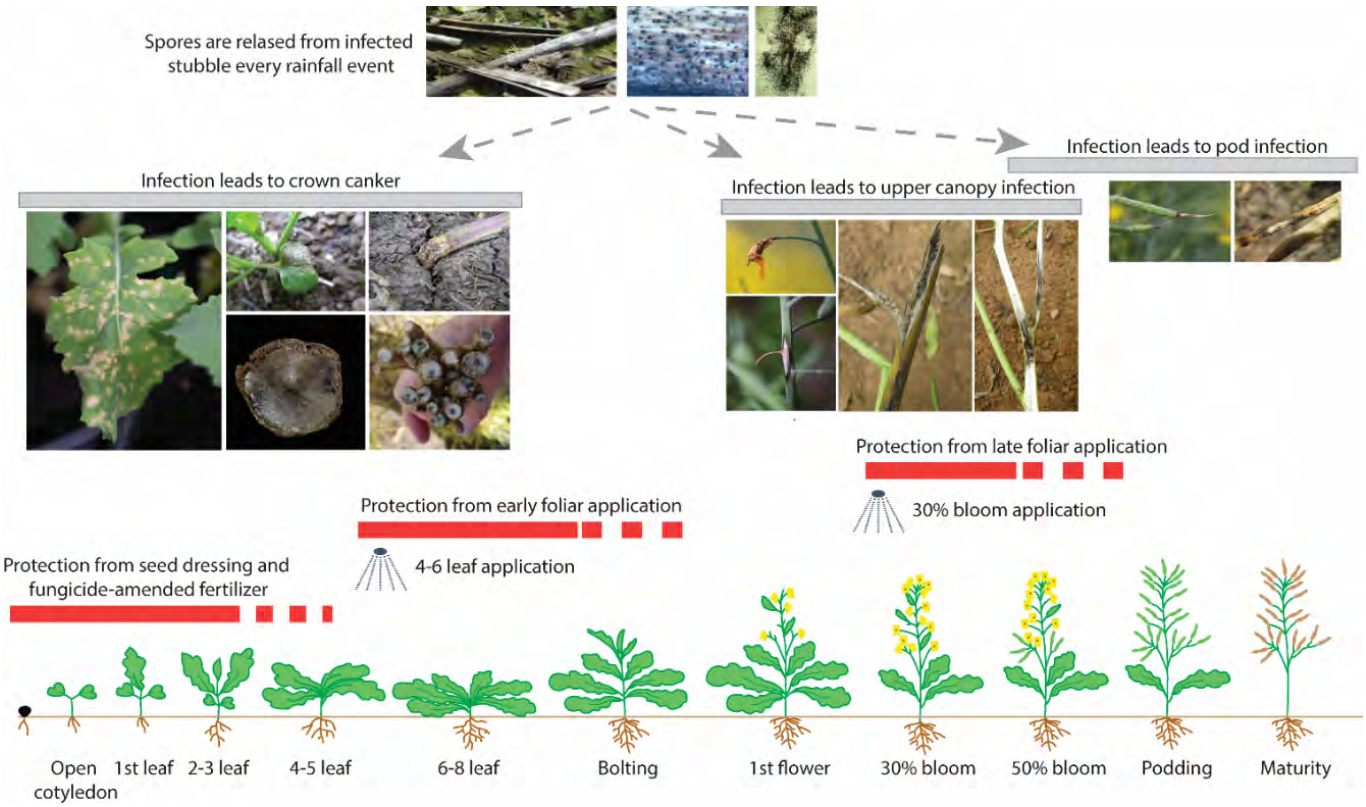

Figure 1. Epidemiology of blackleg disease of canola. Spores are released from infected stubble with each rainfall event during the growing season. If spores land on cotyledons and true leaves, the fungus grows down into the crown and causes crown cankers. However, if spores land on and infect flowers, upper canopy infection may result. Lastly, if spores land on pods, they may infect the pods and underlying seeds. Fungicides are used to control the various forms of blackleg disease, with seed-dressings, fungicide-amended fertilisers and early foliar applications designed to control crown canker, whereas 30% bloom applications are targeted to control upper canopy infection. No chemical control option is available for pod infection.

