GRAINS RESEARCH UPDATE 2026

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Dookie, VIC
Thursday 23 July

CELEBRATING 30 YEARS

GRAINS RESEARCH UPDATE
2026

Dookie

Thursday 23 July

9.00am to 1.00pm

Bar Lounge, Dookie College
940 Dookie-Nalinga Rd

#GRDCUpdates

DOOKIE
GRDC Grains Research Update
convened by ORM Pty Ltd.

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

GRDC Grains Research Update DOOKIE

Contents

GRAINS RESEARCH UPDATE 2026

GRDC

Bar Lounge, Dookie College, Thursday 23 July

PROGRAM

9.00am	Announcements and GRDC welcome	*GRDC representative*
9.15am	Protecting your most perishable asset – latest tips on grain storage	*Chris Warrick, Primary Business*
9.55am	Industry panel – pushing pulses for better crops	*Audrey Delahunty, Agriculture Victoria* *Aaron Vague & Tom Price, FAR* *Candice Robinson, Sefton Agronomics* *Federico Ribalta, Intergrain*
10.35am	Morning Tea	
11.05am	Getting best bang for buck on canola fungicides	*Alec McCallum, University of Melbourne*
11.45pm	Profitable Yield Frontiers	*James Manson, CSIRO*
12.25pm	Risk and reward of N fertiliser decision-making strategies - insights from a national network of RiskWi$e field experiments	*Corinne Celestina, University of Melbourne*
1.10pm	Lunch	

On X? Follow **@GRDCSouth** and use the hashtag **#GRDCUpdates** to share key messages

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.

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.

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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 author would like to thank them for their continued support.

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Notes

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Expanding Opportunities for Pulses in Northeast Victoria

Ash Wallace[1], Josh Fanning[1,2], Jason Brand[3] and Dale Grey[1], Audrey Delahunty[1]

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GRDC project code: DJP2105-006RTX

Keywords

- Pulses, high rainfall zone, faba bean, agronomy, disease

Take home messages

- Pulse production has expanded significantly over the last 15 years in Victoria, including growth of the area sown to faba beans in the northeast. However further opportunities for growth exist.
- Expansion of lentil area has been significant in the Wimmera and Mallee. Expanding pulses in other regions requires careful consideration of soil type and species.
- Development of new varieties across multiple pulse species continue to grow the range of options available for growers in northeast Victoria to incorporate pulses into their rotations.

Background

Pulses are an integral part of Victorian farming systems, offering a profitable crop choice while delivering multiple system benefits. They contribute nitrogen, rotational diversity, provide disease and weed breaks, and open valuable market options. Since their widespread adoption in the 1990s, pulse yield potential has increased significantly. This shift has been supported by improved varietal adaptation, clearer agronomic guidelines, and practical extension programs, which have strengthened regional understanding of sowing windows and risk management for weeds and disease. Herbicide tolerant varieties such as PBA Herald XT, PBA Hurricane XT, GIA Thunder⍉ lentils and PBA Bendoc faba beans have further enabled expansion into new soils and regions, while high grower confidence and consistent profitability continue to drive adoption. These gains form a strong base for the next phase of RD&E across Victoria's diverse pulse producing landscapes. As the 'pulse phase' becomes more embedded and matures within Victorian farming systems, the next challenge, and opportunity, is to expand production into new regions and position pulses for greater resilience, productivity, and profitability under challenging climatic and market conditions.

This panel paper explores key opportunities and challenges for pulse production in northeast Victoria's high-rainfall farming systems. Drawing on perspectives from Candice Robinson (Sefton Agronomics), Federico Ribalta (InterGrain Pulse Breeder), and FAR Australia researchers Aaron Vague and Tom Price, the session will examine future market opportunities, best-practice agronomy and long-term disease management strategies to support profitable and sustainable pulse production in the region.

Changes in the Victorian pulse industry

Since 2010 there has been a steady increase in area sown to pulses in Victoria, growing from around 10% of the area sown in 2010 to 24% by 2025 (Figure 1, Agriculture Victoria, 2025). This has been primarily driven by an increase in the area sown to lentils which has increased from 8% to 23% of crop area in the Wimmera and from 1% to 23% in the Mallee. In the higher rainfall zones, such as southwest and northeast of Victoria, the major pulse is faba bean, with limited intensification observed in pulse adoption compared to other regions.

To better understand impediments to greater uptake of pulses in Victorian crop rotations, evaluation surveys were conducted as part of pulse field days held during 2025. A total of 108 respondents comprising 64% growers, and 23% agronomists responded to a range of questions relating to the incorporation of pulses in local rotations, their management and the challenges that limit production. In each region, the challenges identified by respondents tended to be dominated by one or two key issues specific to that area followed by a broad grouping of ancillary issues where their individual ranking was less clear (Figure 2). Examples for the northeast included managing soil acidity to support pulse growth (i.e. inclusion of lentils) and problem weeds.

Figure 1. Ranking of issues that challenge pulse production across Victorian grain growing regions. Data is based on evaluation surveys of growers and industry representatives attending pulse field days in 2025.

Opportunities to expand pulse production for the northeast Victoria

Since 2021, FAR Australia and Agriculture Victoria, along with collaborators across the region have been working to understand opportunities to better manage pulses in northeast Victoria and southeast NSW as part of the GRDC Pulse Development and Extension projects. Field trials have been conducted focussing on faba bean agronomy to investigate optimal plant density and canopy structure, sowing time, nutrition and disease management with consideration to how these issues change across varieties. Research efforts in northeast Victoria and southeast NSW have been also focused on evaluating performance of pulse species in relation to yield, N-fixation and system-fit to help support decision making around profitable pulse options for this region.

Research outputs specific to two of these areas are provided in in the following papers:

- Performance of pulse species in central and southern NSW – 2021 to 2023, page 21
- Phenological timings for faba bean disease management Victorian high rainfall zone, pages 25-29

The proceeding component of this paper poses questions and highlights opportunities for pulses going forward in the northeast.

Disease management and pathology

With increasing pulse production and tighter rotations between pulses there is increased pressure on plants from disease. Increased production has been achieved through improved varieties and farming systems management, resulting in improved profitability for growers. We are in a golden era, where we have a whole range of options available to control diseases and maximise profitability. However, profitability is reliant on an integrated disease management system which could be stretched with the changing management of pulse production.

Varietal resistance

New varieties have increased production, and, in many cases, improved disease resistance, reducing the reliance on other disease control measures. However, some varieties such as the imi tolerant faba bean, PBA Bendoc, have resulted in a regression in disease resistance and caught some growers off guard. While current resistance ratings are reliable and comparable within a crop × disease combination, continued progress in the NVT disease rating system to improve standardisation across crops will offer greater reliability and confidence in the future.

Widespread uptake of new varieties can create pressure on disease resistance, with the pathogen (pathogens cause disease) able to overcome the resistance to varieties quicker with widespread cultivation. As a result, breeders now seek to include multiple different resistance mechanisms within new varieties to reduce the risk of resistance being overcome. The other challenge with widespread adoption of new varieties, particularly disease resistant varieties, is the temptation to ignore other integrated disease management techniques. This has resulted in several examples of varietal disease resistance being overcome, e.g. PBA HurricaneXT ⦸ resistance to Lentil Ascochyta blight. This will continue to be an ongoing challenge, to ensure we can improve the longevity and durability of genetic resistance when breeders and the industry invest significantly in sourcing new resistance sources.

One of the biggest potential changes in genetic resistance could occur to both *Botrytis* spp. in both faba beans and vetch where we lack varieties rated moderately resistant or resistant, which increases the pathogen population and therefore the risk of pathogen mutations overcoming varietal resistance in other crops that have good resistance. Improvement in these areas would not only protect these crops but also the other crops which are all infected by the same *Botrytis* spp.

Crop Rotations

Increased adoption of pulses in the rotation, results in an increased frequency of pulses in the same paddock, leading to increased disease risk, for example lentil-wheat-lentil rotations. The challenge for the disease management is, do we accept this practice? and the potential for fungicide resistance or varietal resistance breakdown, or do we continue to advocate for a 2-to-3-year break between the same crop? It is important to remember, there are not endless sources of fungicide or genetic resistance available, and the investment required to seek new alternatives is becoming considerably greater. Researchers can seek alternative management practices to reduce disease risk, but will this really reduce the risks of tighter rotations?

Tighter rotations have also resulted in new soilborne diseases, such as *Fusarium* spp., becoming prevalent and now reducing yields in some paddocks. This is an evolving area of research, aiming to provide growers with access to management techniques that reduce this risk.

Cultural practices

The long-running shift towards early sowing has lengthened the time seedlings are above ground during winter when plants grow slowly, and herbicides can delay growth, increasing disease risk. Early establishment can also result in increased canopy density, further adding to the risk of diseases such as botrytis grey mould or chocolate spot. These changes to canopy structure and timing of development have impacted fungicide strategies, e.g. early Ascochyta in susceptible varieties may need to be controlled with earlier fungicide applications than was previously the norm. Alternatively, wider row spacing can increase air flow and potentially delay the requirement for a fungicide at the canopy closure stage. Standing stubble can also help prevent lodging, further reducing disease conducive conditions.

Fungicides

Fungicide options to control disease in pulses have gradually increased over time, with several fungicide groups (Groups M3, M5, 1, 2, 3, 7, 11, 12, M3) now available for most pulse crops at a range of price points. It is imperative we use these in an integrated approach, not reliant on one fungicide group to ensure longevity. In cereals, fungicides are less effective to numerous diseases as pathogens have overcome the fungicides, while in pulses we are seeing changes to available options associated with chemical regulations. We need to ensure that the industry follows label directions, rotate and mix fungicide groups and use integrated approaches so we continue to have this great selection of fungicides available for pulse disease management into the future.

