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SOUTH AUSTRALIA
TUESDAY 23RD
JULY 2024

GRAINS RESEARCH UPDATE

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GRAINS RESEARCH UPDATE

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Lock

Tuesday 23rd July

9.00am to 1.00pm

Lock Football Club, North Terrace, Lock

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Lock GRDC Grains Research Update
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Research Update
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Contents

TOP 10 TIPS

FOR REDUCING SPRAY DRIFT

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01 **Choose all products in the tank mix carefully**, which includes the choice of active ingredient, the formulation type and the adjuvant used.

02 **Understand** how product uptake and translocation may impact on coverage requirements for the target. Read the label and technical literature for guidance on spray quality, buffer (no-spray) zones and wind speed requirements.

03 **Select the coarsest** spray quality that will provide an acceptable level of control. Be prepared to increase application volumes when coarser spray qualities are used, or when the delta T value approaches 10 to 12. Use water-sensitive paper and the Snapcard app to assess the impact of coarser spray qualities on coverage at the target.

04 **Always expect** that surface temperature inversions will form later in the day, as sunset approaches, and that they are likely to persist overnight and beyond sunrise on many occasions. If the spray operator cannot determine that an inversion is not present, spraying should NOT occur.

05 **Use weather forecasting** information to plan the application. BoM meteograms and forecasting websites can provide information on likely wind speed and direction for 5 to 7 days in advance of the intended day of spraying. Indications of the likely presence of a hazardous surface inversion include: variation between maximum and minimum daily temperatures are greater than 5°C, delta T values are below 2 and low overnight wind speeds (less than 11km/h).

06 **Only start spraying** after the sun has risen more than 20 degrees above the horizon and the wind speed has been above 4 to 5km/h for more than 20 to 30 minutes, with a clear direction that is away from adjacent sensitive areas.

07 **Higher booms increase drift**. Set the boom height to achieve double overlap of the spray pattern, with a 110-degree nozzle using a 50cm nozzle spacing (this is 50cm above the top of the stubble or crop canopy). Boom height and stability are critical. Use height control systems for wider booms or reduce the spraying speed to maintain boom height. An increase in boom height from 50 to 70cm above the target can increase drift fourfold.

08 **Avoid high spraying speeds**, particularly when ground cover is minimal. Spraying speeds more than 16 to 18km/h with trailing rigs and more than 20 to 22km/h with self-propelled sprayers greatly increase losses due to effects at the nozzle and the aerodynamics of the machine.

09 **Be prepared** to leave unsprayed buffers when the label requires, or when the wind direction is towards sensitive areas. Always refer to the spray drift restraints on the product label.

10 **Continually monitor** the conditions at the site of application. Where wind direction is a concern move operations to another paddock. Always stop spraying if the weather conditions become unfavourable. Always record the date, start and finish times, wind direction and speed, temperature and relative humidity, product(s) and rate(s), nozzle details and spray system pressure for every tank load. Plus any additional record keeping requirements according to the label.

Program

9.00 am	**Announcements and GRDC welcome**	***GRDC representative***
9.15 am	**Phosphorous management and replacement strategies**	***Nigel Wilhelm,*** *SARDI*
9.55 am	**Integrated pest management strategies**	***Tom Heddle,*** *University of Adelaide*
10.35 am	**Morning tea**	
11.05 am	**Overcoming a shifting seasonal break**	***Therese McBeath,*** *CSIRO*
11.45 am	**Fast graphs for slow thinking**	***Peter Hayman,*** *SARDI*
12.25 pm	**Tactics for minimising frost damage**	***Rhaquelle Meiklejohn,*** *EPAG Research*
1.05 pm	**Close and evaluations**	***GRDC representative***
1.10 pm	**Lunch**	

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Who is AIR EP?

AIR EP
Ag Innovation & Research
Eyre Peninsula

Agricultural Innovation & Research Eyre Peninsula (AIR EP) was officially incorporated on 26 May 2020, with the aim of creating a single entity for farmer driven applied research, local validation and extension of agricultural technologies and innovations on the Eyre Peninsula. The AIR EP Board provides governance oversight and sets the strategic direction for the organisation.

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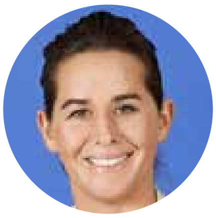

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What we do

- Attract investment in research, development and extension relevant to EP farmers.
- Deliver workshops and events to increase knowledge and skills of farmers and advisors.
- Support farmers to participate in agricultural RD&E.
- Work closely with research providers and leading consultants and advisors to improve farm profitability.

How to get involved

- Become a member
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For a full list of current projects visit the AIR EP website

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The Board is supported by two RD&E Committees, one with a focus on the medium rainfall zone (lower EP) and one on the low rainfall zone (upper EP). These committees focus on setting priorities for RD&E investment in the region, reviewing projects and providing input into events for farmers.

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Slugs, earwigs, millipedes, and slaters – current management options

Thomas Heddle[1], Kym Perry[1], David Logan[1 2], Maarten van Helden[1 2] and Kate Muirhead[1 2].

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GRDC project code: UOA2308-004RTX

Keywords

- canola, IPM, slugs.

Take home messages

- Soil pests remain challenging in retained stubble systems, and the loss of chlorpyrifos reduces control options.
- Control millipedes and slaters before applying slug bait.
- Baiting slugs at sowing is critical to protect crop seedlings from feeding damage.
- A new GRDC slug project is underway to improve slug prediction and management options.

Background

Slugs, earwigs, slaters and millipedes are favoured by modern no-till farming systems that retain stubble and plant residues, which increase soil moisture and organic matter. Consequently, these pests have become increasingly prevalent over recent years (Micic et al. 2008, PIRSA 2018, Umina 2019). In recent seasons, some wet spring conditions have contributed to higher than usual slug populations in some regions. This paper briefly summarises the current situation and control options regarding these pests.

Earwigs, millipedes and slaters: who's the culprit

These pests are all favoured by similar conditions, such as high stubble loads, and may occur together. It is critical, but can be challenging, to identify which pest is responsible for direct plant feeding damage before deciding on control options (otherwise they may be costly and ineffective).

A recent study, funded by SAGIT (S-UA1420), investigated the feeding activity of earwigs, millipedes and slaters in six cropping fields of South Australia (van Helden and Brodie 2022). Infrared cameras were used to observe invertebrate and vertebrate activity on seedlings of seven different crop types – barley, wheat/oat, canola, chickpea, faba bean, lentil, and vetch. Video images were analysed to determine which pests were feeding (n = 16,645 individual pest observations across all crops).

In the six paddocks, most direct feeding on crops was caused by slugs, earwigs and mites (Figure 1). The slater species, *Australiodillo bifrons,* was abundant but did not cause direct feeding damage. Similarly, Portuguese millipede was commonly seen but caused minimal damage.

Millipedes feed largely on organic matter and often do not damage crops, even when in high numbers. Occasionally, millipedes cause feeding in emerging canola, lupin and lucerne (Douglas et al. 2019). Higher millipede abundance is usually associated with organic soil with higher stubble loads. Often, millipedes can be blamed for damage that may be caused by other less visible pests, such as earwigs and certain slater species.

Regarding slaters, species identification is critical, as only some species are damaging. The introduced pill bug, *Armadillidium vulgare*, is highly damaging in emerging lentils and canola and can reach densities of several thousand individuals per m^2 in stubble/trash prior to crop sowing (Perry, unpublished data). This species rolls into a ball when disturbed.

European earwigs are highly damaging in emerging canola and lupins, and to a lesser extent cereals. They become active at night and are often not visible during the day.

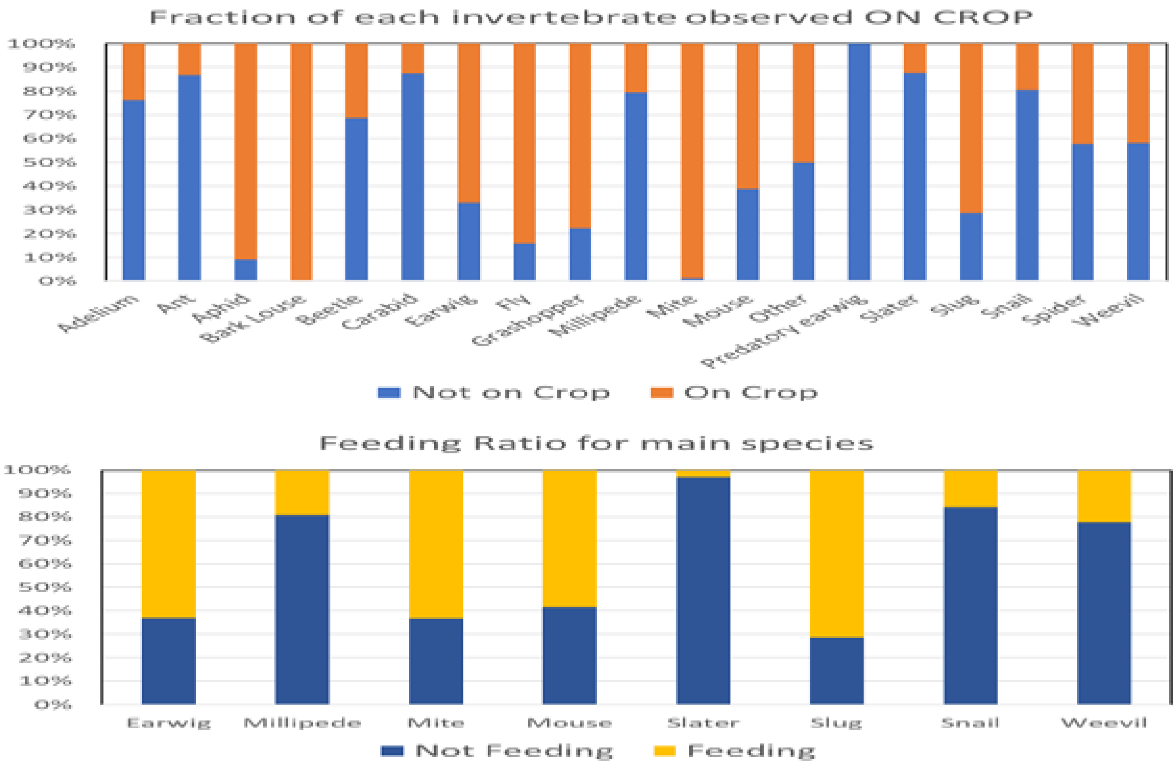

Figure 1. Per cent of invertebrate and vertebrate pests observed feeding (yellow) on crops or not feeding on crops (blue). SAGIT project (S-UA1420).

