SARDI

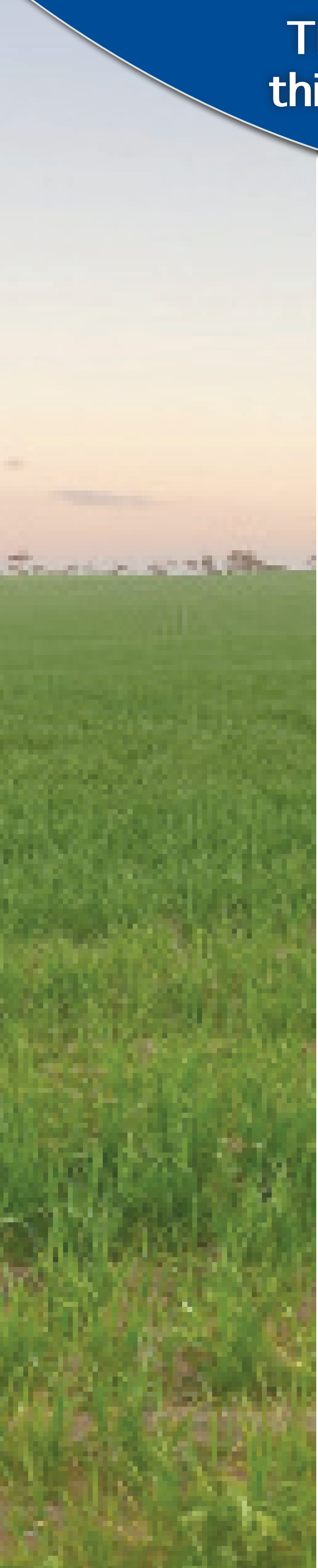
Eyre Peninsula Farming Systems Summary 2025

SARDI - Minnipa Agricultural Centre

Government of South Australia
Department of Primary Industries and Regions

SARDI
South Australian Research and Development Institute

The research contained in this manual is supported by



GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

SAGIT

AIR EP
Ag Innovation & Research Eyre Peninsula

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Adelaide University

SA DROUGHT HUB

CSIRO

Flinders University

UNFS
Upper North Farming Systems

Future Drought Fund

BFIG
BUCKLEBOO FARM IMPROVEMENT GROUP

SA DISCOVERY FARMS

NSW GOVERNMENT
Department of Primary Industries

Thank you to the sponsors of the Eyre Peninsula Farming Systems 2025 Summary

SAGIT

AGT

LongReach
PLANT BREEDERS

PIONEER
BRAND • SEEDS

MarketCheck

INTERGRAIN

Eyre Peninsula Farming Systems Summary 2025

Editorial Team

Amanda Cook	SARDI, Minnipa Agricultural Centre (MAC)
Dr Nigel Wilhelm	SARDI, MAC/Waite
Catherine Paterson	SARDI, MAC
Rebecca Ramsey	SARDI, MAC
Jessica Gunn	SARDI, MAC
Joshua Telfer	SARDI, Port Lincoln
Amy Keeley	SARDI, Port Lincoln

All article submissions are reviewed by the Editorial Team prior to publication for scientific merit and to improve readability, if necessary, for a farmer audience.

This manual was compiled by The Printing Press

March 2026.

Front Cover: Minnipa Agricultural Centre Field Day attendees, September 2025.

Cover design: Kate Gray - The Printing Press, Port Lincoln 2026.

ISBN 1838-5540

SARDI Foreword

On behalf of the South Australian Research and Development Institute (SARDI), the research division of the Department of Primary Industries and Regions (PIRSA), I am pleased to present the 2025 Eyre Peninsula Farming Systems Summary. This publication proudly provides a record of the recent research, development and extension activities carried out at the Minnipa Agricultural Centre (MAC). It provides a resource for Eyre Peninsula (EP) farmers, advisors and other primary industry stakeholders in the region to guide on-farm decisions into the future.