Environment

The environment is one of the most important factors in disease management, and one we have limited control over. Climate modelling, risk initiatives and modelling of conducive disease conditions is improving. We are also able to access more disease model applications and spore trapping information. This information needs to be communicated in a clear and concise manner with the epidemiology of the disease and farming system in mind. Some technologies are not valid for all diseases. Research from SARDI has shown botrytis can be found through most of the season and therefore, the pathogen is always present, and we are just manipulating the other integrated disease management factors to mitigate disease. Therefore, the process of integrating these new technologies to monitor the environment and pathogen within models is reliant on the interpretation.

Pathogen Evolution

The pathogen is often neglected in the story of disease management, particularly in pulses. In cereals, for many diseases, we understand the genetics behind resistance and the pathogen evolution between seasons. In pulses, there is limited to no information. Therefore, we are reliant on NVT ratings or industry information, rather than molecular testing of the pathogen or an annual screening of the pathogen with current knowledge of varietal resistance to ensure the pathogen has not changed. This is particularly important as early information can ensure newly detected pathotypes (variants of a pathogen), that may have fungicide resistance or have overcome varietal resistance, do not become widespread across the environment, or growers can adapt prior to losing grain yield. By maintaining an up to date understanding of the pathogens and applying an integrated approach to their management, the grains industry can continue to minimise the loss of fungicide efficacy and varietal resistance, prolonging control options, minimising yield loss and maintaining profitability.

Weed management and system integration

One of the key benefits traditionally promoted for pulses is improved weed control for the whole cropping system, particularly grass weeds controlled through selective herbicides. However, as the intensity of pulses grew, increased resistance of grasses to several selective herbicides has been observed. Broadleaf weed control in pulses has always been challenging, initially there were limited selective herbicide options and crop competition was poor. However, multiple pulse crops with improved resistance to imidazolinone (IMI; Group 2) herbicides have since been released as well as lentils with tolerance to in-crop application of both IMI and metribuzin chemistry or residual (previous season) clopyralid. Pre-emergent chemistry continues to play a pivotal role, however managing crop safety across variable soils, environments and varieties presents a complex challenge to industry. All of these options nonetheless need to be considered in a system context weighing up where in the rotation is the best place to utilise a given mode of action and adding pulses to otherwise constrained rotations can help to spread the risk of introduce new modes of action compared to intensive cereal-canola based systems.

As the pulse industry has expanded, particularly lentils and faba beans in Victoria and South Australia, we have seen the emergence of alternate challenges. In lentils, reliance on 'IMI' technology combined with tighter rotations has increased the resistance of several weeds (e.g. milk thistle, radish etc.) to this group of herbicides. In addition, problematic weeds such as vetch and tares, which are not fully controlled by imidazoline herbicides have continued to expand in key production zones. As lentils have moved into more challenging soil types and traditional pasture zones, weeds such as capeweed and medic (particularly Group 2 tolerant varieties) have proved challenging to control.

As we look forward, two key challenges are emerging, particularly in crops like lentil which can be highly profitable and desirable to grow in tight rotations: 1) increasing resistance to a range of herbicides and 2) emergence of weed species which were previously unnoticed or a minor issue. However, new opportunities will continue to emerge, which combined with current knowledge provides optimism. It is likely that we will see varieties with subtle improvements in tolerance to registered herbicides in groups 5, 12 & 14 and novel tolerances to other groups. Camera systems able to identify specific weeds in green-on-green situations also continue to develop, requiring new herbicide registrations and use patterns. Utilising the range of herbicide strategies with suitable crop rotations and optimised agronomic practices for each region provides a way forward**,** but at what cost and what are we willing to do to overcome the evolving weed challenge?

Soil constraints and opportunities to expand into

new ground

Soil type has traditionally had a significant impact on the footprint of pulses across southern Australia and based on recent grower surveys, continues to influence their adoption in certain regions (Figure 2). Soil acidity, risk of waterlogging and poor soil structure have all impacted growers' willingness to expand pulses into new areas. Historically this led to a situation where lentils were limited to neutral to alkaline soils in drier areas, while faba beans have been the more dominant pulse in wetter environments with moderately acidic soils. While chickpeas sit somewhere between these species in their tolerance, other factors such as disease risk have limited production area despite offering a range of characteristics which could fit into Victorian grain rotations (GRDC 2017a, b and c).

In regions traditionally associated with acid soils, liming has expanded the areas able to be sown to faba beans, while growers are also experimenting with the pH limitations to growing lentils by expanding into new areas of northern Victoria where cereals, canola and vetch predominate. The rapid expansion of area sown to pulses over the last 15 years in Victoria is unlikely to be repeated, but with careful selection of soils, experimentation and targeted amelioration strategies it may be possible to continue to progress the pulse industry into new areas.

Better adaptation of pulses to Victorian environments

Grain yield and profitability remain the primary drivers of species and varietal choice and have underpinned recent pulse expansion in Victoria. Further growth will depend on RD&E that sustains yield potential and profitability under increasing climatic variability, higher pulse intensity and expansion into new regions. In both established and emerging production areas, varietal performance also underpins broader farming system benefits through biologically fixed nitrogen.

While faba beans dominate pulse production in northeast Victoria, opportunities exist with other pulse species, particularly in seasons or soils where production of the dominant crop species is constrained. For example, in seasons where autumn sowing windows are restricted by wet conditions, spring sowing has traditionally been an option. With the continual development of new varieties, there is potential for a springsown pulse window, with chickpea the most promising possibility. Reliable rainfall and the temperate climate may help offset the constraints that limit wintersown pulses in this region. Recent HRZ trials conducted by SFS using CBA Captain show yield potential of approximately 1.3–2.0 t/ha across a range of plant densities (20, 30 and 40 plants/m^2) and sowing times (mid-Sept and mid-Oct), suggesting good flexibility for opportunistic planting.

For those looking to further widen opportunities for faba beans in their rotations, there are also two new varieties expected for release in the coming years. For example, AF14092 presents an earlyflowering alternative to PBA Samira and PBA Amberley. This variety sets pods 1–2 weeks earlier, giving it an advantage in drier, shorter seasons, while in favourable years it converts this headstart into larger seed size. Disease resistance is comparable to current standards, and it maintains strong lodging tolerance, making it a versatile option for both tough and soft finishing environments. Secondly, AF15283 adds a Group 2 imidazolinone tolerant choice suited for the southwest. It carries MR Ascochyta resistance and an MS rating for Chocolate spot, representing an improvement over Bendoc, alongside excellent lodging and necking tolerance.

In the medium term, there is also the potential to explore opportunistic summer legumes such as soybean and mungbean. Statewide evaluation through the Alterative Legume project, highlighted that these two species are potential options for southwest Victoria, noting optimising of agronomy and market development would be needed. Insight into some of the challenges associated with including a spring/ summer phase were identified through this project, with proactive insect and pest management identified as essential. This is due to the increased pressure associated with limited green material surrounding at that time of year. Further work in defining rainfall triggers for sowing would support growers making informed choices around the risk profile associated with introducing a new crop phase.

These combined opportunities highlight a gradual broadening of pulse choices for southwest Victoria, with winter, spring and potentially summersown options each offering different pathways to diversify rotations, improve system resilience and enhance wholefarm profitability.

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Notes

Phenological timings for faba bean disease management in the Victorian high rainfall zone – HRZ SW (Gnarwarre), Victoria 2021–2025

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GRDC project code: DJP2105-006RTX

Keywords

- faba bean, fungicide, HRZ, phenology.

Take home messages

- Considering the different chocolate spot resistance ratings of PBA Amberley(PBR) (MRMS) and PBA Bendoc(PBR) (S), surprisingly there were no meaningful interactions in yield response between fungicide management and cultivar observed in experiments from 2021–2025.
- Multi spray and SDHI programs give the strongest protection in high risk seasons. 3F, 4F, 2F SDHI, and 4F SDHI provided the most reliable control of chocolate spot and rust. These programs consistently delivered top yields in high disease years.
- A well timed 2 spray program incorporating one SDHI is a high value option. In multiple seasons, 2F SDHI matched or exceeded the performance of 3–4 spray programs. This 2-spray program works best when timed at first flower + 14–21 days.
- Weather dependent single sprays are the most costeffective in marginal seasons. 1F WD delivered the highest return on investment (ROI) in most moderate or low disease seasons.
- Flexible, responsive management maximises profit. Monitoring and adapting spray plans to weather and disease development consistently produced the highest profitability across all seasons.

Notes

Notes

Performance of pulse species in central and southern NSW – 2021 to 2023

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GRDC code: BRA2105-001RTX

Key words

- faba bean, chickpea, vetch, field pea, lupin, lentil, nitrogen fixation, grain nitrogen, pulse, yield

Take home message

- In 2021-2023 trials, for each tonne of shoot biomass (above ~0.7 t/ha), total nitrogen fixation averaged 28 kg/ha
- The average fixed nitrogen remaining after grain harvest (nitrogen balance) was 17 kg/ha for each tonne of shoot biomass (above ~1.7 t/ha)
- Grain nitrogen concentration ranged from 5.5% in lupins, down to 3.2% in chickpea. Nitrogen removal per tonne of grain harvested was ranked from albus lupin > narrow-leaf lupin > vetch > lentil = faba bean = field pea > chickpea
- Faba beans were the highest yielding species on average (2.6 t/ha) but had the largest variability in yield. Field peas were the second highest yielding species (2.1 t/ha), with lower variability in yield than faba beans.
- Gross income (grain value + residual nitrogen value) was highest in faba beans (on average), but there was a general trend that species with high average income (faba beans and lupins) had high variability. Field peas had the lowest average income, but the lowest variability.

Introduction

In 2021 GRDC initiated a project focused on 'Best Practice Pulse Agronomy' that brought together a unique group of organisations including Frontier Farming, Grain Orana Alliance, FAR Australia and AgGrow Agronomy. Led by Brill Ag it established two major themes of pulse crop research activity:

1. Maximising economic yield and nitrogen (N) fixation in regional environments.
2. Developing locally relevant research knowledge on limitations to pulse production and productivity. Research to date has focused on plant density, disease management, nutrition management, inoculation strategy, phenological development, and herbicide tolerance.