Management of earwigs, millipedes and slaters

For earwigs, millipedes and slaters, there are currently limited management options available, and no pesticides registered for in-crop use in broadacre crops. Fipronil-based and thiamethoxam-based seed treatments are registered for earwigs in some crops, but provides limited protection of seedlings from chewing damage or loss. Broad-spectrum insecticides that are registered in-crop for use on other pests in SA may have some efficacy against these invertebrate pests, but control is usually limited by lack of coverage in heavy stubble and growers must only use products according to the registered label. Always read and follow product labels.

How best to manage these pests requires more research. The best available strategies at present are likely to be to reduce refuges and food sources in paddocks, such as by removing stubble and trash residues. If high numbers of earwigs or slaters are detected prior to crop sowing, avoid planting canola or other susceptible crops. In canola, rapid plant establishment (early sowing, high vigour varieties) is one of the best defences against pest attack.

Although rarely damaging to crops, millipedes will consume snail and slug bait and should be controlled before applying molluscicide baits.

Slugs

The grey field slug (*Deroceras reticulatum*) and the black keeled slug (*Milax gagates*) are damaging species that have become more prevalent in some locations in the past few years. Slugs require moist habitats to survive and are typically found in wetter regions (for example, >400mm annual rainfall) or in wetter seasons. Current integrated management strategies for slugs include cultivation, stubble burning, rolling to compact the seed bed, molluscicide baits, and biological control (for example, carabid beetles, flatworms).

Slug monitoring project (UOA2308-004RTX)

Optimizing slug management: Enhancing capacity and capability through population modelling and innovative management strategies (Dr. Kate Muirhead, Dr Kym Perry, Dr. David Logan, Dr. Thomas Heddle)

A new study funded by GRDC, 'Optimising slug management: enhancing capacity and capability through population modelling and innovative management strategies' (UOA2308-004RTX), is investigating predictive models of slug risk to broadacre agriculture in southern and western growing regions of Australia. Thirty sites across SA, VIC, NSW and WA are being monitored monthly to determine the abundance of slug species. The project aims to provide growers with decision support tools to identify and manage slug risk.

From seven sites, 1039 slugs have been collected to date from which four species have been confirmed: the black keeled slug (*Milax gagates*), striped field slug (*Ambigolimax* sp.), the grey field slug (*Deroceras reticulatum*) and the brown field slug (*Deroceras* sp.).

This project, which will continue through to 2026, aims to identify the triggers for emergence and feeding damage of these species, and will investigate new management tactics, such as spring baiting.

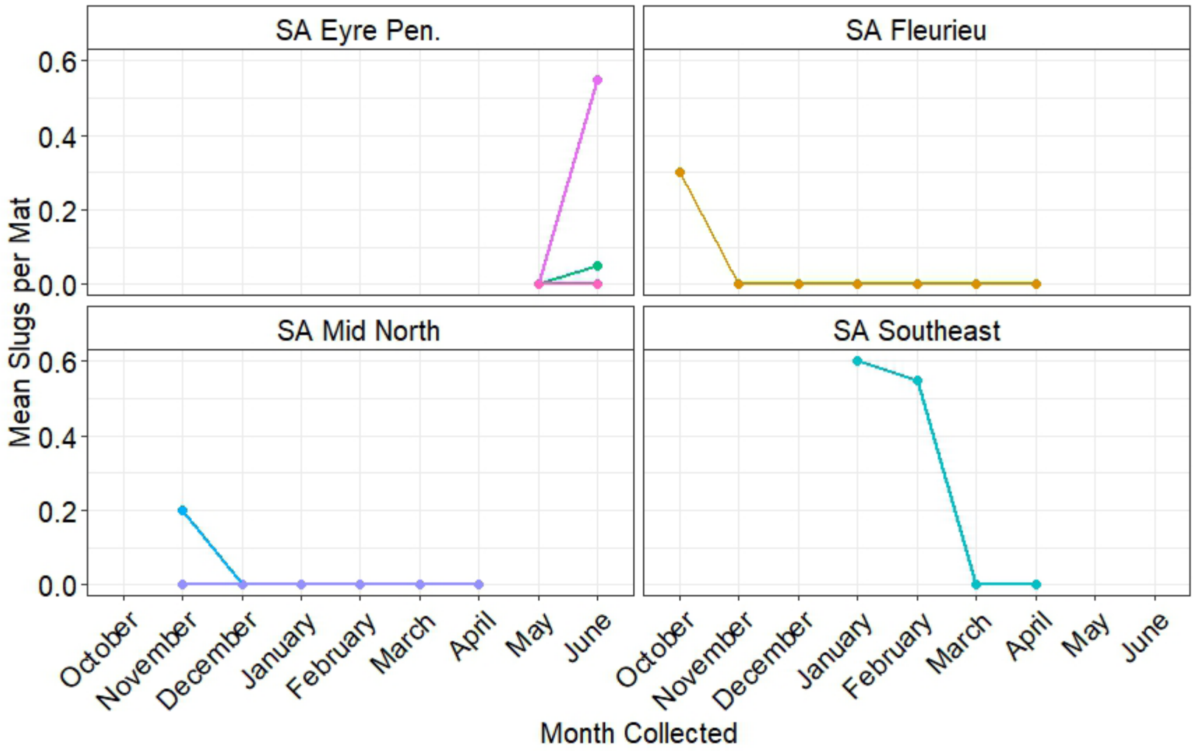

Figure 2. Slug populations across South Australia including Eyre Peninsula, Fleurieu Peninsula, Mid-North and Southeast.

Tips for baiting slugs

In areas at risk, baiting is an essential part of effective integrated slug management. Below are key management tips for effective baiting.

Monitoring

Monitor high-risk paddocks using refuges for slugs, such as mats, tiles or similar (for example, wood, bricks, drums with water). Paddocks at risk include those with previous slug damage. Canola is particularly susceptible to seedling damage or loss, especially in paddocks with clay soil. Slugs begin emerging with cool, moist conditions. Most slugs prefer temperatures ranging between 14–18°C. Monitor risk areas before and at sowing.

Bait lines are an effective alternative to refuges – simply apply a line of baits along a seeding row and check for dead slugs after 1–3 days. Bait lines need to be re-applied every 7–14 days depending on rate of bait breakdown.

Baiting for best results

To protect seed and emerging seedlings from slugs, baiting needs to be immediately after sowing, following rolling if this culture method is integrated into management. If populations are high, or other pests are feeding on baits, baits may need to be reapplied as per label rates. Monitoring after bait application is necessary to ensure bait remains to protect seedlings: that is, if there is no bait left, reapply baits that day.

Control slaters and millipedes

Slaters and millipedes will consume slug and snail pellets. If present in high numbers before crop sowing, these pests must be controlled before applying baits. In some scenarios, if baiting fails to control slugs and/or snails and there are high populations of slaters and millipedes, these species may be consuming the baits with no consequences to their survival before slugs/snails get to the baits.

Know your slugs: 'Slugs in crops: the back pocket guide'

Different regions may have more than one species of slug attacking crops. Use the 'Slugs in crops: the back pocket guide' (see link below) to identify your slug species. If you don't know which species you have, you can send photos to PestFacts or the Slug Team at SARDI/University of Adelaide.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the authors would like to thank them for their continued support. The authors also thank SAGIT for funding support. We wish to acknowledge all the growers and consultants who have helped collect the data for these projects.

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van Helden M, Brodie H (2022) Caught red-handed: Revealing invertebrate species and conditions causing seedling damage in field settings. (https://sagit.com.au/project/caught-red-handed-revealing-invertebrate-species-and-conditions-causing-seedling-damage-in-field-settings-s-ua1420/)

PestFacts south-eastern (http://www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/)

Slugs in crops: the back pocket guide (https://grdc.com.au/__data/assets/pdf_file/0030/578127/240513-Slugs-in-crops-the-back-pocket-guide.pdf)

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Notes

LOOK AROUND YOU.

1 in 5 people in rural Australia are currently experiencing mental health issues.

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The GRDC supports the mental wellbeing of Australian grain growers and their communities. Are you ok? If you or someone you know is experiencing mental health issues call *beyondblue* or Lifeline for 24/7 crisis support.

beyondblue
1300 22 46 36
www.beyondblue.org.au

Lifeline
13 11 14
www.lifeline.org.au

Looking for information on mental wellbeing? Information and support resources are available through:

www.ifarmwell.com.au An online toolkit specifically tailored to help growers cope with challenges, particularly things beyond their control (such as weather), and get the most out of every day.

www.blackdoginstitute.org.au The Black Dog Institute is a medical research institute that focuses on the identification, prevention and treatment of mental illness. Its website aims to lead you through the logical steps in seeking help for mood disorders, such as depression and bipolar disorder, and to provide you with information, resources and assessment tools.

www.crrmh.com.au The Centre for Rural & Remote Mental Health (CRRMH) provides leadership in rural and remote mental-health research, working closely with rural communities and partners to provide evidence-based service design, delivery and education.