Results and discussion

Current scenario in 2026

The 2026 season began with good rainfall in early March and then consistent rainfall events from March–June, allowing good opportunities for early sowing and crop establishment. The early, consistent rainfall also matured canola stubble early, resulting in release of ascospores in May (much earlier than typical). Coupled with warmer than average temperatures, many canola crops matured quickly through the vegetative phases to begin flowering in June, putting them at high risk of both crown canker and upper canopy infection.

Genetic resistance

The best way to determine loss of resistance is to monitor the amount of crown canker and UCI at the end of year. In the current blackleg management guide for the latest WA regional resistance group, if the resistance group is coloured green, it should be effective in your region (Table 1). However, you can also check the resistance status on-farm by looking for leaf lesions. If the major gene resistance is effective (has not been overcome) there will be few, if any, blackleg leaf lesions (plants are immune). If you do not have effective major gene resistance in your cultivar (most cultivars), simply use the blackleg rating.

To confirm that resistance has not eroded in your cultivar, it is highly advised to cut and inspect the plant crown (see the blackleg management guide for details). If blackleg levels are low, then continue current practices. However, if blackleg is increasing over time, changing cultivars is recommended.

The rule of thumb is that if there is 30% or more of the crown discoloured when the stem is cut open, it is likely to cause yield loss. UCI levels can also be determined at plant maturity (commencement of seed colour change) by observing darkened branches and darkened pith (see the blackleg management guide for photos of crown canker and UCI).

Table 1: Status of canola resistance groups in selected NSW and Vic sites (2025 data). Cultivars with effective major gene resistance groups (green) are immune to blackleg.* Resistance Group letters refers to the cultivar major gene resistance, see GRDC Blackleg Management Guide for more information.

2025 site	Resistance Group						
NSW	A	B	C	D	F	H	S
Gerogery*							
Lockhart							
Vic	A	B	C	D	F	H	S
Charlton							
Diggora							
Hamilton							
Horsham*							
Streatham							
Wunghnu							
Yarrawonga							

**Green = effective; Yellow = partially effective; Red = ineffective. Note: in 2025 some sites had low blackleg severity, insufficient disease to make recommendations.*

The GRDC/DPIRD apps BlacklegCM and UCI BlacklegCM are very useful aids to determine if fungicide application is likely to provide an economic return. Low disease levels will not cause yield loss and will reduce the likelihood of fungicide resistance occurring – the aim is to increase yield, not to grow the cleanest crop.

Fungicide applications

Fungicides are going to be profitable in 2026. With the consistent rainfall and warmer conditions, blackleg disease is extremely severe across Victoria and South Australia. Consider applications of fungicides for both control of crown canker and upper canopy infection. The fungicide application will depend on the growth stage of your crop. If crops are still less than 8-leaf, then a foliar fungicide should be used to protect against crown canker. If crops are past this stage, then foliar fungicides will be required for upper canopy infection. It is years like 2026 when fungicides are necessary to help keep blackleg at bay. When choosing fungicides, consider rotating actives to reduce the risk of fungicide resistance.

Fungicide resistance

In 2025, 249 stubble populations of the causal fungus of blackleg disease were collected from the field and used to inoculate seedlings treated with nine commercial fungicides. Ten days post-inoculation, disease was measured, and a none/low, moderate or high resistance score (RS) determined for each chemistry for each blackleg stubble population (Figure2). Isolates were also collected from representative samples to confirm the detection of resistance. No resistance was detected towards the QoI (Group 11) fungicides in any region (data not shown).

For Victoria, 56 stubble populations were screened which represented the Wimmera, Western District and Northeast regions (Figure 2). High levels of resistance were detected for the DMI (Group 3) chemistries, suggesting that field failure is possible if using these chemistries. No resistance was detected to the SDHI (Group 7) chemistries, although moderate levels of resistance were detected in a small number of samples which will be worth monitoring in 2026.

Isolates were collected from infected leaf tissue from SDHI-treated plants and confirmed to have resistance to these chemistries. Three different mutations were detected and varied in their efficacy towards each of the SDHI actives. For the DMI-resistant isolates, no cross resistance was detected for mefentrifluconazole.