This paper reports on the findings from Theme 1 above for the 2021 to 2023 seasons.

Materials and methods

Trials were conducted at 19 sites across southern and central NSW from 2021 to 2023 (Table 1). Sites were selected to be regionally relevant with challenges (both perceived and real e.g., low pH, sodic

and/or poorly drained soils) that may restrict the inclusion and production of pulses in the rotation. The research is not designed to compare the performance of pulses in a benign situation but is focused more on determining the performance of pulse species for yield and N fixation in the local environment where adapted species may thrive, but less adapted species may struggle.

Table 1. Site description of pulse agronomy research sites from 2021 to 2023						
Site	Sowingdate	Rain(mm)		pH(Ca) 0–10cm	AvailableN (kg/ha)	Sitedescription
		Jan-Mar	Apr-Nov			
2021						
Barellan	13May	270	435	4.5	63(0–60cm)	Acidicsandyloamsoil.
Buraja	7May	180	450	4.6	54(0–10cm)	Moderatelyacidicsiltyloamsoil
Canowindra	3May+ 20May[1]	290	490	4.8	192(0–120cm)	Moderatelyacidic,welldrainedred loamsoil
Caragabal	29April+ 18May[1]	280	480	5.0	53(0–60cm)	Slightlyacidicloamwithsubsoil sodicity
Ganmain	28April+ 18May[1]	220	360	5.3	82(0–60cm)	Slightlyacidicloamsoilwithsubsoil sodicity
Gol.Gol	31May	0	114	7.7	85(0-120cm)	Alkalinesandyloam
Parkes	31May	290	485	5.7	126(0–90cm)	NeutralpH,moderatelyheavysoil typewithsubsoilsodicity
2022						
Barellan	6May	255	537	5.2	76(0–60cm)	Welldrainedsandyloamsoil
Ganmain	9May	185	572	5.5	115(0–80cm)	Generallywelldrainedloamsoilbut sitewasverywetin2022.
Trundle	28June	155	705	5.6	103(0–90cm)	Generallywelldrainedloamsoilbut sitewasverywetin2022.
Wellington	23May	235	780	5.4	120(0–60cm)	Greybasaltsoil,wetin2022.
Wentworth	12May	20	390	8.1	42(0-120cm)	Alkalinesandysoiltype
2023						
Arumpo	14April+ 27April+ 15May[3]	52	200	7.5	69(0-100cm)	Alkalinesandyloamsoil
Barellan	9May	124	168	4.9	54(0-60cm)	Welldrainedsandyloamsoil
Caragabal	19April+ 19May[2]	195	185	5.9	110(0-100cm)	Welldrainedloamsoil
Daysdale	3May	99	257	4.9	85(0-100cm)	Welldrainedacidicloamsoil
Dunedoo	10May+ 10June[1]	171	184	5.2	112(0-60cm)	Welldrainedloamsoil
Ganmain	5May+ 24May[3]	125	185	5.9	87(0-100cm)	Clayloamtopsoilwithsodicsubsoil
Trangie	9May	120	152	4.7	93(0-90cm)	Welldrainedacidicloamsoil

[1]Faba beans, vetch and lupins sown at earlier sowing date; field peas, lentils and chickpeas sown at later sowing date.
[2]Faba beans, vetch and lupins sown at both sowing dates; field peas, lentils and chickpeas only at later sowing date
[3]All species sown at all dates

N fixation was determined by collecting biomass samples at peak biomass (mid-podding stage before leaf drop) and analysed using the 15N natural abundance technique (Unkovich et al., 2008) to determine what proportion of the N in the biomass was derived from the atmosphere (NDFA). Once the quantity of NDFA in above ground biomass was calculated (peak biomass * N content of biomass * NDFA%), total N fixation (N-fix) was calculated by multiplying by a co-efficient that estimates the root contribution (1.5 for faba beans, field peas, lentils, lupins and vetch; 2.0 for chickpeas. These figures (1.5 and 2.0) are known as 'root factors' and are described by Swan et al. (2022). The root factor calculation makes an allowance for below ground N (e.g. in roots and nodules) so an improved estimate of total N fixed can be provided. Finally, the N balance is calculated by subtracting the N removed in grain (grain yield * grain N%) from total N fixed.

Results

Total nitrogen fixation

Total N fixed by the pulse species across the sites was closely related to crop biomass. For each tonne of biomass >0.7 t/ha, total N fixation was ~28 kg N/ha (Figure 1). Some crop biomass figures were very high in 2021 and 2022 due to high rainfall, with biomass >20 t/ha and total nitrogen fixation above 600 kg/ha. However, the 'average' pulse crop grew 6.4 t/ha biomass and fixed 163 kg N/ha.

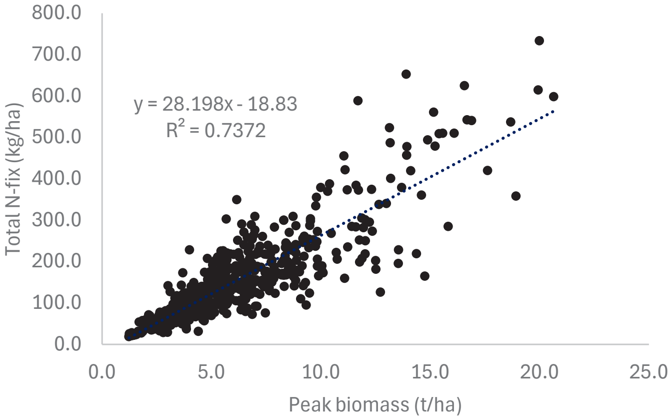

Figure 1. Relationship between peak biomass of pulses and total N fixed (N-fix) in NSW Pulse Agronomy trials from 2021 to 2023.

Nitrogen removal in grain

Nitrogen concentration in the grain was highest in lupin and lowest in chickpea. Within the lupin species (data not shown), albus lupins had N concentration of 60 kg N/tonne, while narrow-leaf lupins had N concentration of 52 kg N/ tonne. Faba beans, field peas and lentils all had grain N concentration from 40–42 kg N/tonne of grain (Figure 2). Vetch hay (from nearby trials) had an average N content of 27 kg N/tonne of hay (data not shown). The grain N concentration of each pulse species was consistent across sites and seasons.

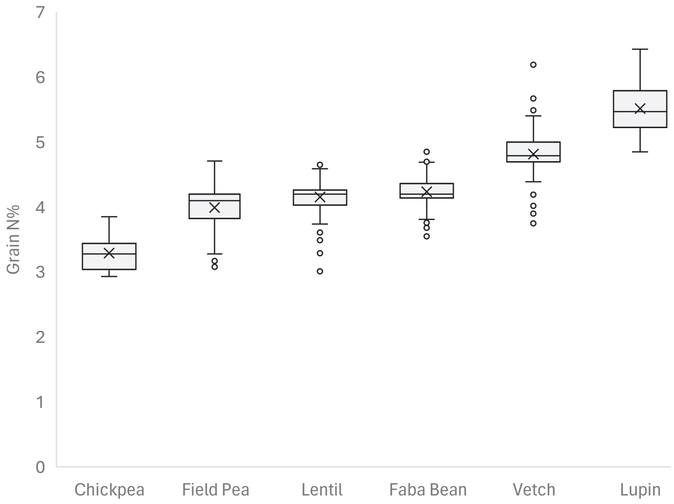

Figure 2. Average grain N concentration of pulse species in trials in southern and central NSW from 2021 to 2023.

Nitrogen fixation and nitrogen balance across species

The median nitrogen fixation of field peas, vetch, lupin and faba beans were all in the range from 150–165 kg N/ha. Chickpeas and lentils were lower at 114 and 84 kg N/ha respectively (Figure 3). Faba beans and lupins had average nitrogen fixation from 185 to 200 kg N/ha, which was well above their median nitrogen fixation as the data was skewed by the very high biomass in some trials in 2021 and 2022.

N balance is a measure of total nitrogen fixation minus nitrogen removed in grain. N balance was positive in 95% of observations. Field peas, vetch and faba beans had a nitrogen balance in the range of 75 to 90 kg/ha. The high N concentration in lupin grain and low N concentration in chickpea grain meant that lupin and chickpea nitrogen balance was similar, despite lupins fixing more nitrogen.

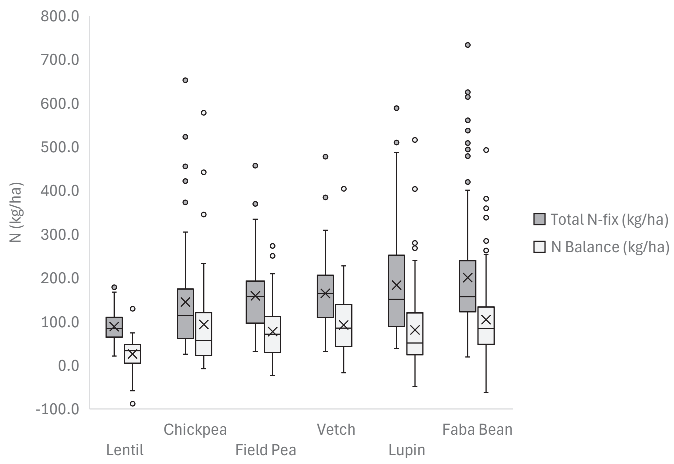

Figure 3. Total nitrogen fixation and nitrogen balance of pulse species from 2021 to 2023 across NSW Pulse Agronomy Trials.

Income from grain and residual nitrogen

Gross income was calculated for each species (vetch not included), adding together the value of grain (yield * assumed price) and value of residual nitrogen (Figure 4). Price assumptions were based on average prices for the 2021–2023 period:

- Chickpeas = $600/tonne
- Faba beans = $420/tonne
- Field peas = $450/tonne
- Lentils = $700/tonne
- Lupins = $500/tonne
- Nitrogen = $1.75/kg

Faba beans had the highest average gross income at $1346/ha but the most variability of any species and a much lower median income of $901/ha. At the other extreme, field peas had low variability with an average of $1050/ha and a median income of $975/ha. Field pea income at the lower quartile (75% of observations above this point) was $752/ha compared with lupins and faba beans which were both around $550/ha at the lower quartile.