Glove Box Guide to Mental Health
The *Glove Box Guide to Mental Health* includes stories, tips, and information about services to help connect rural communities and encourage conversations about mental health. Available online from CRRMH.

www.rrmh.com.au Rural & Remote Mental Health run workshops and training through its Rural Minds program, which is designed to raise mental health awareness and confidence, grow understanding and ensure information is embedded into agricultural and farming communities.

www.cores.org.au CORES™ (Community Response to Eliminating Suicide) is a community-based program that educates members of a local community on how to intervene when they encounter a person they believe may be suicidal.

www.headsup.org.au Heads Up is all about giving individuals and businesses tools to create more mentally healthy workplaces. Heads Up provides a wide range of resources, information and advice for individuals and organisations – designed to offer simple, practical and, importantly, achievable guidance. You can also create an action plan that is tailored for your business.

www.farmerhealth.org.au The National Centre for Farmer Health provides leadership to improve the health, wellbeing and safety of farm workers, their families and communities across Australia and serves to increase knowledge transfer between farmers, medical professionals, academics and students.

www.ruralhealth.org.au The National Rural Health Alliance produces a range of communication materials, including fact sheets and infographics, media releases and its flagship magazine *Partyline*.

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Reducing risks to canola establishment under marginal conditions– defining the fundamentals

Kenton Porker[1] , Therese McBeath[1], Andrew Fletcher[2] Matthew Nelson[2], Laura Goward[3], John Kirkegaard[3], Andrew Ware[4], Brett Masters[4], Tom Jones[5], Jackie Bucat[6], Colin McMaster[7]

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GRDC project codes: CSP2212-005RTX,CSP1907-001RTX

Keywords

- Canola, germination, emergence, establishment.

Take home messages

- A new project is undertaking research to determine the critical environmental conditions for successful canola establishment.
- Canola has the same fundamental requirements in all growing regions; moisture, temperature, seed soil contact and soil strength. These factors can all be influenced by management and environment.
- Timing of establishment is generally more important than plant density for achieving grain yield potential.
- Wet soil is cool soil - at a depth of 2.5cm within the seedbed, wet soil could be greater than 8°C cooler than wet soil.
- Consider the temperature forecast when sowing early - soil surface temperatures can be up to 20°C hotter than air temperature.
- Different moisture thresholds are required for germination, cotyledon emergence and survival to be determined by this project.
- Soil texture will influence thresholds for sowing depth - canola is more likely to emerge from deeper sowing (3 – 5cm) on sandy soil than clay soil.
- Seeder setup is likely to play a larger role in establishment from depth.

Background

Canola suffers from unreliable establishment; however early establishment is crucial for aligning crop development with the environment and maximising yield potential. Typically, only 50% of germinated seeds will successfully establish, leading to issues including reduced yield, increased weed problems and potentially costly resowing. This results in an estimated annual cost of $100M–$200M from poor establishment. Climate change and farming adaptations are expected to exacerbate this issue. For example, the desire to sow and establish canola early to maximise yield potential coincides with less favourable seedbed conditions. Seedbed conditions are often hotter and drier, and more volatile than those for other crops that can be sown later and deeper in the soil. A new national GRDC project aims to use a combination of lab and field experiments with simulation modelling to focus on the underlying processes affecting canola establishment and provide management strategies to mitigate establishment risks. Successful establishment is driven by the same fundamental requirements across all regions; moisture, temperature and seed soil contact., However, the fundamental thresholds to derive rules of thumb for establishment have not been yet established or validated.

A review focusing on management and environmental factors influencing canola establishment identified key research areas:

1. Interaction of moisture and temperature on early sowing establishment.
2. Impact of sowing depth and moisture-seeking ability.
3. Effects of crop residue/stubble on early sowing establishment.
4. Influence of soil crusting and strength on seed growth.

Defining Canola Establishment:

Canola establishment, often vaguely defined, is considered successful when a crop develops a leaf canopy and root system large enough for the plants to grow on their own when they are no relying seed reserves for growth. Emergence is noted when cotyledons appear, but establishment is achieved at the 3-4 true leaf stage. This involves coordinated processes (Figure 1) of seed germination, hypocotyl extension, and growth of leaves and roots (Nelson et al 2022).

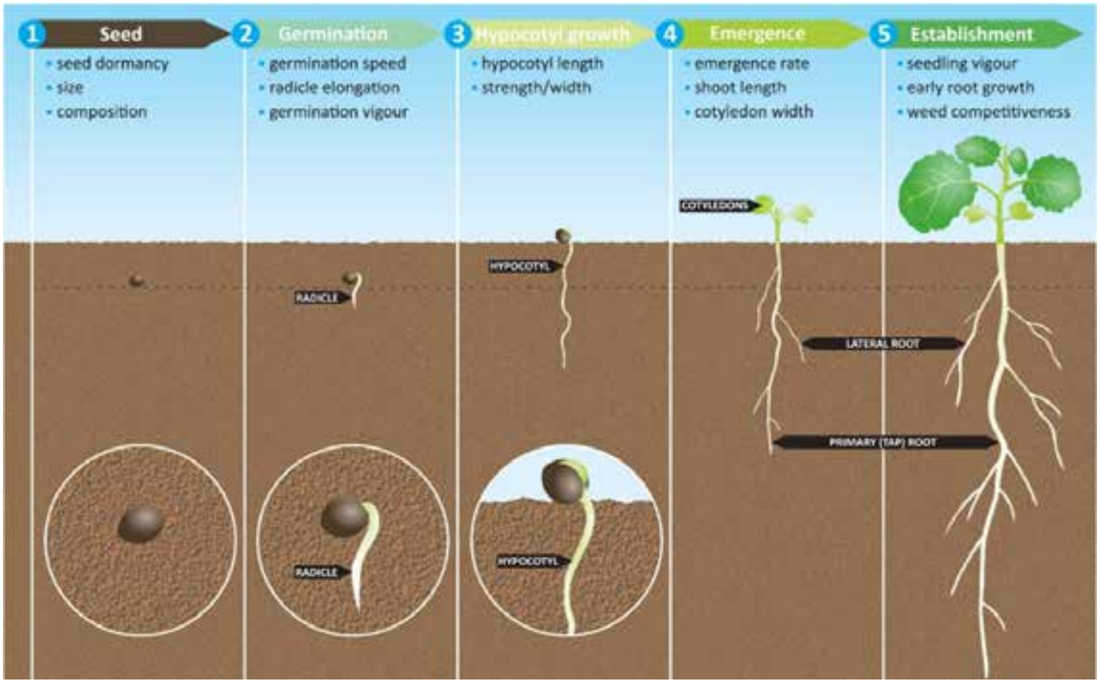

Figure 1 Growth stages between sown seed and establishment in Canola. Taken from Nelson et al. (2022).

Responses to temperature

Studies focusing on canola and related brassicas have primarily investigated germination responses to low temperatures. Optimal germination temperatures range between 25-35°C, with a base temperature of about 5°C, below which the process of germination halts. High temperatures above 35 to 40°C drastically reduce germination, often stopping it entirely. However, effects of supra-optimal temperatures remain less studied.

In 2023, field trials across Australia explored water, temperature, and soil texture gradients. These trials, including at Wynarka (sandy soil in the SA Mallee) and Ungarra (alkaline, dispersive clay on the Eyre Peninsula), involved manipulating and monitoring temperature and water at various depths in the seedbed. A significant observation was that, during April-May, surface soil temperatures in both clay and sandy soils were up to 20°C hotter than air temperatures, often exceeding accepted germination thresholds. In contrast, temperatures at 2.5cm depth in the seedbed were only up to 5°C higher than air temperatures, with the effect more pronounced in the sandy soil. This suggests that canola might have better germination prospects at cooler temperatures deeper in the soil and highlights the need to consider sowing depth in Early April when temperatures are warmer. A crucial observation from the studies is the significant cooling effect of wet soil on temperature. For instance, at Wynarka, when soil temperature was measured in the furrow late in the afternoon a day after sowing, a marked difference was noted. In sandy soil with less than 2% moisture, the temperature was 30.1°C, compared to 22.2°C in wet soil at 2.5 cm depth in the seedbed, indicating an 8°C difference. This temperature difference was less pronounced, deeper in the seed bed as both the extra layer of soil and increased moisture buffers temperature. This finding underscores the potential impact of soil moisture and depth on moderating heat stress and influencing germination timing (Figure 2).

The thermal time for canola emergence is reported to be between 90°C.d and 115°C.d. This metric can be used to estimate emergence time under optimal conditions. In southern Australian environments, this typically translates to 4-5 days under average late March to early April soil temperatures of 25°C, 7-8 days at 15°C in late April to early May, and over 12 days in May when temperatures drop below 10°C (McDonald, G., & Desbiolles, J. ,2023). This may help in understanding and predicting canola germination and emergence in varying soil moisture and temperature conditions.

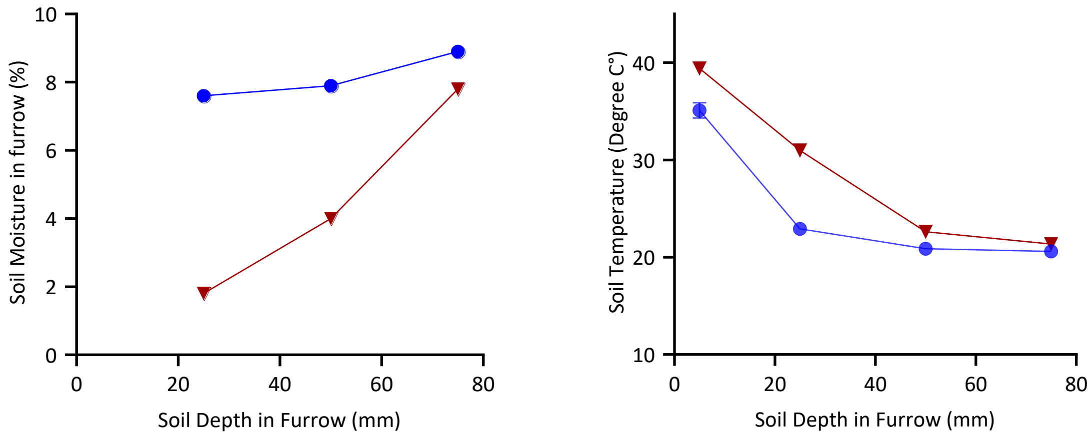

Figure 2. Soil moisture and temperature in the seed bed furrow at different depths (2.5cm, 5cm, and 7.5cm) at Wynarka in 2023 18 April under ▼ Dry conditions and ● Watered (25mm) conditions the day after sowing.