The research documented in the summary is a result of a shared effort from researchers and investors. I thank the contributions from the MAC staff, PIRSA-SARDI, the Grains Research and Development Corporation (GRDC), the South Australian Grains Industry Trust (SAGIT), Ag Innovation & Research Eyre Peninsula (AIR EP), the Australian Government's Future Drought Fund (FDF) including the SA Drought Hub and the SA Discovery Farms, the EP Landscapes Board, Adelaide University, Flinders University and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Thank you once again to SAGIT for their ongoing support toward the printing of the 2025 EP Farming Systems Summary, with 1000 copies being distributed.

Following a tough 2024 season the dry start to the 2025 season was a challenge for many EP farmers. This necessitated changes to sowing plans - reassessing crop choices, timings, and priorities to suit the conditions. Winter rains improved soil moisture levels assisting crop establishment and progress and cooler grain filling conditions resulted in better than expected grain yields. It is challenging seasons such as 2025 that the value of the research at the MAC comes into its own, supporting EP grain growers to maintain their significant contribution to the broader SA grain sector through innovation in farming practices, and the adoption of new technology on farm.

The MAC team again worked hard to plan and deliver a successful 110 year field day and dinner. This year we celebrated 110 years supporting Eyre Peninsula farmers with agricultural research and innovation to support low rainfall farming systems. The success of the event continues, with more than 150 stakeholders from the region attending, including growers, consultants, researchers, and industry representatives from across the EP and beyond. Topics covered included managing herbicide residues, GRDC National Variety Trials, lentil management, nitrogen cycling, optimising barley biomass, water issues on EP and carbon farming. A dinner was held in conjunction with the field day to celebrate the 110 year anniversary. Several long standing MAC staff were recognised for their contributions to the industry including, Nigel Wilhelm, Amanda Cook, Wade Shepperd, Leala Hoffman and John Kelsh.

I look forward to working with the MAC team and harnessing the support of our EP partners, to ensure that 2026 is a success, and that MAC builds on the opportunity ahead to be innovative and provide independent and relevant information to growers in the region.

Dr Paul Petrie
Acting Research Director, Crop Science

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

SAGIT Foreword

The 2025 growing season presented significant challenges for the Eyre Peninsula - and indeed for the state, different to those of 2024, with a very late start to the season creating conditions for drift on lighter soils, July and August the only true winter rainfall months and finishing with higher-than-average rainfall for many areas in November. October presented a number of hot northerly wind events with spring frosts less prevalent than in 2024 (in general). Despite these challenges, EP grain growers continue to demonstrate remarkable resilience and skilled management of the EP soils. The trustees of the South Australian Grain Industry Trust (SAGIT) understand the challenges that seasonal conditions bring. However, we believe ongoing investment in research and development will drive advancements in production, helping growers overcome these challenges. We understand that EP growers face unique challenges specific to the environment, alongside broader constraints experienced statewide.

SAGIT is proud to support the EP Farming Systems Summary, a valuable resource filled with practical and relevant information of research trial results designed to help EP farmers improve the profitability of their farming systems.

In 2025 SAGIT received 57 research applications totalling $11.05M and was able to fund 28 with a value of $2.28M. In addition, 10 projects were funded with other research partners. The SAGIT trustees understand the importance of working closely with partners to maximise the value of the voluntary grower contribution including the Grains Research and Development Corporation (GRDC), the South Australian Drought Resilience Adoption and Innovation Hub, the South Australian Research and Development Institute (SARDI: the research division of the Department of Primary Industries and Regions SA), and the South Australian Sheep Industry Fund.

In 2025, six of the ten co-funded projects had relevance to the EP. Funding was approved for an Applied Grains Research Intern to be based at the SARDI Minnipa Agricultural Centre. Amanda Cook is the senior researcher who will guide the intern's exposure to a wide range of EP research projects, assist in the design of a project of their own and ensure their attendance at industry events. The EP internships in the past have resulted in most interns gaining employment in the research field on the EP thereby increasing the research capabilities for the peninsula.