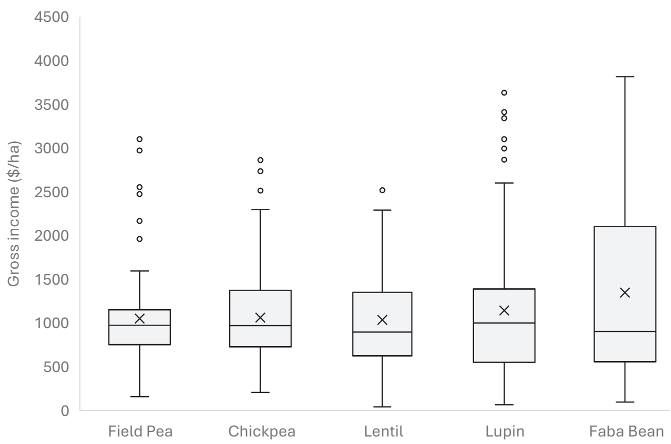

Figure 4. Gross income (grain yield * price) + (residual N * N price) of pulse species in NSW Pulse Agronomy Project from 2021 to 2023.

Discussion and conclusion

Nitrogen fixation in pulses is closely related to crop biomass, with average nitrogen fixation in this project of ~28 kg N/ha per tonne of above ground biomass. There were many instances within the project where total nitrogen fixation exceeded 300 kg N/ha (e.g. faba beans in the wetter seasons of 2021 & 2022), however the average for all pulse crops was 6.4 t/ha biomass and 163 kg N/ha fixed. Practices to maximise biomass and N fixation in pulses include:

- Select high biomass species that are adapted to the local environment (soil type and climate).
- Minimise the effects of soil constraints such as acidity and sodicity.
- Ensure effective pulse nodulation.
- Ensure adequate nutrition is supplied, especially phosphorus.

The value of a pulse crop to a farmer is a combination of income received for grain and value of residual nitrogen. Despite their relatively low price, faba beans were able to generate a very high income (25% of observations were above $2100/ha), but gross income was highly variable. Faba bean yield was average or below average in lower rainfall environments. Field peas on the other hand rarely reached the high values of faba beans, but had consistent income and importantly, the highest income of any species at the lower quartile level. The introduction of the new variety APB Bondi, makes field peas worth reconsidering for growers in low-medium rainfall environments. The nitrogen fixation value of lentils was the lowest of all species, but its high grain value meant its total income was closer to average.

The economics reported here are obviously sensitive to future changes in the price of pulses and nitrogen. If the price of nitrogen increases relative to the price of pulse grain, the choice of pulse crop would favour species that fix more N. If the price of N reduces relative to the price of pulse grain, the choice of pulse crop would favour species that have high yield and/or high price.

Individual results from every trial from this project is available at Online Farm Trials (www.farmtrials.com.au/), which is a great resource for applied, local agronomy research. This work couples well with GRDC Farming Systems research to gain a full understanding of the role of pulses in regional farming systems.

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Notes

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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.

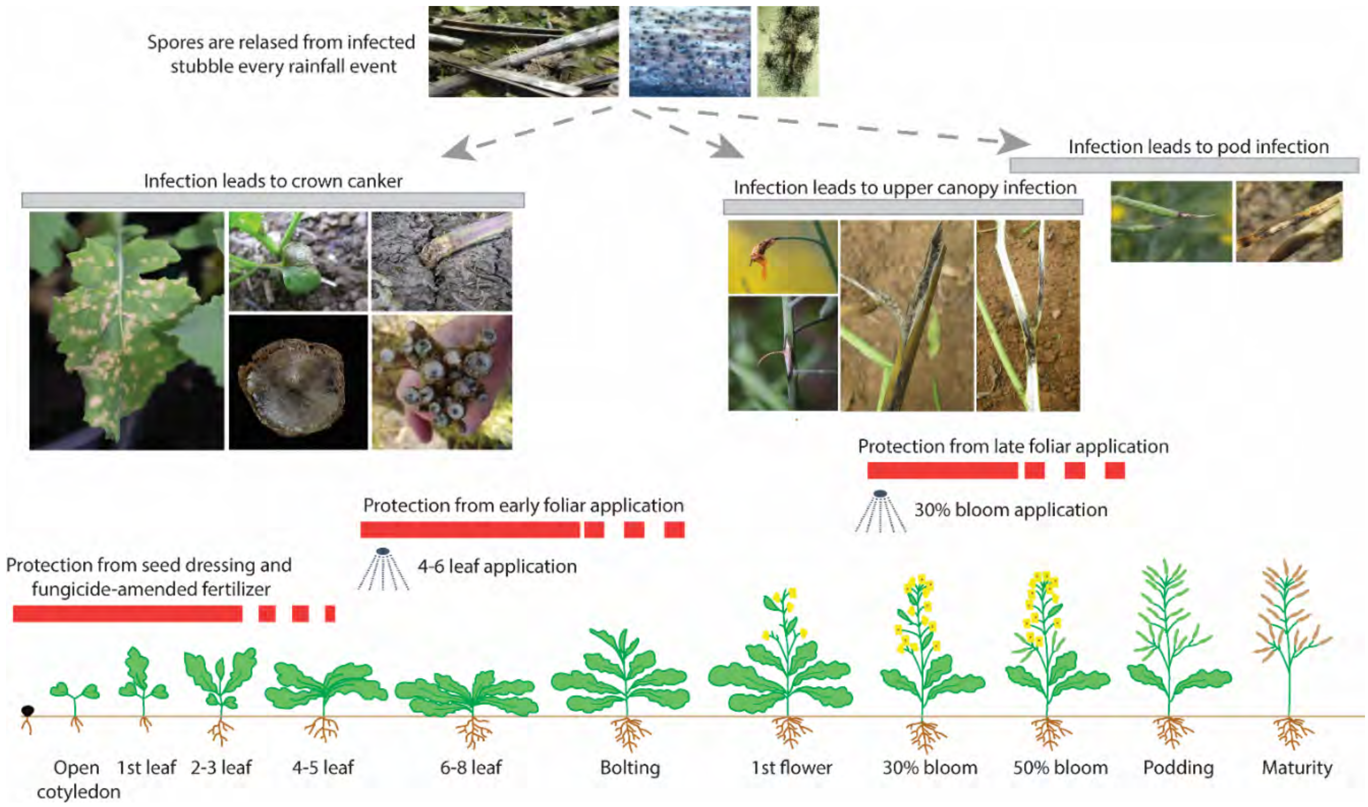

Figure 1. Epidemiology of blackleg disease of canola. Spores are released from infected stubble with each rainfall event during the growing season. If spores land on cotyledons and true leaves, the fungus grows down into the crown and causes crown cankers. However, if spores land on and infect flowers, 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*	Red	Red	Red	Green	Yellow	Green	Green
Lockhart	Red	Red	Red	Green	Yellow	Green	Yellow
Vic	A	B	C	D	F	H	S
Charlton	Red	Red	Red	Yellow	Yellow	Green	Green
Diggora	Red	Red	Red	Green	Green	Green	Green
Hamilton	Red	Red	Yellow	Green	Green	Yellow	Green
Horsham*	Red	Red	Red	Red	Yellow	Green	Yellow
Streatham	Red	Red	Red	Green	Red	Green	Yellow
Wunghnu	Red	Red	Red	Yellow	Yellow	Green	Green
Yarrawonga	Red	Red	Red	Yellow	Yellow	Green	Yellow