Moisture responses

The critical point in which germination is inhibited is crucial for comparisons across soil types, which exhibit different soil water release curves based on their texture. For canola, critical water potential is generally reported between -0.8 and -1.2 MPa for *germination*. However, this range might not be sufficient to guarantee *emergence* since it falls below the thresholds for any plant growth (the wilting point is at -1.5 MPa). Soil texture is a key factor, as it significantly influences soil moisture percentages and makes interpretation difficult until these numbers are converted to a known metric such as rainfall amount. For instance, the clay soil at Ungarra has a wilting point of 8%, while the sandy soil at Wynarka has a wilting point of 3.6% (as measured by suction pressure plates).

Field trials and lab experiments (with results still pending) were conducted to assess soil moisture levels both above and below the crop's lower limit. In 2023, plots were modified using tarps to exclude rainfall. A notable observation from the Wynarka sandy soil is that as little as 5mm of supplementary water applied at sowing (on 18 April) to a dry seedbed raised the soil moisture above the lower limit, leading to establishment comparable to that in soil at field capacity (figure 3). In contrast, in conditions of dry soil, emergence did not occur until 6.8mm of accumulated rainfall from 5 May to 11 May. This amount was just enough to reach the wilting point and trigger germination and emergence almost a month later than optimal, and outside the preferred sowing window for canola.

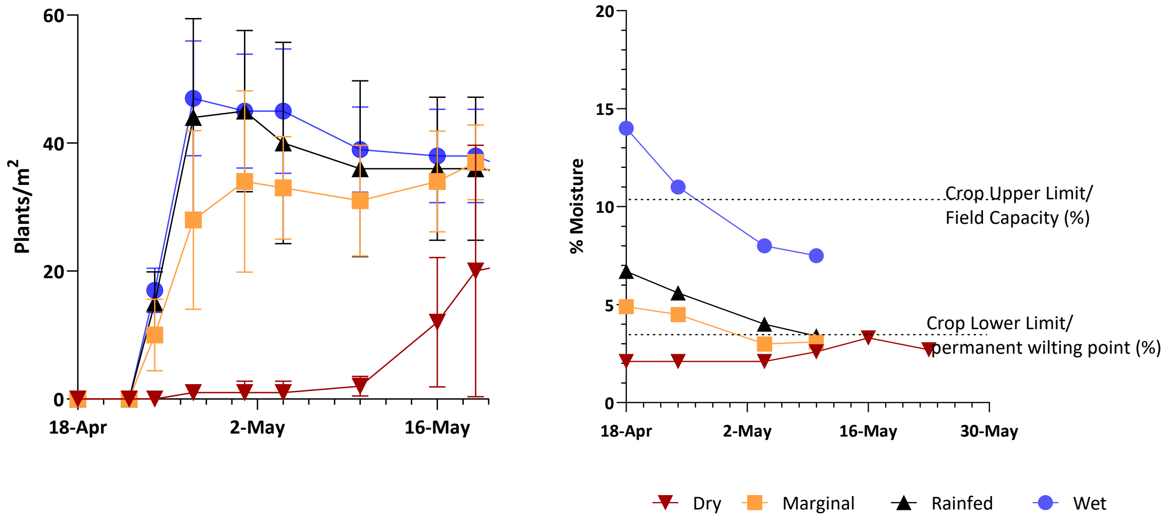

Figure 3. Plant establishment over time at 4 variable seedbed moisture profiles (2.5cm deep) at Wynarka in 2023, the cultivar was Hyola Regiment XC sown at 60 viable seeds/m^2 . Dry was tarped from the start of March until sowing to ensure dry seedbed, marginal was tarped for the same period with 5mm of water applied just prior to sowing, and wet had an additional 25mm of water at sowing.

Preliminary lab results highlight that canola's germination might occur below the wilting point, but achieving successful hypocotyl growth, cotyledon survival, and leaf emergence requires different moisture thresholds. Future research is directed towards understanding how germination inhibition relates to temperature under low moisture conditions. A key objective is to develop practical guidelines for predicting rainfall needs across various soil types, considering factors such as soil water repellence and the diversity in soil texture across different paddocks.

Implications for Yield Response

Yield responses in canola are often more closely linked to the date of emergence rather than plant density, owing to the crop's ability to compensate for reduced plant establishment. This was evident in the 2023 Wynarka trials, where early establishment correlated with higher yields. For instance, the marginal seedbed treatment that established on 23 April yielded 0.8t/ha more than crops established on 13 May under seemingly more ideal seedbed conditions (Table 1). This outcome underscores the importance of timely planting and the potential for increased yield by capitalizing on small rainfall events in April. These findings are significant for strategic farming practices, emphasizing the need for timely actions to optimize crop establishment and yield in canola farming.

Table 1. Establishment and yield response to selected treatments in the Canola cultivar Hyola Regiment XC at Wynarka on a sandy soil in 2023.

Sow Date	Treatment	Establishment Date*	Total Emergence (plants/m^2)	Grain Yield (t/ha)
17 Apr	Wet Seedbed (25mm water applied)	21 Apr	63 a	3.7 a
17 Apr	Marginal Seedbed (Dry seedbed + 5mm water)	23 Apr	30 b	3.6 a
17 Apr	Dry Seedbed	18 May	25 b	2.3 c
5 May	Wet Seedbed (25mm)	13 May	63 a	2.8 b

**Establishment date is expressed as days to achieve 20 plants/m2*

Sowing depth:

There has been renewed interest in deeper sowing as farmers sow canola increasingly early and seek moisture through deeper sowing. Research has generally shown that deeper sowing reduces canola establishment. In NSW, Brill et al. (2016) showed 30% reductions in canola emergence between 25mm and 50mm and a 70% reduction between 2.5cm and 7.5cm sowing depth on a heavier soil type. Results from the Wimmera in 2023 also found a 33% reduction in emergence from 2cm to 5cm deep on clay soil.

This was not the case on sandier soil types suggesting different thresholds with limited reduction in establishment from 2 – 5cm at Wynarka, and Kimba, however a 60, and 66% reduction in establishment respectively going from 2 – 7.5cm deep. This suggests the deep sowing threshold in sandy soils is higher than heavier textured soils with a rapid decline from 5cm rather than 2.5cm deep. Further analysis of all seedlings from the soil at Wynarka in 2023 showed establishment reduced by 10% for every 1cm deeper seed placement below 5cm at optimal moisture irrespective of soil temperature.

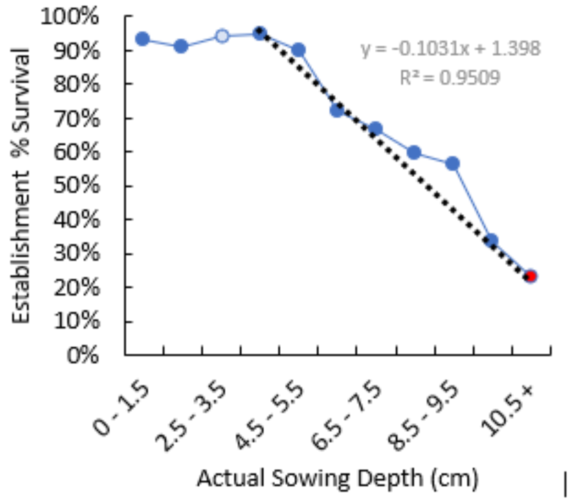

Figure 4. Relationship between seedling sowing depth and establishment survival from 5 April sowing at Wynarka sandy soil under optimal seedbed moisture conditions.

Although emergence was poor from > 5cm on these soils there were still some seeds that were able to emerge from this sowing depth and survive. This provides opportunity to exploit the interactions. Other management strategies such as cultivar type, seed size, and vigour also interact and are being explored. In a genetic study, Nelson et al. (2023) found that canola emergence at 50mm sowing depth was approximately 50% of the emergence rate at 20mm sowing depth for four common commercial cultivars across seven trials. They also tested a diverse range of genotypes from an international diversity panel and found that the best varieties from this diversity panel had emergence rates at 50mm sowing depth of up to 70% of their emergence rate when sown at 20 mm sowing depth. These cultivars originating from overseas sources, tended to be those identified as either having longer hypocotyls or high germination vigour. In contrast, Australian varieties uniformly have short-medium length hypocotyls. A new GRDC project (CSP2307-002RTX) has begun the process of introducing long hypocotyl genes from overseas varieties into Australian varieties with the aim of improving establishment potential. These are not yet commercially available. The other factor not discussed in this paper is the interaction between soil texture, compaction and soil strength which becomes more important when discussing soil depth and can be influenced by engineering and seeder setup.

Conclusion

This project will continue to work towards establishing the fundamental critical thresholds to update guidelines and reduce canola establishment failure. Key messages to date include:

- Establishment timing is more crucial for yield than plant density, with early sowing often leading to better outcomes.
- Consider the temperature forecast and soil moisture status at sowing as wet soil is cooler than dry soil, and surface soil temperatures can significantly exceed air temperatures, potential affecting seed development from shallow sowing.
- Sowing depth and soil type (ie.. sandy vs. clay) greatly influence germination and emergence thresholds and seeder setup and soil strength requires more investigation when scaling up.
- Deeper sowing typically reduces establishment, especially in heavier soils, however varietal differences, particularly in hypocotyl length and germination vigour, impact emergence, prompting efforts to incorporate beneficial traits from international varieties into Australian ones.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the authors would like to thank them for their continued support. We would also like to acknowledge and thank all cooperating farmers technical staff and project collaborators from other regions of the national project.

Useful resources

https://grdc.com.au/resources-and-publications/all-publications/publications/2023/crop-establishment-and-precision-planting

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Notes

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Fast Graphs for slow thinking– an example using nitrogen

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GRDC project code: CSP2303-015BGX, RiskWi$e

Keywords

- climate, nitrogen, risk.