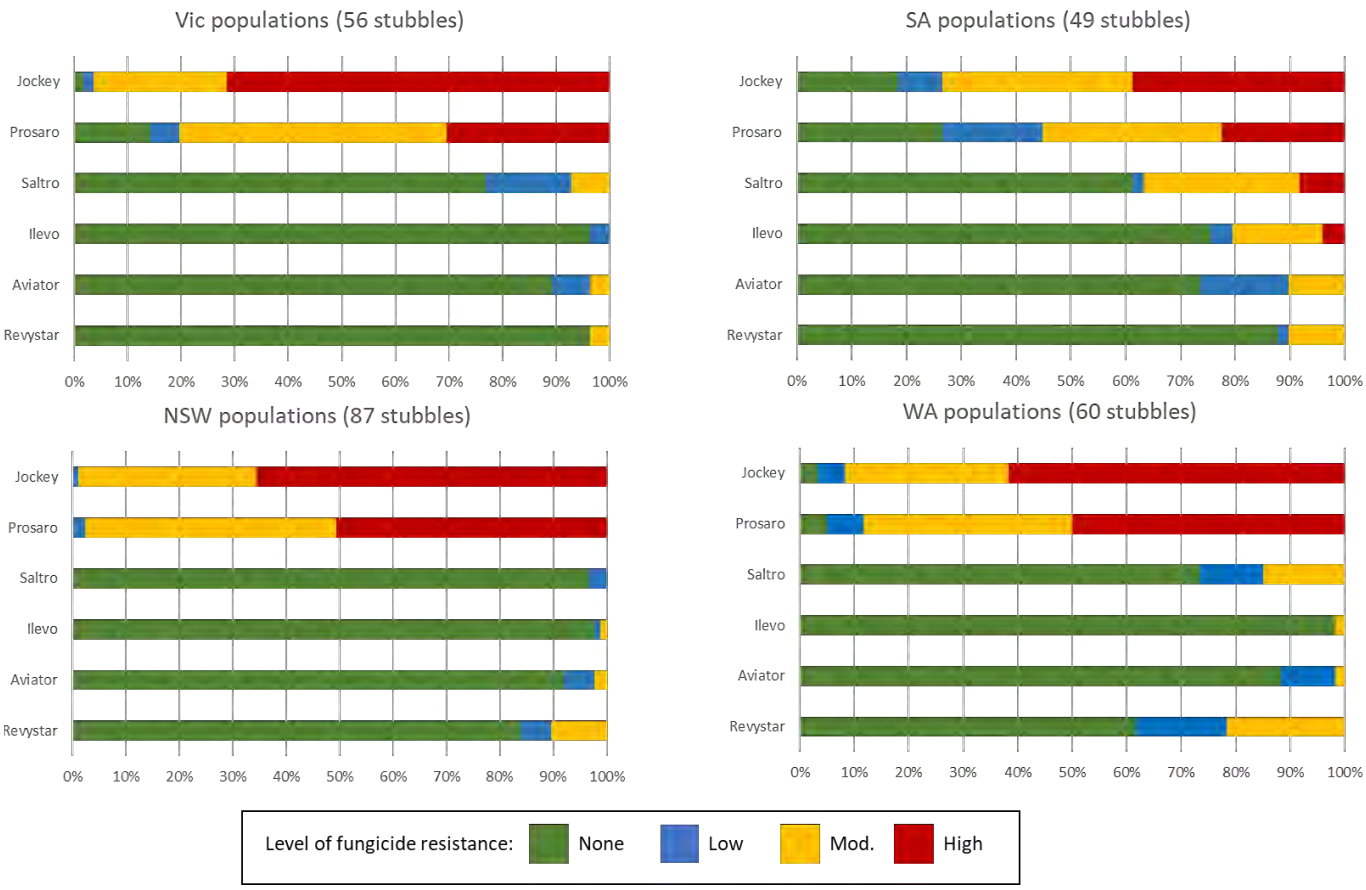

Figure 2. Percentage of stubble populations with varying levels of fungicide resistance towards each of the fungicides: Jockey® (Group 3, Fluquinconazole), Prosaro® (Group 3+3, Tebuconazole + Prothioconazole), Saltro® (Group 7, Pydiflumetofen), ILeVo® (Group 7, Fluopyram), Aviator® XPro (Group 7+3, Bixafen + Prothioconazole) and Revystar® (Group 7 + 3, Fluxapyroxad + Mefentrifluconazole). Resistance to the Group 3 chemistries has been detected in all regions whilst resistance to the SDHI chemistries is currently restricted to South Australia. These fungicides have been used as representatives of the various actives that are available for blackleg control. Note Jockey is no longer registered but fluquinconazole is available as FMC Rider®.