The Lead Agriculture Teacher project received approval and is co-funded with the South Australian Sheep Industry Fund. Sue Pratt has continued her valuable work of mentoring Agriculture Teachers across the state and providing curriculum material for them. In 2025 Sue visited the following EP schools - Cummins, Cleve Area School, Whyalla Secondary College and Kimba Area School. Sue mentored nine teachers at those schools and has a further ten EP schools with whom she communicates regularly. The value of this program can be seen via the increased number of students studying agriculture and seeing it a future career.

Other areas where Sue's influence is having an impact are,

- increased industry alignment in school agriculture programs through strong partnerships with PIRSA, Landscapes Boards, Ag Institute of Australia, industry bodies and universities,
- expansion of agriculture programs to eight new schools and
- attendance at ten careers events to promote agriculture to students.

A project funded in 2025 and that will be of interest to EP growers is titled "Evaluating Commercial Products to Enhance Phosphorus Fertiliser Efficiency" (SAGIT project code: ASO 05225) to be researched by Dr Sean Mason. In 2025, the project has undertaken a critical benchtop product review of a large number of commercially available products that claim to improve P efficiency from fertilisers or unlock soil P. In 2026, shortlisted products from the review will be evaluated in field trials. This project has arisen in part from Andrew Polkinghorne's Churchill Fellowship study where he investigated the various liquid phosphorous products and various phosphorous coatings available in the Europe, USA and Canada.

The trustees have noted the increased area planted to lentils on the EP. The Global Grain Genetics project at Coorabie and other sites in SA (SAGIT project code GGG 6624) continued in 2025. The project seeks to identify new varieties which have superior performance in low rainfall areas. In 2024, yellowing of some varieties attributed to iron (Fe) deficiency was observed on highly calcareous EP soils. Foliar Fe was applied and assessed. Genetic variation for iron deficiency symptoms was observed and elite breeding lines with putative improved levels of Fe efficiency over all commercial varieties on these soil types were evaluated in the 2025 trials.

SAGIT continues its support of projects through the Soil Cooperative Research Centre (CRC), many of which have direct relevance to EP farming systems. The CRC will conclude on 30 June 2027, the focus for the next eighteen months will be on farmer adoption of the research outcomes achieved by the CRC.

2025 saw the retirement of Ted Langley from the SAGIT Board. Ted represented SA growers for nine years on the Board and we thank him for his valuable contribution. He has been replaced by Felicity Turner who is based in the upper Southeast where she farms with her husband Mark. She has experience in managing research and development projects and extension for organisations such as Ag Excellence Alliance, MacKillop Farm Management Group, Southern Farming Systems, Mallee Sustainable Farming and Women Together Learning.

We continue to have the support and insights of local farmers on the SAGIT board. Lock grower and SAGIT trustee Andrew Polkinghorne brings invaluable insights to help guide our efforts to address the needs of Eyre Peninsula growers. Andrew's Churchill Fellowship report is a valuable read.

SAGIT is dedicated to delivering research and supporting the publication of resources necessary for South Australia's grain growers to succeed. The EP Farming Systems Summary is one of many initiatives we are proud to fund. Our trustees and management team commend everyone involved in its preparation and production. On behalf of SAGIT, I hope you find this publication insightful and practical. Wishing you a successful and rewarding season in 2026.

Dr Andrew Barr
SAGIT Chair

GRDC Foreword

Hailing from Buckleboo, the EP Farming Systems Summary has been a well-read document in my family household in years gone by. It plays an important role in delivering results and insights direct to growers from locally adapted research. So it is a full circle moment now to reflect on the collaboration between research partners, researchers, growers, advisers and the entire ecosystem it takes to deliver local RD&E and results each year.

The 2025 growing season on the Eyre Peninsula highlighted the inherent variability and challenge of farming in southern Australia. An incredibly dry start, wet July and variable spring, produced mixed outcomes across the region, leaving many growers managing tight rainfall windows and periods of temperature stress. While the season proved particularly difficult for some, others benefited from timely decisions and local conditions. Overall, the year reinforced the importance of adaptability and informed decision-making within farming systems.

As planning begins for the 2026 season, reflection on the aspects of production that can be influenced is critical. While weather and markets remain outside growers' control, decisions around crop selection, rotations, agronomy, genetics and input management continue to have a strong impact on performance. Recent seasons have shown that attention to detail, timeliness and well-designed systems consistently support more reliable outcomes, even in challenging years.