Take home messages

- N budgeting using 40kg N/t of wheat is simple, widely used, and robust. However, the rule is usually applied to a single target yield and only considers the year of application. The single target yield makes it hard to think clearly about risk and the annualised focus ignores carryover and /or long-term rundown of N.
- When choosing a single target yield, a grower has one chance in 10 of selecting the right rainfall decile. Concern about applying too much N contributes to conservative rates which have been identified as an important cause of the gap in actual and potential yield and profit.
- The N theme in RiskWi$e is working with farming systems groups in a co-learning exercise to better understand the risk-reward relationship of different approaches to N fertiliser decisions over the 5-year project. Some groups are examining a long-term strategic approach using N Bank that considers the N requirement of the farming system in the context of its soil and climate. This has the attraction of a simpler set and forget approach to N management rather than tactically responding to the economics and climate of a single season.
- For growers and advisers who do want to consider a seasonally responsive approach to N management, we have developed the Fast Graphs for Slow Thinking spreadsheet (Figure 2), which uses the 40kg N/t wheat rule to consider the upside and downside by budgeting across all 10 deciles. We also encourage users to vary the rate of N carryover and see how this changes the risk and reward outcome.
- Seasonal climate forecasts are best understood as increasing the likelihood of some deciles and decreasing the likelihood of other deciles. This contrasts with the media headlines of 'El Niño outlook for a dry spring' and the quest for a forecast of a single decile. The Fast Graphs for Slow Thinking spreadsheet has been designed to examine the shift in probabilities.

Introduction

Annie Duke was a professional poker player who then pursued an academic career in decision making. She famously said, "How life turns out is determined by luck and the quality of our decisions". Notably we can only control the quality of our decisions and this paper provides an example of a decision-making process used to improve the quality of decision making where both chance and skill are involved. To illustrate this example the authors have used the decision of nitrogen application.

Overview of Riskwi$e and N theme

RiskWi$e (RiskWi$e - GRDC) runs from 2023 to 2028 and seeks to understand and improve the risk-reward outcomes for Australian grain growers by supporting grower on-farm decision-making. RiskWi$e was a response to grain growers drawing attention to the increase in risk associated with grain production. RiskWi$e is working through Action Research Groups (ARGs). In South Australia, grain growers from Eyre Peninsula are involved via the AIR EP ARG. The Central ARG is led by Hart Field Day Site and includes the Mid North High Rainfall Zone (MNHRZ); Murray Plains Farmers (MPF);

Northern Sustainable Soils (NSS); and Upper North Farming Systems (UNFS). The Mallee and South-East are covered by the ARG led by the Birchip Cropping Group and include Mallee Sustainable Farming (MSF) and the Coomandook Ag Bureau.

Groups are addressing a range of themes including sowing decisions, enterprise agronomic and financial decisions and managing the resource capital. Nitrogen decision is a common theme for all groups. The N theme of RiskWi$e is one of several GRDC investments in N because getting decisions about N management more right, more often will improve grain grower enduring profitability. Evidence from the GRDC paddock survey project, along with analysis of protein levels in wheat and barley receivals, indicate that N deficiency is an important contributor to the yield gap for Australian grains. While it is rarely economic to chase maximum yield, there is good reason to suspect that N deficiency is causing a profit gap as well as a yield gap. In RiskWi$e, the N decisions theme is working with the ARGs to take a whole-of-system approach to assess N decision strategies encompassing fertiliser and legume use. Part of the approach is to '**challenge the annualised thinking associated with N applications and budgeting that arguably amplify perceived risk**'. This paper complements a paper in these proceedings by James Hunt, (leader of N theme in RiskWi$e) who has written a clear summary of the basics of N budgeting.

The simple rule of 40kg N per tonne of wheat is useful 'bucket chemistry' which highlights the substantial upside of N in a good season. N budgeting involves estimating the demand of N from the crop (20kg plant N per tonne), the supply of N from the soil (50% efficiency in our example) to provide a total soil N supply required (40 kg soil N per tonne) and balancing any shortfall in soil N with added fertiliser N. Later in this paper, we will raise some problems with the ways that N budgeting has been applied. However, there is a lot to like about this simple rule. Using common units of kg N/ha for crop N demand and supply of N from soil and fertiliser makes budgeting possible. Prior to N budgeting, growers were confronted with a soil test of nitrate in parts per million, kg of fertiliser product and yield in t/acre or bags per acre. The simple maths of a budget is empowering. For example, if someone reports a 4-tonne crop (soil mineral N needed is 4t/ha x 40 kg soil N/t = 160 kg N/ha) coming from 50kg starting soil N and 50kg/N as fertiliser, agronomists and growers immediately question the source of the extra 60kg N/ha. The robust simplification of these biological based maths also provides for a simple economic assessment. When there is enough water for an extra tonne of wheat, 40kg of N is an excellent investment. If we assume a urea price of $700/t, one kg N is about $1.50 (700 *.46) and 40 kg N is $60. If we also assume $10/ha as application cost, then $70 N cost is a good investment for a tonne of wheat.

Estimating the supply of N can be challenging

Estimating the supply of N usually relies on deep N soil testing, although many agronomists use estimates based on paddock history. In the future, it is likely that protein monitors will be used with yield maps to provide a map of N removed from different parts of the paddock. The protein content of the grain, especially in a good season, is very informative with protein content below 11.5% often indicating N supply limited yield (G. McDonald, review published in Unkovich et al., 2020). In broad zonal terms, high yield high protein (>12.5%) is likely to have received more N than the crop required, low yield low protein (<11.5%) and high yield low protein (<11.5%) did not receive enough N to maximise yield, while an area with low yield high protein (>12.5%) maybe constrained by factors other than N. The N removal maps, sometimes referred to as N off-take maps can be loaded into spreaders to ensure N replacement accounts for the variability in N removal and sub-paddock yields can be improved.

Estimating N mineralisation can be challenging and is discussed in more detail by Hunt et al in these proceedings. One approach for paddocks with a long cropping history is to exclude in-crop mineralisation from the N budget because an over-reliance on in-crop mineralisation will rundown soil organic carbon. In addition, N mineralisation and N immobilisation often approximate each other (cancel out) in paddocks with a long cropping history. Other N budgeting approaches include Yield Prophet®, which will include mineralisation and immobilisation in the N limited yield or the rule of 0.15kg N/ha per mm of growing season rainfall (GSR). The exact number for the supply of N will be uncertain, especially with spatially variable soils.

Estimating the crop demand for N is difficult because of the uncertain finish to the season

Estimating the target yield of an irrigated crop is relatively easy. Picking a target yield for dryland grain crops is difficult. The water limited yield in medium rainfall zones ranges from less than 1t/ha in a poor season to close to over 8t/ha in a good season with a corresponding N requirement of 40 to 200 kg N/ha. In the low rainfall zone, these numbers might be adjusted to 0.5t/ha to 5t/ha, and in high rainfall, 4t/ha to over 12t/ha.

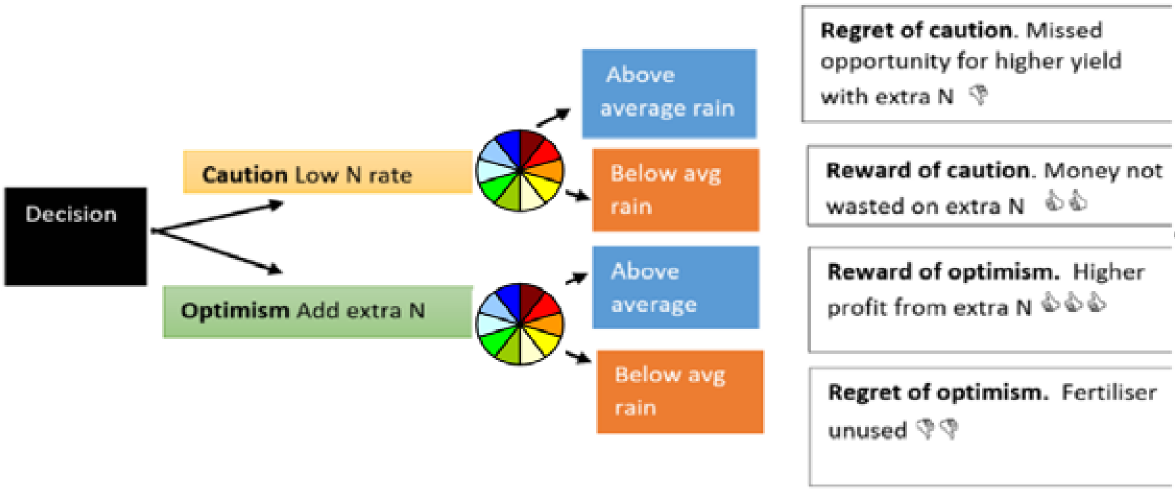


Figure 1. A simple N decision tree that considers an in season tactical decision to add extra N. In this example above and below average rainfall have equal probabilities of occurring but the rewards and regrets of optimism are greater than the rewards and regrets of caution.

When using a rainfall decile to estimate the target yield, there is one chance in 10 of being right. A grower can aim for decile 3 and receive a reward of caution for the lower N rate in a dry finish, but a regret of caution when missing out on the potential returns in an above average finish. Alternatively, a grower can be optimistic and pick decile 7 and enjoy the reward of optimism if the season turns out to be wetter than average but face a regret of optimism in a dry finish. Most of us are loss averse: we care more about losing money than gaining money. Some growers and advisers point to the time dimension, where the up-front cost (risk) of N is immediate and certain, whereas the gains (rewards) from N are uncertain and lie in the future. The longer-term costs of under fertilising and running down soil N and soil carbon are even more diffuse and lie further into the future.

Looking beyond the horizon of the year of application with N Bank

N budgeting is usually treated as a problem to be solved within the year of application. If 40kg N/ha are added with the hope of an extra 1t/ha and the season turns out drier and only 20kg/ha was needed for 0.5t/ha, cost of the unused 20kg of N is written off as a loss. This ignores the experimental evidence showing a portion of unused nitrogen is usually available for the next crop. A review of long-term experiments that used labelled 15N shows 66% of applied fertiliser N is recovered over a 3-year period, with 44% on average in year one and 22% on average recovered in the follow years (Vonk et al 2022). Therefore, in any one year the soil provides the bulk of the crop N requirement, and this highlights the need to pay attention to the soil N reserve and soil organic matter.