Controlled environment experiments were conducted to test different fungicide application strategies and their impact on selection of fungicide resistance. Populations of fungicide-resistant and fungicide-susceptible isolates were generated and used to inoculate plants with different fungicide applications. Disease severity was measured to determine the impact of the different fungicide applications on a selection of fungicide-resistant isolates. Population changes will be measured in 2026.

On-farm data for the past six years were collected from growers where SDHI resistance has or has not been detected. Different farming practices were compared to detection of resistance to determine whether there were any correlations between specific practices and selection of fungicide resistance.

Glasshouse experiments, using fungicide-resistant and fungicide-susceptible populations, indicated that the 4–8 leaf foliar application is driving selection of fungicide resistance. This result was supported by analysis of the on-farm fungicide use data from 25 growers, whereby there was a significant (correlation 0.505, p=0.036) correlation with the use of the 4–6 leaf foliar application and the detection of fungicide resistance. The data suggest that, in the absence of the 4–8 leaf foliar application, susceptible isolates can enter the plant and dilute the effect of the resistant isolates, therefore slowing selection of fungicide resistance.

The plant can tolerate around 30% internal infection before any yield loss occurs and therefore, by allowing infection to occur between the 4 leaf and 30% bloom growth stages, it is unlikely to get yield loss but will maintain the efficacy of the fungicides.

Sclerotinia

Sclerotinia is a complex disease, and is almost impossible to predict when it will occur and how much yield loss it will cause. Sclerotinia across a region will be more severe in years with wet springs, tight canola rotations, rotations with double broadleaf crops and early flowering. Many crops will fit this description in 2026. However, individual crops within the same region and seemingly identical conditions will get very different levels of disease severity.

Within the same region, some crops should be sprayed with a fungicide, and some should not – but it may be impossible to determine at the time of fungicide application. Consequently, the best determination is for the grower to know the history of individual paddocks.

If yearly scouting identifies paddocks that have a past history of sclerotinia and the same paddock has the high-risk indicators as described above, a fungicide should be applied. The SclerotiniaCM app is an excellent spray decision tool.

Recommendations

- Where possible, use other management strategies to minimise disease pressure, such as selecting cultivars with high blackleg disease rating or isolation of 500m from last year's stubble.
- Plants can tolerate up to 30% infection before yield loss. Remember that fungicides always control disease, but disease doesn't always cause yield loss.
- Applications at 30–50% bloom are likely needed due to early flowering
- Cannot apply fungicides past 50% bloom due to MRLs.
- If fungicides are required, minimise the number of applications. For example, if sowing early, avoid using a 4–6 leaf foliar spray for crown canker. If sowing late, the crop may require a 4–8 leaf foliar spray for crown canker but may not require a 30% bloom foliar spray for upper canopy infection.
- If applying multiple fungicides in a season, rotate chemical groups as well as specific actives, where possible.
- Avoid 4–8 leaf early foliar applications where possible to reduce risk of fungicide resistance.

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. We also thank the Australian Research Council and industry partner Syngenta, for part of the funding for this work. Lastly, we thank all the agronomists that have provided stubble and other associated data for use in this project.

Useful resources

For more information on managing blackleg disease:

Blackleg management guide (https://grdc.com.au/resources-and-publications/all-publications/factsheets/2026/blackleg-management-guide)

BlacklegCM – Blackleg management app (https://www.agric.wa.gov.au/apps/blacklegcm-blackleg-management-app)

UCI BlacklegCM – Blackleg upper canopy infection management app (https://www.agric.wa.gov.au/apps/uci-blacklegcm-blackleg-upper-canopy-infection-management-app)

SclerotiniaCM – Sclerotinia management app (https://www.dpird.wa.gov.au/online-tools/sclerotinia-cm--sclerotinia-management-app)

CropLife Australia resistance management (https://www.croplife.org.au/resources/programs/resistance-management/)

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Notes

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Acknowledgements

We would like to thank those who have contributed to the successful staging of the Cummins 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 and Spraytec

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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**).

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

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

6. Getting best bang for buck on canola fungicides
Ang Van de Wouw, University of Melbourne

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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

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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
❑	❑	❑	❑	❑

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