**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.

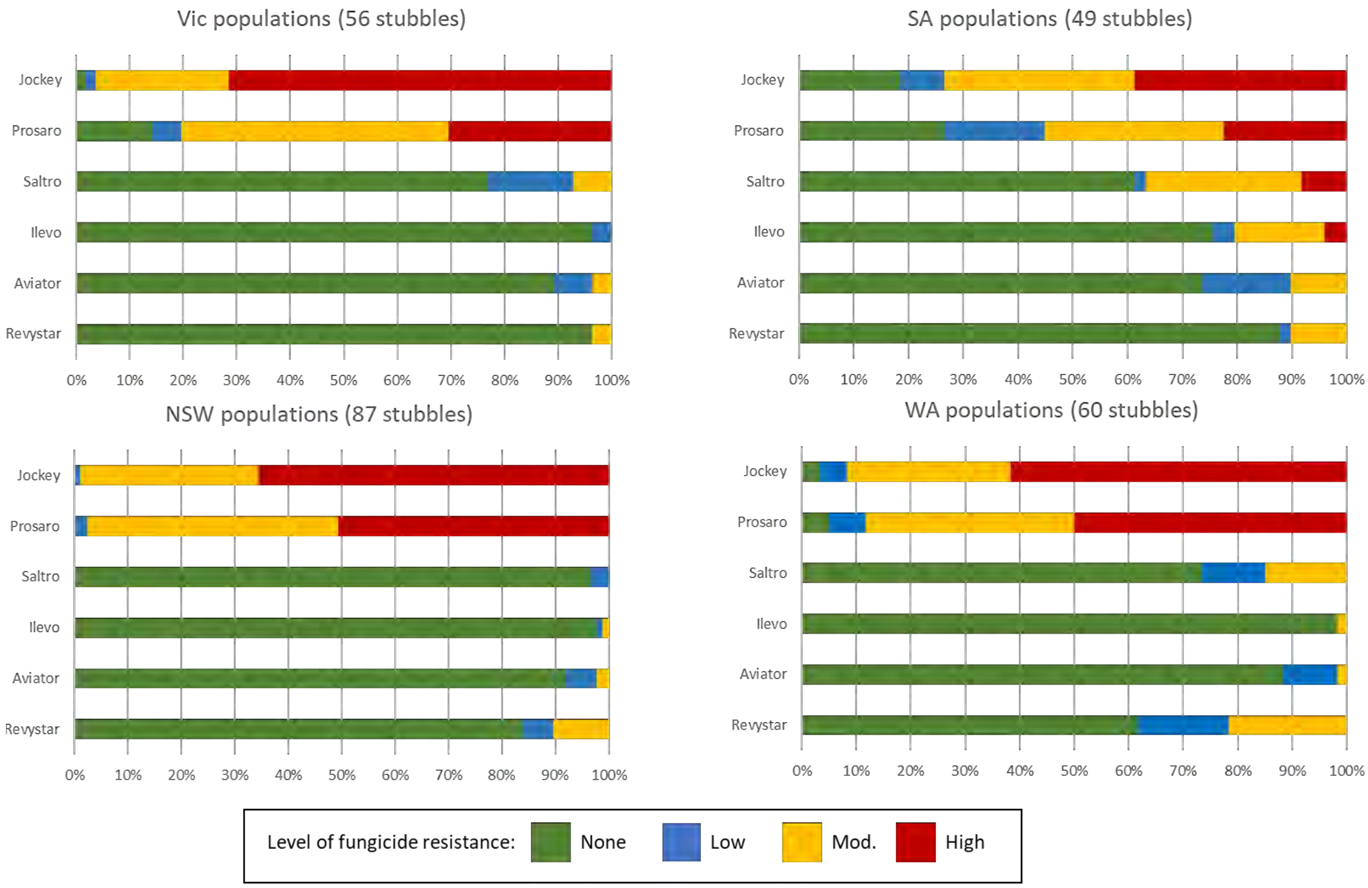

Figure 2. Percentage of stubble populations with varying levels of fungicide resistance towards each of the fungicides: Jockey® (Group 3, Fluquinconazole), Prosaro® (Group 3+3, Tebuconazole + Prothioconazole), Saltro® (Group 7, Pydiflumetofen), ILeVo® (Group 7, Fluopyram), Aviator® XPro (Group 7+3, Bixafen + 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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Profitable yield frontiers – how do we know that wheat crops are set up for success before we know what the season will do?

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GRDC project codes: CSP2404-020RTX, CSP2504-013RTX

Keywords

- critical period, tactical agronomy, wheat, yield potential

Take home messages

- Cereal crops determine their yield potential during the critical period (from flag leaf emergence to anthesis), but most inputs are applied earlier, and the season's potential only becomes apparent later.
- To set up crops for success, align the critical period to favourable conditions with timely establishment and phenology.
- To set up crops for success, achieve high radiation interception at flag leaf emergence with early establishment, plant spacing and N rate.
- We introduce 'Ringmaster Agronomy' to frame crop management as making crops 'jump through hoops', that is, crops must fall within a range of growth that is known to position them well for the rest of the season. We aim to establish 'hoops' for the start of the critical period to guide decision-making.

Background

The GRDC Profitable Yield Frontiers (PYF) project is based on a simple principle: profit increases when crops are better set up to capture water-limited yield potential, particularly the upside in favourable seasons. In cereals, yield potential is determined during the critical period from late stem elongation to flowering (Slafer et al. 2023), with grain number governed by the duration of this window, crop growth rate, and assimilate partitioning.

Crop condition in the critical period is largely determined earlier, through canopy size, radiation interception, water supply, and nitrogen availability. This creates an economic tension, as many yield-defining decisions must be made when seasonal outcomes are uncertain and/or logistics constrained. PYF therefore aims to develop a physiology-led framework that helps growers and advisers:

- set systems up to more consistently achieve water-limited yield potential
- identify when tactical adjustments are likely to pay
- benchmark the evolving frontier of water-limited yield.

The focus is on identifying which management levers matter most, and how their value shifts with starting conditions (for example, plant available water (PAW), emergence) and seasonal stress timing.

Method

We conducted small-plot experiments at Lock, Hart and Bordertown in South Australia, and Birchip, Natya, Yarrawonga and Dookie in Victoria. The experiments in 2024 included emergence date, crop type and variety, nitrogen strategy and irrigation. One set of 2025 experiments included emergence date, crop type, variety and nitrogen strategy, and a second set included nitrogen strategy, irrigation and plant spacing. Two emergence dates targeted the early and late side of a 'timely' sowing window at each site. Two nitrogen strategies were budgeted on initial soil water, rainfall to date, and estimates of decile 2 or decile 8 rainfall from application to harvest. A third similar strategy targeted a decile 8 finish but deferred the date of N application. Crop types were wheat and barley with three to four varieties of each, covering a range in phenology types. Irrigation was 30–40mm at the onset of the critical period. Plant spacing manipulated the canopy at the onset of the critical period through plant number and row spacing. We also drew on an National Variety Trials (NVT)dataset made available to us by the GRDC.

Results and discussion

The mismatch between timing of decisions and timing of yield-determining conditions

Most agronomic decisions, that is variety choice, sowing date, herbicide applications and fertiliser rates, are made by stem extension in August. However, most of the variation in yield-determining growth conditions occurs later, and little information is available about the future of the season. For illustration, moisture supply estimated from rainfall by the end of July explained only 42% of variation in NVT yields in north east Victoria, where yields have varied from 1t/ha to 7.5t/ha in 36 trials from 2015 to 2023.

Introducing Ringmaster Agronomy

Tactical agronomy needs a target to set up crops to achieve the profitable yield frontier. We expect that there will be a lower limit to growth (and other metrics) to ensure yield potential is attainable, and an upper limit to growth that avoids poor outcomes in yield or grain quality. These lower and upper limits can be thought of as a 'hoop' that a crop must 'jump through' to be well-positioned for an unknown seasonal outcome. We call this 'Ringmaster Agronomy' (Figure 1). If we can define hoops based on sound evidence and physiological reasoning, then we can support agronomic decision-making in a few ways. First, it would provide a clear target to guide decisions about early season inputs. Second, it would be more concrete and less ambiguous to benchmark a crop mid-season. Third, it would increase our understanding of the links between agronomic causes and grain yield effects, enabling faster learning from experience and experiments. We aim to quantify the hoops for the Southern Region, and once established, our methods could be downscaled with local data or adapted to other growing regions.

Figure 1. An AI generated illustration of 'Ringmaster Agronomy' that frames management as making crops 'jump through hoops'. We hypothesise that there are lower and upper limits to growth early in the season that correspond to maximising the chance of a high yield. We aim to quantify these limits for the Southern Region, and they could be adjusted with local data.

The critical period determines grain number and a crop's yield potential

A large body of evidence shows that grain yield variation, that is from 1t/ha to 10t/ha, is mostly explained by grain number (Slafer et al. 2022) the trait best related to yield. In this context, it is relevant to identify the main determinants of GN m-2 in response to genetic and environmental factors as well as the trade-offs between them. In the present study we compiled a large database across the literature to analyse the relative importance of components when affected by genetic or environmental factors, producing small or large changes in GN m-2 and its components, either numerical (the number of spikes per m2, SN m-2; and the number of grains per spike, GN spike-1. This is corroborated by our dataset of Shotgun[A] wheat from Victoria and South Australia in 2025 with a range of 1–8t/ha (Figure 2). In 28 NVT trials from north east Victoria, grain number explained 78–99% of grain yield variation for 55 genotypes that occurred in more than 10 location-years and had a yield range of more than 4t/ha in the dataset.

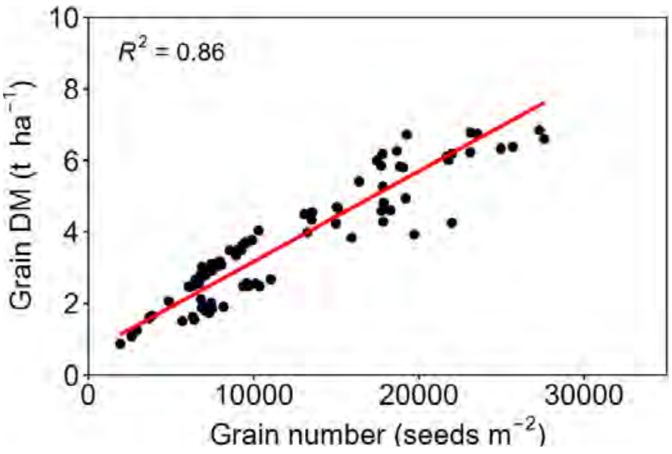

Figure 2. Association of grain number and grain dry matter (DM) at maturity for 2025 experiments in Lock, Hart, Birchip, Dookie and Yarrawonga.

In turn, grain number is determined by crop growth and stress during a developmental window often called the 'critical period' (Carrera et al. 2024). In cereals, this window is from flag leaf emergence to anthesis. 'Critical period thinking' suggests that agronomic 'hoops' should be placed at flag leaf emergence to bridge the gap between input decisions made earlier and seasonal outcomes that become apparent later.

Matching critical period to environment sets up crops for success

It is well established that targeting the optimal flowering period sets up crops for success by protecting yield potential from temperature and drought stress. Yet it is not so well appreciated that this target also serves to place the critical period in a favourable window with enough resources that supports crops to set their potential at a high level.

The critical period of timely crops occurs before severe water stress, so one key factor for its success is the vapour pressure deficit (VPD) that affects the potential water use efficiency (WUE) of shoot growth. VPD measures how strongly the air draws moisture out of plants. If VPD is high, atmospheric demand is high and crops obtain less carbon per mm of transpiration, so potential WUE declines. Figure 3A shows an estimate of the upper limit to WUE for a given daily VPD from Rodriguez and Sadras (2007). It shows that from mid-August to mid-October, the range in which the critical period might occur, potential WUE is highly responsive to VPD. Figure 3B shows how emergence date for 2024 and 2025 trials at Yarrawonga and Dookie affected the date of the onset of the critical period (flag leaf appearance) for Shotgun$^{\text{Ⓟ}}$ wheat. Delayed emergence led to a delayed critical period that fell within a window that was likely to be less supportive of rapid growth. Figure 4 gives evidence that grain yield and VPD in the critical period have a clear relationship within and between two sites with contrasting VPD regimes in 2025.