The planning horizon of this tactical approach is within the year of application and is part of the 'annualised thinking' that arguably amplifies the risk. An emerging alternative is a more strategic approach to nitrogen decisions, and one such approach is to use N banking. A grower using the N bank approach still needs an estimate of pre-sowing soil N and must make operational decisions about the timing of topdressing to ideally coincide with rain but is spared the angst of worrying about trying to get N exactly right each year by dealing with the uncertainty of the finish to the season. This is a simple rule with a 'set and forget' approach) and estimates the target winter mineral N bank that is necessary for your soil and climate. In this approach, fertiliser N is used to top up the winter mineral N pool to the N banking target. (Hunt et al 2023.

A grower and adviser can choose to be completely strategic (e.g., fertilise the farming system) and ignore what is happening in any season, or they can be completely tactical (e.g., single crop and year focus) and fine tune with as much information as possible from soil probes, models and seasonal forecasts along with the price of wheat, cost of nitrogen, the farm cashflow and interest rates. If being completely tactical, it is important for enduring profitability to keep an eye on the long-term N balance, which is often negative in many cropping systems (Norton and Elaina vanderMark 2016). Different growers will find the strategic or tactical approach more appropriate for their business and personality. It is also possible to set a longer-term strategic horizon and respond tactically in some years.). The rest of this paper addresses a tactical approach. If a grower chooses to be tactical, rather than choosing a single target yield, it is not much extra work to consider a range of outcomes and weigh the choice against these outcomes.

Getting tactical decisions more right, more often with decision analysis

The process of decision analysis is an established approach from applied economics for dealing with decision making under uncertainty. Although grain growers might not use terms like reward and regret of optimism and caution, they understand the concepts through lived experience. One response is that the decision tree shown in Figure 1 does little more than describe the dilemma of the post-seeding N decision with no solution. If we don't know whether the rainfall will be above or below average, we don't know which branch to take.

Decision analysis is a formalised way of weighing different futures. The simple decision tree in Figure 1 uses thumbs up and thumbs down to rank the four outcomes, but with a few assumptions these can be converted to profit or loss as $/ha. If the chance of above or below average is taken as 50%, we can then compare the probability weighted average the economic uncertainty. Although we don't know what the coming season will be, grain growers have access to:

1. a robust N budgeting rule (e.g., 1 t wheat requires 40 kg of soil mineral N/ha, while 1 t of canola requires 80 kg N/ha),
2. local historical rainfall records, which are the envy of many other parts of the world,
3. robust water-use conversion functions for wheat, barley and canola (see paper by James Hunt in these proceedings).
4. Widespread understanding of deciles as a concept of probability and risk,
5. seasonal forecasts that are far from perfect but much better than guessing and are presented as probabilities.

Fast Graphs for Slow Thinking

Fast Graphs for Slow Thinking is a reference to the book 'Thinking Fast and Slow' by Daniel Kahneman (winner of Nobel Prize for economics). Kahneman distinguishes between fast thinking, which is instinctive, recognises patterns and jumps to conclusions, and slow thinking, which is more deliberative and logical. Fast thinking is efficient, and part of that efficiency is the quick creation of a for both branches of the tree. An argument that a decision can only be made with perfect knowledge of the future ignores the numerous ways that decisions are made in so much of modern life, including aviation safety, health, internet searches and artificial intelligence.

Not all decisions that grain growers are making can be squeezed into a numerical decision analysis framework. Many decisions are routine and best practice, such as summer weed control to conserve soil water and mineral nitrogen. Other decisions may be regarded as minor and are not worth the time and effort (e.g., fungicide seed dressing in high rainfall cropping systems). Some decisions are too **complicated**, such as crop sequences for a paddock with hard-to-control weeds and their seed bank. These could be solved with extensive numerical analysis but might be better completed by using a checklist and conversation with an advisor who has had to tackle this problem previously. Then there are other decisions where extensive numerical analysis is unhelpful, such as succession planning. These are **complex** because the solution depends on other humans. N budgeting offers a simple approach for tactical, post-seeding N decisions. The main reasons the decision is difficult is because (i) the climate uncertainty elevates the crop response uncertainty, and (ii) the nitrogen price is often a high proportion of gross margins which amplifies coherent, plausible narrative. Comparing the upside and downside of a decision involves weighing a range of possible futures. This is mentally demanding, but relatively easy in a spreadsheet. Our idea is to get the information quickly into a graph that shows the upside and downside of the N investment (we estimate less than 20 minutes), so that we can then have a useful conversation about the risky decision. This follows the advice of Professor Bill Malcolm, the Farm Management economist from the University of Melbourne: 'simple figuring and sophisticated thinking'.

This version of Fast Graphs for Slow Thinking wasn't developed as another decision support system for nitrogen; the aim was to explore how the upside, downside and probability weighted average of N decisions are changed by the cost of N and price of wheat, levels of carryover N, and seasonal climate forecasts. In doing this, we were testing the usefulness of a simple decision analysis to run the N budget across deciles, rather than pick a single target yield.

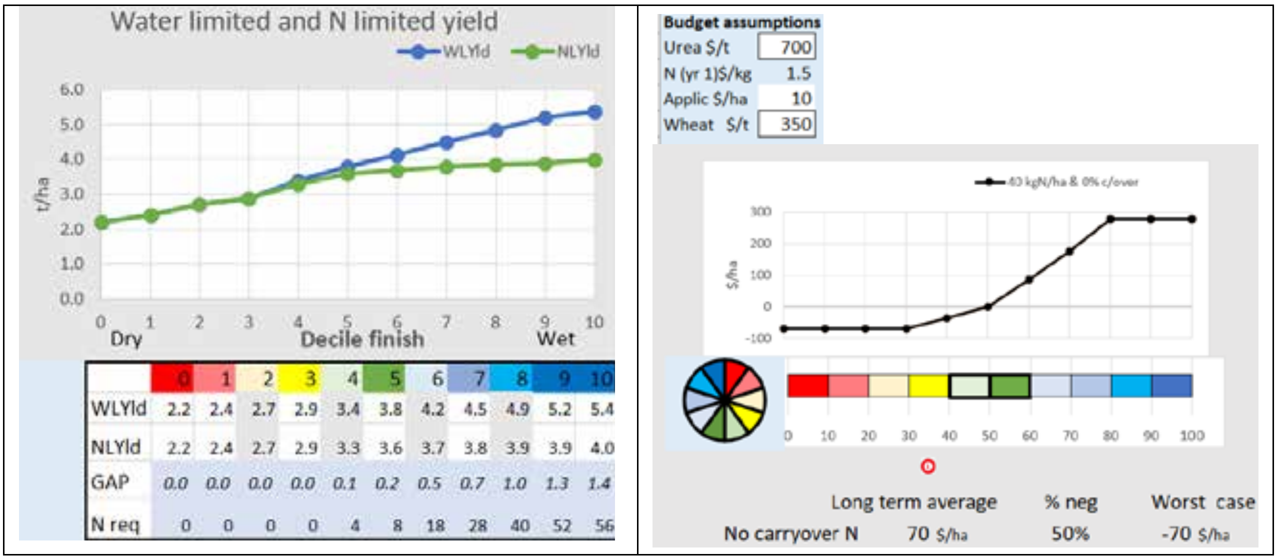
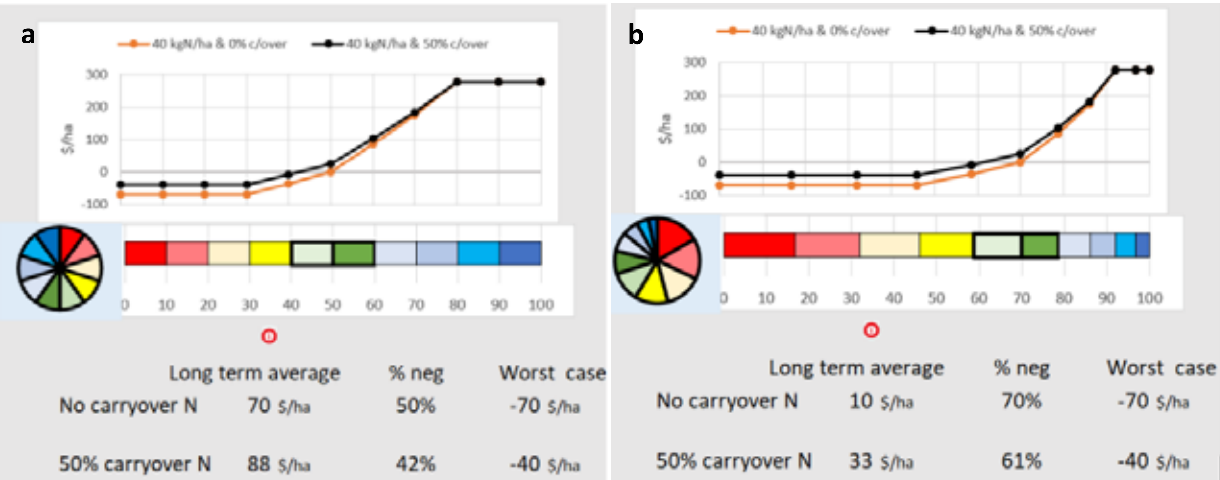


Figure 2. Screenshot of Fast Graphs for Slow Thinking, showing the water and nitrogen limited yield (left hand panel) and the profit by decile graph (right hand panel). The profit by decile graph is for the application of 40kg N, which is similar to aiming for decile 8 where the gap between the water and N limited yield is 1t/ha.

Using Fast Graphs for Slow Thinking, if we assume: (i) no carryover of N, (ii) urea $700/t, (iii) application cost of $10/ha, (iv) wheat price at $350/t and a rainfall decile 1 to 10 yield response for added fertiliser N from 2.2 to 4.0 t/ha (Figure 2), the worst case is a loss of $70/ha ($60 of Urea for 40kg N + $10 for application). The best case is 1t of wheat at $350 less $70, and a profit of $280/ha. The upside wedge is substantially better than the downside, and the probability weighted average profit is $70/ha (Figure 2 right hand panel at the bottom).