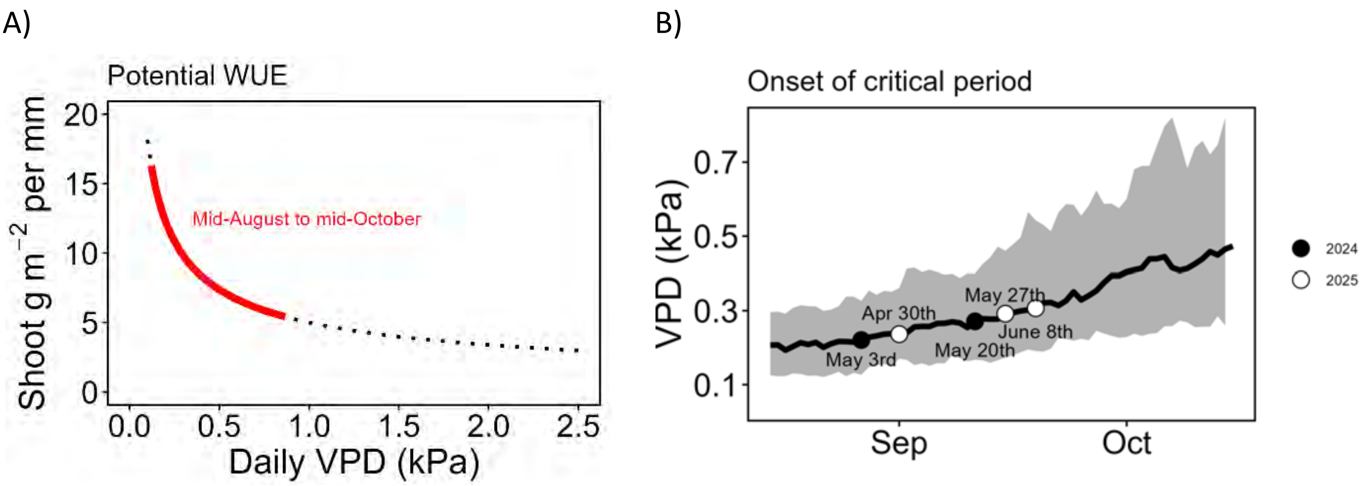

Figure 3. WUE, VPD and timing of the critical period. A) Potential WUE of shoot growth as a function of daily VPD. The range for mid-August to mid-October, when the critical period is likely to occur, is highlighted in red. B) Median (black line), 10th and 90th percentile (grey ribbon) of VPD from mid-August to mid-October. Points are dates of flag leaf emergence at Yarrawonga and Dookie in 2024 and 2025, labelled with their corresponding emergence dates.

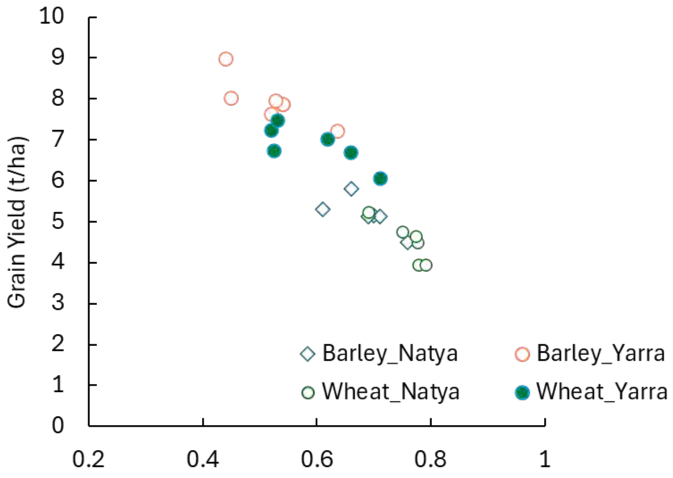

Figure 4. Association of VPD in the critical period with grain yield at Yarrawonga and Natya.

Adequate early growth sets up crops for success

Another key factor for critical period success is radiation supply and capture. We found a strong association between radiation interception at the start of the critical period and grain number at harvest (Figure 5). This is partly explained by how suboptimal radiation capture limits photosynthesis and growth. However, not all site-years showed a growth penalty from lower radiation capture, suggesting that other mechanisms are at play. Some data suggest that the ability to generate reserves of carbohydrate and nitrogen in stems and leaves, also associated with radiation interception at the start of the critical period, can support grain number determination. Whatever the mechanism, theory and evidence currently support a management strategy that targets close to complete radiation interception by flag leaf emergence, and we aim to refine this target after closer inspection of the data.

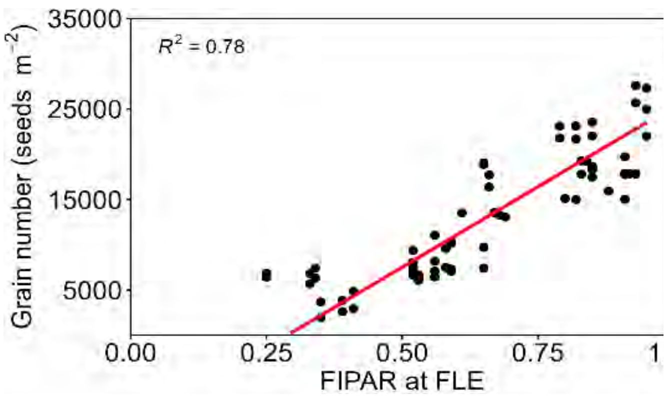

Figure 5. Association of FIPAR (fraction of intercepted photosynthetically active radiation) at FLE (flag leaf emergence) and grain number at maturity.

Conclusion

We highlighted that attaining profitable yield frontiers is challenged by unpredictable seasonal outcomes. The PYF project is developing ways to incorporate knowledge about crop status into decision-making, and here we outlined the concept of 'Ringmaster Agronomy' that suggests there is a range of growth that positions wheat crops well for an unpredictable spring. Management can aim to make crops 'jump through' this range of growth, or 'hoop'. Given theory and new local evidence, we recommend that the hoop(s) be placed at flag leaf emergence, the onset of wheat's critical period. Crops are set up for success when their critical period is aligned to when there is a high probability of favourable conditions. They are also set up for success when they arrive at the critical period with sufficient growth. Sufficient growth means having enough canopy biomass by the critical period to capture the yield opportunity the environment is likely to support and in part to achieve close to complete radiation interception. Further work is required to understand what sufficient growth thresholds are, the mechanisms that link critical period status with yield, and to reliably quantify the lower limits that constrain potential and the upper limits that penalise yield or quality. In the meantime, growers and agronomists can incorporate the date of flag leaf emergence and the degree of radiation interception into their repertoire of key traits that benchmark whether a crop is set up for success.

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Achieving water-limited yield frontiers more profitably (https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2025/02/achieving-water-limited-yield-frontiers-more-profitably)

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Nitrogen fertiliser decisions – the good, the right and the risky

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Keywords

- decisions, nitrogen, profit, risk.

Take home messages

- The 'right' N fertiliser decision maximises profit, replaces N taken out in grain plus any N lost from the soil, and minimises chances of losing money in any given year.
- It is difficult to make the 'right' N decision every year, but 'good' decisions are relatively easy and are more likely to be 'right', particularly when reviewed over several years.
- There are many ways of making 'good' N decisions that suit different decision-making preferences – pick one that suits you and use it.
- Check that your 'good' decision-making system is 'right' in the short-term using grain protein, and in the long-term using a partial N balance.

Background

Risk is a term that has taken on many definitions, but is commonly used to describe the chance of something negative happening. However, the more formal definition is that there is a range of outcomes associated with an action (both positive and negative), and that the probabilities of the different outcomes are known. This definition perfectly describes N fertiliser decisions in Australian cropping systems. When a decision is made about how much fertiliser N to apply to a crop and when, there is a range of possible outcomes in terms of the effect on yield, quality, logistics, labour and profit (some positive, some negative). The probabilities of these different outcomes can be estimated, based on soil tests for water and mineral N, and historic climate data, either using a complex tool like Yield Prophet® or simpler tool based on rainfall deciles like Yield Prophet Lite.

'Good' and 'right' decisions

Nitrogen decisions are a clear demonstration of the difference between 'good' and 'right' decision making. 'Right' or 'wrong' relates to the outcome of a decision. For this discussion, 'good' or 'bad' relates to the process of deciding. A 'good' decision is based on available evidence and information, with appreciation of both likelihood (probability) and consequences (outcomes) of any action that is taken (Nicholson 2019). A 'bad' decision is made in the absence of evidence and relies on assumptions and guesses. 'Good' decisions can be both right and wrong when reviewed in hindsight. Whether an N fertiliser decision is 'right' or 'wrong' largely depends on seasonal conditions following N application (rainfall, temperatures, etc.), which, in Australia, are highly variable. Whether an N decision is 'good' or 'bad' depends on the evidence used to make the decision, and if the performance of the decision-making process or system is reviewed and adjusted over the longer term.

How to make 'good' N fertiliser decisions

GRDC RiskWi$e has been evaluating different N fertiliser rate decision-making processes (Table 1) in a national network of field experiments. An emerging finding from this network of experiments is that there are lots of ways to make 'good' N decisions that use different sources of evidence, and that there are 'good' decision-making processes available that suit a broad range of decision-making preferences. Some of the decision-making processes in Table 1 are highly active and analytical, and require a lot of input information and time on behalf of the decision maker, e.g. Yield Prophet or Protein+Replacement. Others, such as N banks or Financial, are more passive, require less information, and don't explicitly consider risk in the decision-making process, but an appreciation of risk is embedded in their derivation.

Table 1: The different N decision-making processes being evaluated in GRDC RiskWi$e. The methods evaluated at each site were chosen by local action research groups, so not all methods are included at all sites.