Figures 3a and 3b show the return (profit/ha y axis) from adding 40 kg N/ha assuming urea is $700/t, urea spreading is $10/ha and wheat is valued at $350/t. In Figure 3a the rainfall decile outcomes (coloured rectangles on the x-axis) are equally distributed. In Figure 3b the probability of receiving mean rainfall (coloured rectangles on the x-axis) is shifted from 50% (equally distributed deciles) down to 30% (skewed distribution of deciles to the dry end). In both graphs the orange line with orange circles shows returns ($/ha) from each decile assuming no N carryover into subsequent years. The black line with black circles shows the impact of 50% of applied N carrying over into the following year.

In the graphs the considerations for carry over N include (i) a proportion between 0% and 90% of the unused N will be available for subsequent crops, and (ii) the N carried forward to the next crop is valued as the saving in N fertiliser. Figure 3a and 3b show how carryover N of 50% reduces the loss in poor seasons but has no impact in good seasons because there is no unused N in rainfall deciles 8 and above. The long-term average improvement in this example for N carryover is $18/ha ($88/ha – $70/ha) where there is an equal distribution of rainfall deciles (figure 3a) and $23/ha ($33/ha – $10/ha) where there is skewed distribution of rainfall deciles toward the drier outcomes (figure 3b).

A shift in the odds from 50% chance of above median rainfall down to only 30% will adjust the shape of the upside and downside (Figure 3a compared with 3b). Importantly, a forecast doesn't change the position on the y-axis (e.g., possible profit). If the season finishes as a poor season in the drier deciles, there will be a loss; if the smaller chance (figure 3b) of a good season occurs, the grower will have a substantial return. A forecast doesn't change the future, it changes the likelihood of different future outcomes occurring. In other words, the forecast changes the width of the downside and upside wedge, not the height. If we assume 50% carryover of N, the climate outlook change from >50% of mean rainfall down to >30% of mean rainfall reduces the probability weighted average from $88/ha down to $33/ha (Figure 3a compared with 3b). The spend was $72/ha ($62 on urea plus $10 on spreading) so a profit of $88/ha where we have 50% N carryover represents a $1.00 dollar risks for $2.07 reward (income) and $1.07 profit using the long-term average (Figure 3a). In this scenario the loss is generated in 42% of the years experienced. The drier outlook (Figure 3b) represents a $1.00 risked for a $1.40 reward (income) and $0.40 profit where the loss occurs in 61% of years. This is explained by the scewed distribution of the seasonal decile outlook (figure 3b).

As the psychologist Paul Slovic says, 'our emotions are not good at arithmetic, we tend to think of future events as 100% or 0%'. Revising the likelihood of deciles based on a forecast is easily done in a spreadsheet and growers easily recognise patterns of shifts in graphs, especially if they were involved in providing the underlying information.

We started this paper arguing that N budgeting could benefit from looking beyond the horizon of a single year and considering a range of outcomes. Topdressing decisions in 2023 were difficult because many growers had removed a lot of grain in 2022, had a good start, followed by widespread rain in June but a forecast for increased chance of dry conditions and discussion of El Niño. Looking beyond the horizon of the single year, with the understanding that not all unused N will be lost and an appreciation of the benefits of building soil N, are enough for some growers to take a set and forget approach of N bank. Other growers are interested in the coming season as well as the long term. As with the example in Figure 3b, because an El Niño outlook doesn't eliminate the upside, the wetter deciles often contribute to a positive probability weighted average. This highlights the benefits of considering both the upside and the downside of N budgets.

Conclusion

The RiskWi$e project is about better understanding risk and reward in all parts of the grain farm and is therefore more than an initiative about N risk-reward. It does however provide a rich opportunity for conversations about the risk and reward of N use in our grain production systems. Because getting N topdressing exactly right is almost impossible due to the variable climate, it is better to consider the consequences of erring on the side of applying a bit extra N or too little N. The cautious approach of too little N can have a substantial cost of missing the opportunity of turning 40kg of N to 1t of wheat. The long-term cost of applying less N than is replaced by a legume phase is a run-down in soil N and soil carbon.

The strategic approach of using N banking is attractive as a robust 'set and forget' rule. The N bank method sets a winter mineral N target for your soil and climate combination and the grower simply tops the existing winter mineral N level up to the pre-determined mineral N target. If the carryover N from last season is high, then the mineral N top up is low and vice versa. A proportion of growers in a proportion of years will want to tactically adjust their N. Budgeting tactically across deciles takes a bit longer than budgeting for a single target yield, but we have found that once growers see the graph showing the upside and downside, decision making becomes easier.

'Fast Graphs for Slow Thinking' could complement N banking to adjust the target when there is a forecast for increased odds of dry (deciles 1 2 and 3) or wet (>= decile 7). The GRDC funded Local Climate Tool (forecasts4profit.com.au) shows that for many sites in South East Australia, El Nino or Positive IOD leads to a doubling of the chances of being in the bottom two deciles and La Nina or Negative IOD a doubling of the chance of decile 9 and 10. GRDC investment in projects with the Bureau of Meteorology have contributed to seasonal forecasts showing the chance of deciles rather than just above or below median.

The end point is more complete conversations about risk and reward which are improved by insights from the behavioural sciences. Our contention is that the applied economic tool of decision analysis has a role, not so much in the answer it provides, but in the conversations we have about probability, recency bias, loss aversion and planning for a single, most likely future. Fast Graphs for Slow Thinking is one approach to simulate thinking for improved decision making.

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- Use break crops and double break crops, fallow & pasture phases to drive the weed seed bank down,
- In summer cropping systems use diverse rotations of crops including cereals, pulses, cotton, oilseed crops, millets & fallows.

Mix & Rotate Herbicides

Rotating buys you time, mixing buys you shots.

- Rotate between herbicide groups,
- Mix different modes of action within the same herbicide mix or in consecutive applications,
- Always use full rates,
- In cotton systems, aim to target both grasses & broadleaf weeds using 2 non-glyphosate tactics in crop & 2 non-glyphosate tactics during the summer fallow & always remove any survivors (2 + 2 & 0).

Increase Crop Competition

Stay ahead of the pack

Adopt at least one competitive strategy (but two is better), including reduced row spacing, higher seeding rates, east-west sowing, early sowing, improving soil fertility & structure, precision seed placement, and competitive varieties.

Double Knock

Preserve glyphosate and paraquat

- Incorporate multiple modes of action in the double knock, e.g. paraquat or glyphosate followed by paraquat + Group 14 (G) + pre-emergent herbicide
- Use two different weed control tactics (herbicide or non-herbicide) to control survivors.

Stop Weed Seed Set

Take no prisoners

- Aim for 100% control of weeds and diligently monitor for survivors in all post weed control inspections,
- Crop top or pre-harvest spray in crops to manage weedy paddocks,
- Consider hay or silage production, brown manure or long fallow in high-pressure situations,
- Spray top/spray fallow pasture prior to cropping phases to ensure a clean start to any seeding operation,
- Consider shielded spraying, optical spot spraying technology (OSST), targeted tillage, inter-row cultivation, chipping or spot spraying,
- Windrow (swath) to collect early shedding weed seed.

Implement Harvest Weed Seed Control

Capture weed seed survivors

Capture weed seed survivors at harvest using chaff lining, chaff tramlining/decking, chaff carts, narrow windrow burning, bale direct or weed seed impact mills.

WeedSmart Wisdom

Never cut the herbicide rate – always follow label directions
Spray well – choose correct nozzles, adjuvants, water rates and use reputable products,
Clean seed – don't seed resistant weeds,
Clean borders – avoid evolving resistance on fence lines,
Test – know your resistance levels,
'Come clean. Go clean' – don't let weeds hitch a ride with visitors & ensure good biosecurity.

Tactics for minimising frost damage on Eyre Peninsula

Rhaquelle Meiklejohn1, Brett Masters[1] and Andrew Ware[1]

[1]EPAG Research

GRDC project code: AIP2203-001SAX

Keywords

- Frost

Take home messages

- High frost-risk areas on Eyre Peninsula can experience over 30 frost events from June to October.
- The large time range where damaging frosts can occur made it difficult to identify a flowering time or varietal phenology that was able to avoid frost damage in high-risk areas, but barley consistently experienced less damage than wheat.
- Canopy temperatures were consistently warmer in ameliorated sandy soils compared to their more natural state. However, this didn't always reduce crop damage from frost events.
- Understanding your risk and zones within a paddock can support improved economic outcomes for growers through slightly different management.

Background

Extensive crop damage and financial losses were driven by frost events occurring across large areas of Central and Eastern Eyre Peninsula over the four years leading up to 2022. This GRDC-funded project aimed to enhance the knowledge and confidence of growers in the Eyre Peninsula's frost-prone areas, enabling them to adopt and implement practices that minimise the impact of frost on their profitability.

While growers understand that a complete solution to avoiding damage from frost is not currently possible, several strategies were identified by local advisors and growers for their potential to reduce frost damage. These strategies were evaluated to develop localised information on their optimal implementation.

Method

A combination of field trials located at Tooligie and grower paddock demonstration strips situated across the frost prone areas of Eyre Peninsula were used to evaluate a range of management strategies considered useful to reduce frost damage.

The strategies evaluated included:

- Determining whether longer-maturing varieties should be planted to avoid frost damage and whether fast-maturing varieties can be planted early to mature before frost events occur.
- Assessing the potential advantage of planting mixtures of varieties with differing maturity times. This approach could mitigate the impact of a frost event on one variety by having another variety with a different maturity time continue to grow unaffected.
- Investigating reports of certain nutrients and products that can be applied to crops to either enhance plant resilience against frost or reduce the levels of ice-nucleating bacteria.
- Exploring anecdotal evidence suggesting that soil amelioration practices on sandy soils might reduce frost damage.