Decision-making process	Abbreviation	Description
Nil	NIL	Nil top-dressed N control. Starter fertiliser (for example, MAP) at sowing only.
District practice	DIS	N rate determined by local N decision-making process.
National average	NAT	National average N fertiliser rate (45kg N/ha) applied each season.
N Bank Conservative	NB_CON	25kg N/ha less than environment economic optimum.
N Bank Optimal Profit	NB_PRF	Environment economic optimum N bank target.
N Bank Optimal Yield	NB_YLD	25kg N/ha more than environment economic optimum.
Decile 1	YP_D1	Yield Prophet or Yield Prophet Lite assuming 100% probability or decile 1 rain for remainder of season (severe drought).
Decile 2-3	YP_D3	Yield Prophet or Yield Prophet Lite assuming 75% probability or decile 2–3 rain (moderate drought).
Decile 5	YP_D5	Yield Prophet or Yield Prophet Lite assuming 50% probability or decile 5 rain (median).
Decile 7-8	YP_D7	Yield Prophet or Yield Prophet Lite assuming 25% or decile 7–8 rain (favourable).
Forecast Responsive	YP_BOM	Yield Prophet or Yield Prophet Lite informed by Bureau of Meteorology 3-month seasonal climate forecast.
Financially Responsive	FIN	Apply as much N fertiliser as can be purchased with 8% of gross income from the previous season at current market value of urea.
Replacement	REP	Amount of N removed in grain applied as fertiliser N in the following season.
Replacement + Protein	REP_PRO	Replacement of N removed in grain +/- extra based on protein content of previous crop.
Replacement +30%	REP_HI	Apply N fertiliser equal to grain N offtake from previous season plus 30%.
Replacement -30%	REP_LO	Apply N fertiliser equal to grain N offtake from previous season minus 30%.
Enhanced fertilisers	EEF	N fertiliser is supplied with coatings to reduce losses (for example, urease inhibitors, polymers, nitrification inhibitors)
Manure	MAN	Proportion of N supplied through addition of manure of known N content

The difference between the GRDC RiskWi$e experiments and past N experiments is that they evaluate decision-making processes or systems rather than fixed rates, and that the treatments are applied to the same plots year after year, allowing effects to accumulate and long-term performance of different decision-making processes to be evaluated. This long-term approach has revealed that 'good' decisions are much more likely to be 'right' decisions when reviewed over more than one season, because both unused N and water carry-over to subsequent crops. Carry-over of N compensates for one-off over-fertilisation by reducing costs or boosting yield in subsequent seasons. Often N deficient crops don't extract all the available soil water, and this can compensate for one-off under-fertilisation by increasing yield in subsequent years. Reviewing performance over many seasons means that decision-making processes based on probability have a larger number of years to approach the probability distribution used to predict risk.

How to make 'right' N fertiliser decisions

In the analysis of the experiments, we use several criteria including profit, risk, water-use efficiency, environmental losses and maintenance of soil organic matter, to evaluate how 'right' different decision systems are. A key finding was that long-term yield and, to a lesser extent, profitability (gross margin) was largely explained by mean (long-term average) N rate (Figure 1 and Figure 2).

Whilst different decision methods vary in how much N they recommend in a single year and this can result in a decision being 'right' or 'wrong' in that season, when considered over the long term, these annual differences even out. At most sites, gross margin has a weaker and flatter relationship with N rate (Figure 2) compared to grain yield. That is, decision-making systems can vary quite a bit in how much N they apply on average, but the mean gross margin is similar. Mean annual gross margins are roughly equivalent at mean annual N rates varying from 0 to 90kg N/ha at Bute, 40–90kg N/ha at Curyo, 80–160kg N/ha N at Dookie and 50–150kg N/ha at Griffith.

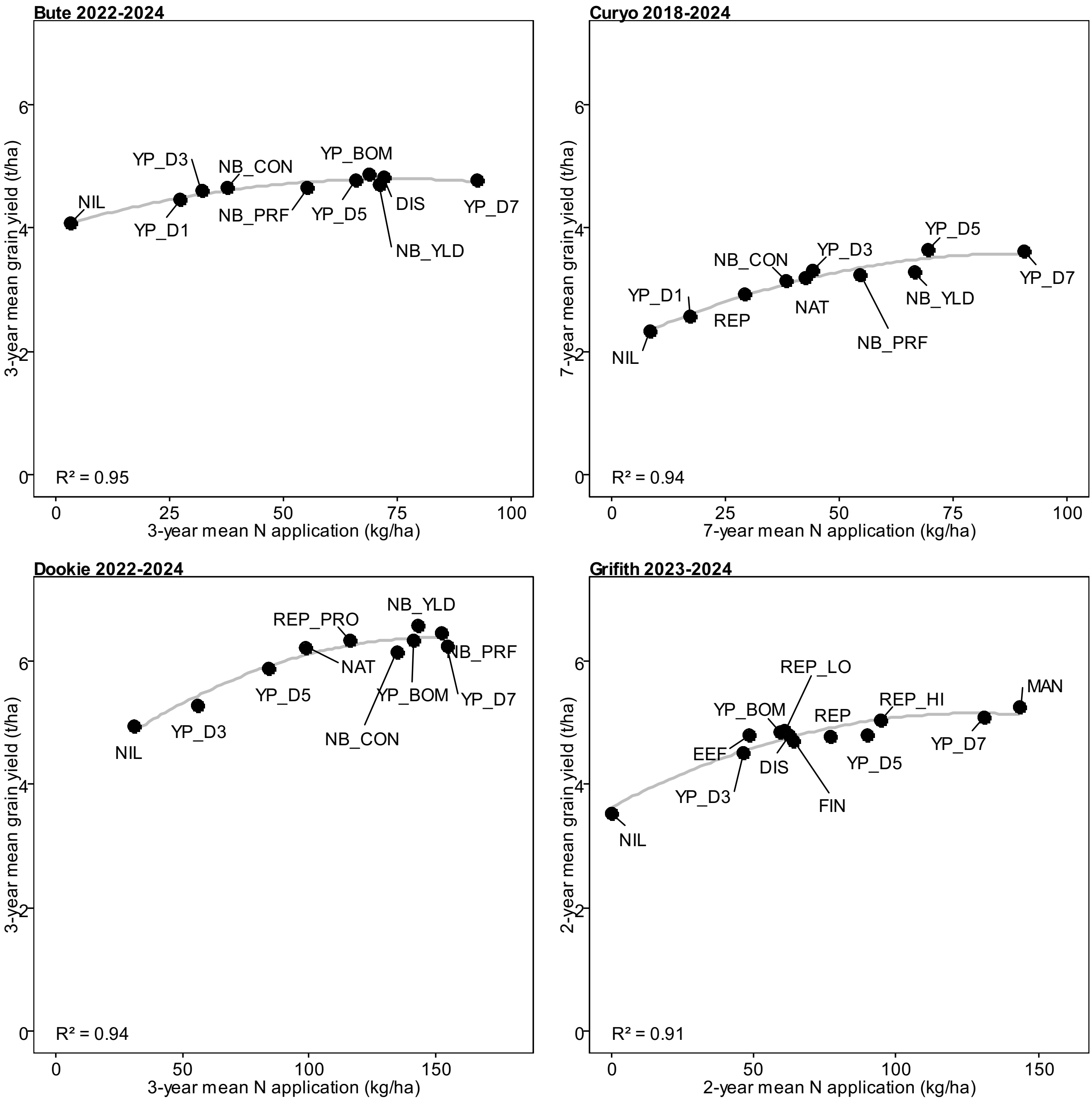

Figure 1. The relationship between mean annual N application and grain yield for a subset of four sites from the GRDC RiskWi$e network (Bute, Curyo, Dookie and Griffith). See Table 1 for a list of treatment abbreviations.