These strategies were identified by a project steering committee, consisting of five experienced local consultants, in consultation with Mick Faulkner, a consultant from Mid-North South Australia with considerable experience in frost research, as well as frost researchers from Western Australia.

Results and discussion

Varietal Phenology: This trial showcased various sowing time and variety combinations available to growers to avoid frost exposure. Extending this work over two contrasting growing seasons highlighted the complexity of making these decisions without reliable frost and rainfall forecasts. Multiple frost events, both early and late in the season, made it challenging to consistently choose a wheat variety and sowing time strategy that reduced frost risk without the benefit of hindsight. Barley consistently achieved higher yields across several phenology and sowing time combinations than wheat in frosty environments.

Crop Type: In 2022, a trial of different crop types demonstrated the varied reactions of crops like canola, beans, lentils, and vetch to frosty environments. Growers and advisors sought to understand the relative frost damage risk across a range of break crops, especially given the growing importance of these crops in the farming system and the decline in livestock production. The recent expansion of lentil cultivation across central and upper Eyre Peninsula necessitated more knowledge about frost impacts on lentils and the suitability of alternative break crops such as faba beans. The work conducted in 2022 found that lentils experienced more frost damage than faba beans.

Nutritional Amendments and Ice-Nucleating Bacteria Control Products: This trial aimed to assess the value of various products purported to improve crop resilience to frost damage. Claimed mechanisms included foliar transpiration inhibition, nutrition-based sugar enhancement, plant health enhancement, floret sterility reduction, and antibacterial properties. Over two years in high frost incidence environments, none of the products demonstrated a yield benefit beyond correcting well-documented nutritional deficiencies, such as low potassium levels in sandy soils.

Zoning: Frost damage consistently affects certain landscape areas due to topography and air movement. Consequently, some paddock areas incur significant frost damage, while nearby areas remain unaffected. With advancements in precision farming equipment, growers can now manage high frost risk areas differently. To evaluate the benefits of such management, phenology, crop type, and nutritional amendment trials were mirrored in both high and moderate frost risk zones within the same paddock. Data showed that high-risk zones experienced more severe frost damage, and strategies like sowing longer-season wheat varieties (winter varieties) and various barley varieties had higher value in high-risk zones. This demonstrated the value of managing zones differently. Collecting data over additional seasons will be crucial for modelling yields and frost damage accurately, aiding growers and advisors in making informed management decisions based on frost risk.

Soil Amelioration: Anecdotal evidence from growers and previous research in Western Australia suggested a potential relationship between soil amelioration on sandy soils and frost mitigation. Data and observations from eight sites over 2022 and 2023 allowed direct comparisons between ameliorated and original soil compositions. Six of the eight site comparisons found that soil amelioration occasionally reduced daily canopy temperature fluctuations, with temperature differences increasing as conditions became more extreme. Some events were up to a few degrees warmer during the coldest overnight periods. Instances where amelioration did not result in warmer temperatures were found on heavier textured soils. Understanding the underlying mechanisms may help quantify the soil-temperature interaction level needed to reduce frost damage.

Conclusion

Between 2017 and 2021, large areas of Eyre Peninsula suffered from severe frost. In 2022 and 2023, various strategies were evaluated to minimise frost damage. These strategies included assessing varietal phenology and sowing times, using mixtures of varieties with different maturities, applying nutritional and ice-nucleating bacteria products, zoning, and soil amelioration.

The project found that high-risk areas can experience over 30 frost events from June to October, making it difficult to avoid frost solely through variety selection and sowing time. Identifying high-risk frost areas and managing them differently proved valuable.

Additionally, the project demonstrated that ameliorated sandy soils had warmer canopy temperatures during frost events.

Acknowledgements

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December 2023

ANDREW RUSSELL, PANEL CHAIR

Rutherglen, Victoria

Andrew is the managing director and a shareholder of Lilliput Ag, and a director and shareholder of the affiliated 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. She has recently started 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 executive officer and project manager since 2013.

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.

MICHAEL TRELOAR

Cummins, South Australia

Michael is a third-generation grain grower who produces wheat, barley, canola, beans, lupins and lentils on a range of soil types. He has been involved in a number of research organisations, including the South Australian Grain Industry Trust (of which he was chair for four years), the Lower Eyre Agricultural Development Association and the South Australian No-Till Farmers Association (both of which he has been a board member).

NEIL FISHER

Adelaide, South Australia

Neil's family grain farming legacy dates back to 1889, giving him an extensive understanding of the challenges faced by grain growers in SA and Victoria across the Mallee, Wimmera and Riverina regions. With his wife Jenny, he retains a cropping/grazing property at Bordertown, producing wheat, canola, barley, beans and hay. He has held chief executive and board roles in organisations including Sugar Research Australia, Grains Council of Australia, Grape and Wine Research and Development Corporation and Plant Health Australia. Neil has previously worked for GRDC managing a large portfolio of research projects.

PETER DAMEN

Kindred, Tasmania

Peter is a grower from north-western Tasmania with more than 10 years' experience growing and processing commercial grain crops. He holds a degree in agricultural science from the University of Tasmania. Peter has production, research and development experience in quinoa, oats, buckwheat, spelt, hemp, adzuki beans, wheat, barley, ryegrass and more. He is working at Tas Stockfeed, focusing on technical support, sales and grain procurement and processing. In 2017, he was recognised as the Young Farmer of the Year.

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.

DR PATRICIA FLYNN

Douglas, Victoria

Patricia is a grower in the southern Wimmera, Vic. She holds a Bachelor of Science (Honours) from the University of Western Australia and a PhD from the Australian National University. Her expertise lies in farming systems research with a specific interest in soils management and farm business profitability. Patricia is the financial manager of a family mixed cropping and Merino sheep enterprise – Kwangaloo Pastoral. She held research and development positions at the WA Department of Agriculture, CSIRO, and what was the Department of Primary Industries in Victoria.

CRAIG BAILLIE

GRDC Executive Manager

Craig Baillie is GRDC's general manager of applied research, development and extension. He has oversight of research areas including sustainable cropping systems (agronomy and soils) and crop protection (pests, weeds and diseases). He also has responsibility for GRDC's grower and stakeholder engagement at a national level.

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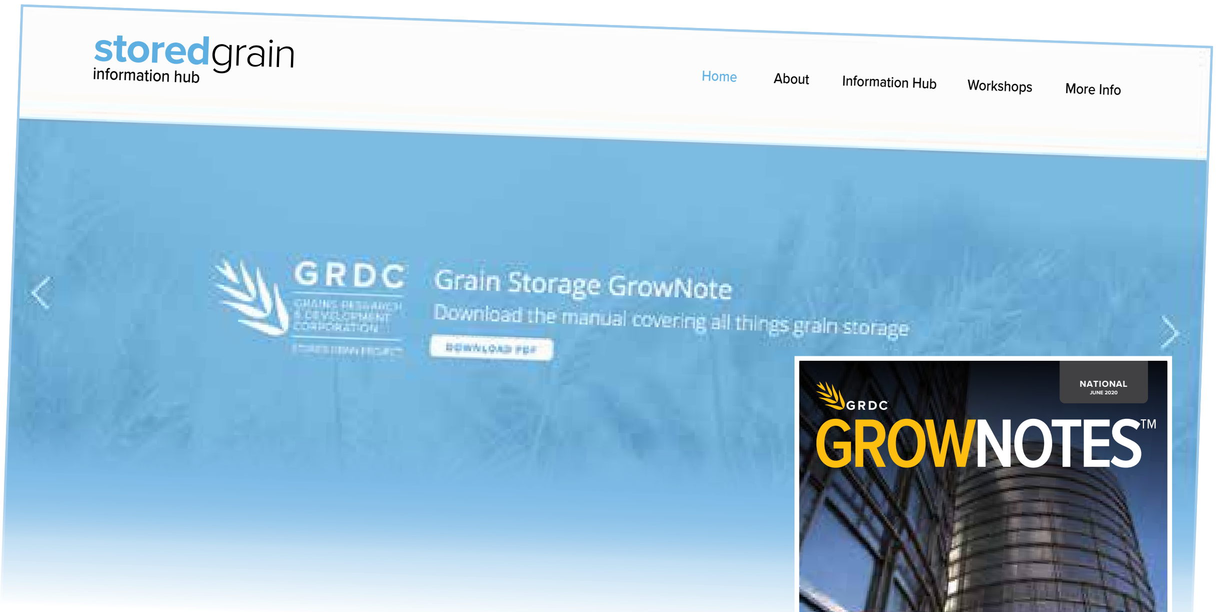

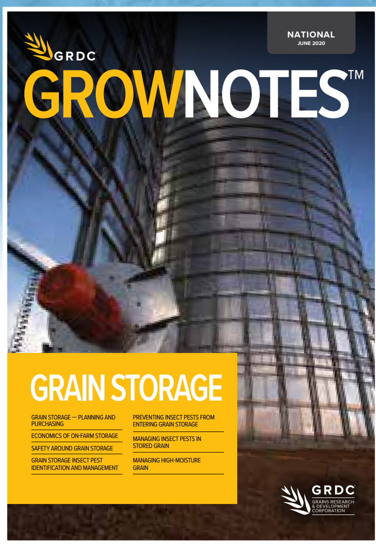

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- The local GRDC Grains Research Update planning committee that includes growers, advisers and GRDC representatives.
- Partnering organisation: Air EP

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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. Phosphorous management and replacement strategies: *Nigel Wilhelm*

Content relevance ☐ /10 Presentation quality ☐ /10

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

3. Integrated pest management strategies: *Tom Heddle*

Content relevance ☐ /10 Presentation quality ☐ /10

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

4. Overcoming a shifting seasonal break: *Therese McBeath*

Content relevance ☐ /10 Presentation quality ☐ /10

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

5. Fast graphs for slow thinking: *Peter Hayman*

Content relevance ☐ /10 Presentation quality ☐ /10

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

6. Tactics for minimising frost damage: *Rhaquelle Meiklejohn*

Content relevance ☐ /10 Presentation quality ☐ /10

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☐

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

☐

Thank you for your feedback.

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