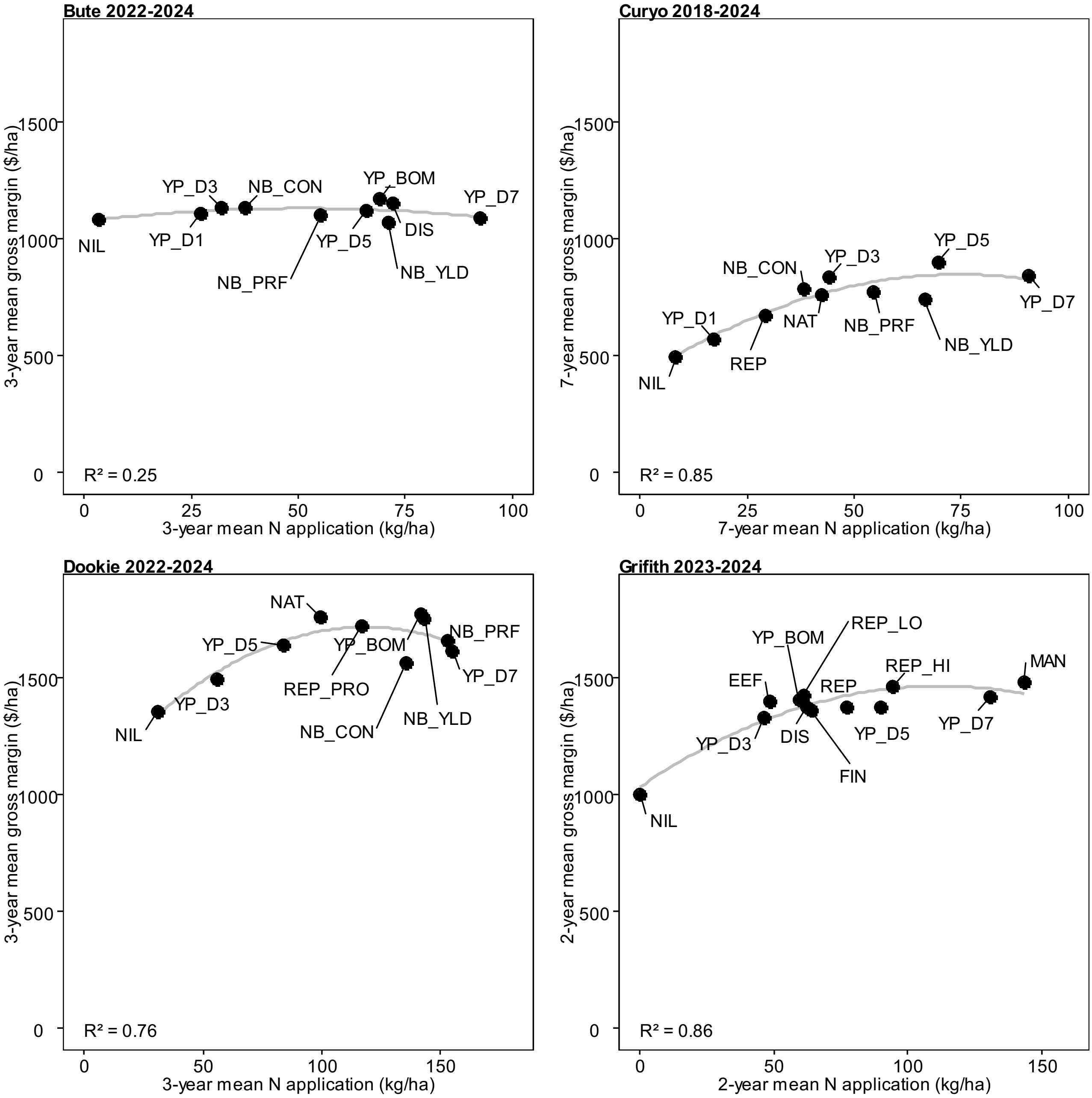

Figure 2. The relationship between mean annual N application and gross margin for a subset of four sites from the GRDC RiskWi$e network (Bute, Curyo, Dookie and Griffith). See Table 1 for a list of treatment abbreviations.

Despite the flat response, active evidence-based analytical systems, like Yield Prophet, that consider risk in their decision making, are consistently profitable (that is, ‘right’) at most sites, but more passive systems are often equally profitable, or not far behind. For example, at all sites YP_D5 and YP_BOM treatments frequently sat at the peak of the fitted curves, but NB_PRF or REP usually had similar mean N application rates and profit.

An implication of the finding that long-term average N rate explains >90% of variation in yield is that ‘bad’ decisions not based on evidence in the year of application can be ‘right’ if, over the long term, they achieve the average optimum N rate for a given environment. This means that very passive N decision-making processes (e.g. same N rate on every crop in every year) can also achieve close to maximum yield and profit, provided the outcome of the decision process are reviewed over the short and long term, to ensure the decision is ‘right’. Reviewing and adjusting simplistic decisions in this way validates them with evidence, so even the simplest of decisions need to be evidence-based to be ‘good’.

The simplest way of reviewing decision-making performance over the short term is by reviewing grain protein data. A consistent finding of the RiskWi$e experiments is that profit is maximised in cereals when grain protein is between 10 and 12% and, in canola, between 22 and 24%. If protein contents are lower than these ranges, crops were likely to be N deficient and didn’t yield as well as they could have, which reduces gross income and profit. If they are higher than these ranges, more N was applied than necessary to achieve maximum yield, which increases variable costs, and, in some cases, excessive N reduces grain or oil yield, which reduces gross income.

Keep the system in balance

Given that a broad range of decision-making systems can deliver equivalent gross margins, how can we further evaluate decision-making systems to tell which systems are most ‘right’? Partial N balance is an easy and powerful way for growers and advisers to evaluate how ‘right’ an N decision system has been over the longer term (>3 years). Partial N balance is the difference between major N inputs to the cropping system (fertiliser and legumes) and N exports in grain and hay. The term ‘partial’ is used because N losses, atmospheric deposition, non-rhizobial N fixation and animal export are not included because they are hard to estimate, tend to be relatively small, and cancel each other out. A cropping system which has higher N inputs in fertiliser and legumes than the N exported in the grain has a positive partial N balance. A system which has lower fertiliser and legume N inputs compared to grain export has a negative N balance and is mining soil organic N to maintain crop productivity. Mining soil organic N releases CO_2 into the atmosphere, as soil organic matter mineralises and is not replaced due to N deficiency, limiting the formation of stable soil organic matter.

At all GRDC RiskWi$e field sites, there are N decision-making systems that are profitable but also maintain a neutral to slightly positive partial N balance (Figure 3). This means they generate N recommendations that put back what is taken out in grain and are unlikely to be mining soil organic N and emitting CO_2. Maintaining soil organic matter also provides a buffer that reduces risk associated with N management decisions. This is illustrated by comparing N rate and gross margin in Figure 2 at Curyo (0.7% soil organic carbon from low rainfall, light soil texture and a long history of long fallowing) with Dookie (1.2% organic carbon from high rainfall, heavier soil texture and a long history of legume pastures). At Curyo, the Nil and low N applying treatments are substantially less profitable than YP_D5 because there is very little mineralisation in favourable seasons to support crop yield, and yield is very reliant on getting N fertiliser decisions ‘right’. At Dookie, the Nil and low N applying treatments are not as far behind YP_D5, because mineralisation is able to better support yields in favourable seasons, which means there is less pressure to get N decisions ‘right’ in every single year.

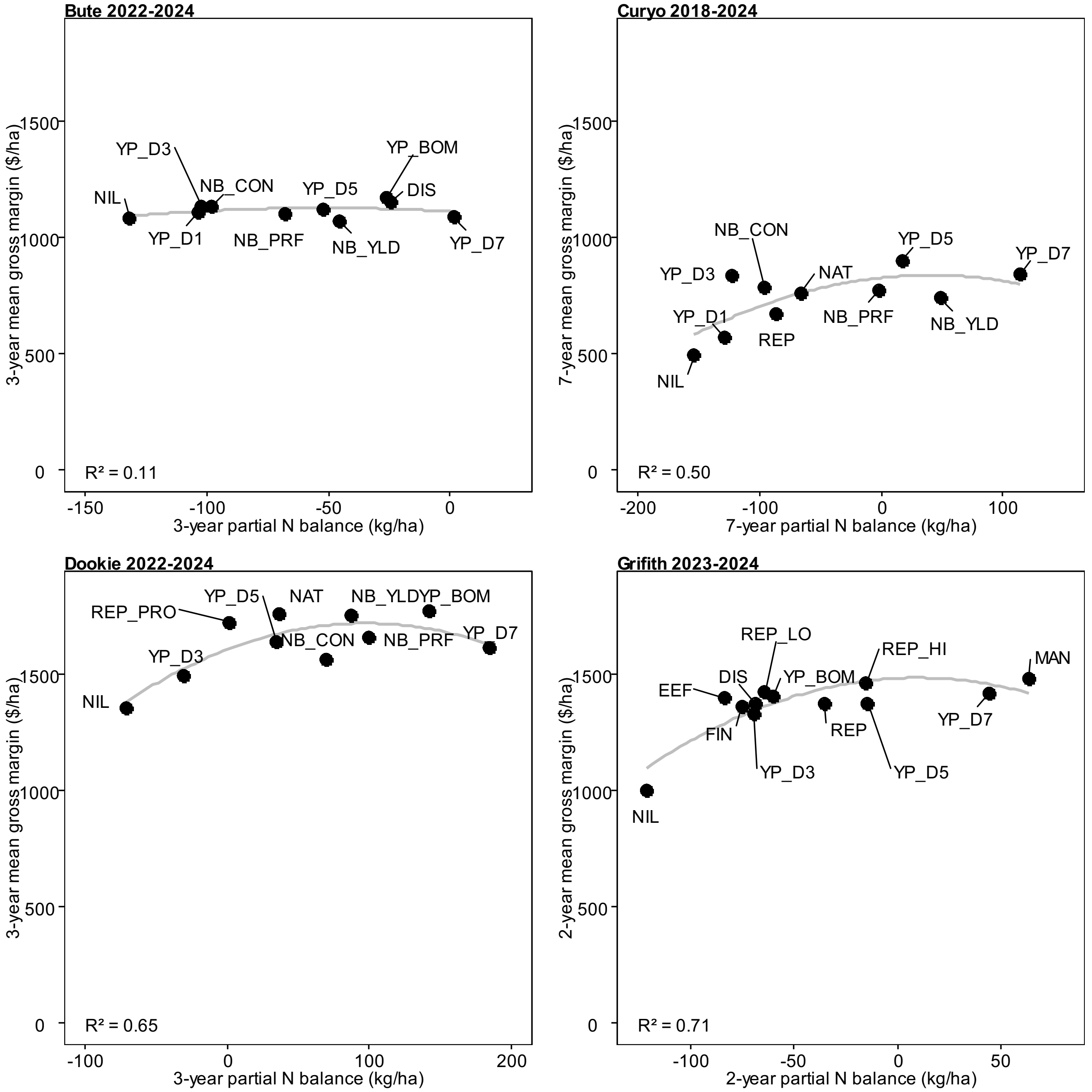

Figure 3. The relationship between partial N balance and gross margin for a subset of four sites from the GRDC RiskWi$e network (Bute, Curyo, Dookie and Griffith). See Table 1 for a list of treatment abbreviations.

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.

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RiskWi$e – the National Risk Management Initiative (https://research.csiro.au/riskwise/)

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- Partnering organisation: Riverine Plains

- Trade display supported by: Polytex and Spraytec

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2026 Dookie 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. Protecting your most perishable asset - latest tips on grain storage
Chris Warrick, Primary Business

Content relevance ☐ /10 Presentation quality ☐ /10

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

3. Industry panel - pushing pulses for better crops in the north
Audrey Delahunty (Agriculture Victoria), Aaron Vague and Tom Price (FAR), Candice Robinson (Sefton Agronomics), Federico Ribalta (Intergrain)

Content relevance ☐ /10 Presentation quality ☐ /10

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

4. Getting best bang for buck on canola fungicides
Alec McCallum, University of Melbourne

Content relevance ☐ /10 Presentation quality ☐ /10

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

5. Profitable yield frontiers
James Manson, CSIRO

Content relevance ☐ /10 Presentation quality ☐ /10

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

☐

6. Risk and reward of N fertiliser decision-making strategies – insights from a national network of RiskWi$e field experiments
Corinne Celestina, University of Melbourne

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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