In September 2025, the GRDC Southern Panel visited the Eyre Peninsula to meet growers and industry representatives as part of their spring tour. The tour, led by current Southern Panel member Andrew Ware, and immediate past member Michael Treloar, provided input to guide GRDC's investment decisions by giving panel members a chance to directly engage with growers, advisers and researchers in the paddock. The continued growth of the lentil industry (and their performance in challenging conditions), and innovation in managing sandy soils shown by growers and researchers were a couple of highlights. Labour shortages, the future of regional communities and emerging agronomic and business challenges were also key topics of discussion.

As part of the tour the Southern Panel visited the South Australian Research and Development Institute (SARDI) Minnipa Agricultural Centre. The Centre's close partnerships with Eyre Peninsula growers and industry, continue to deliver locally relevant and practical research and it was great to see SARDI MAC celebrate 110 years of doing so.

The Grains Research and Development Corporation (GRDC) is proud to support this work through ongoing investment in research, development and extension guided by grower priorities and regional insight. Ongoing investment in the region via projects delivered by SARDI and other research partners on the Eyre Peninsula are targeting farming systems challenges and opportunities specific to the region, to ensure research remains practical, relevant and directly applicable to on-farm decision-making.

Recent GRDC investments with SARDI Minnipa Agricultural Centre include NVT trial delivery, NGN-Stopping seed set of barley grass on the upper Eyre Peninsula (UOA2403-011RTX), NGN-Lentil check discussion groups to maximise profitability of lentil production in the Upper Eyre Peninsula (UOA2303-007RTX), GRDC project led by NSW DPI on Geospatial analytics to predict the impact of residual herbicides on establishment and yield (DPI2306-013RTX), the GRDC project led by CSIRO Soils II: Management to sustain production potential in the low to medium rainfall environments of the Southern cropping region (CSP2403-017RTX). GRDC, SARDI and the South Australian Grain Industry Trust (SAGIT) once again collaborated to produce the National Variety Trials South Australian Crop Sowing Guide, providing independent, regionally relevant information to assist growers and advisers with variety selection and agronomic planning.

In the back half of 2026 GRDC will be targeting the Eastern and Central Eyre Peninsula with a series of National Grower Network Forums, which we use to identify both strategic and locally responsive investment opportunities. NGN forums are open to all growers, agronomists and industry stakeholders, and often result in tangible local RD&E investment, so come along and engage with us around how you think your levy dollars are best spent to address local challenges. Farm Business Updates will also return to Eyre Peninsula again in 2026 with an event in Kimba on 1 July, and Grains Research Updates at Cummins and Streaky Bay on the 29 and 30 July, all great avenues for getting up to speed with the latest findings from a selection of locally relevant RD&E programs.

The research reported in this Eyre Peninsula Farming Systems Summary demonstrates the strength of collaboration between GRDC, SARDI, SAGIT, AIR EP, EPAG and other industry partners. It highlights how targeted investment and strong local engagement help translate research outcomes into improved practice, supporting growers to navigate seasonal variability and position their businesses for future success.

Courtney Ramsey
Senior Regional Manager - South
Grains Research and Development Corporation

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Contents

Minnipa Agricultural Centre update

Amanda Cook & Rebecca Ramsey
SARDI

Welcome to the twenty seventh Eyre Peninsula Farming Systems Summary, providing detailed reports on the outcomes of RD&E carried out on Eyre Peninsula and related environments across Australia.

In 2025, SARDI Minnipa Agricultural Centre celebrated 110 years of working with Eyre Peninsula (EP) growers to drive agricultural research and innovation in low rainfall farming systems. Research topics currently being delivered for evolving low rainfall farming systems include new crops, such as lentils, new varieties tested with the NVT program, new herbicides and issues of residues, new agricultural technology and the uptake of new farming systems, such as stripper stubble and disc seeding systems. SARDI and the Minnipa Agricultural Centre continue to ensure relevant research is delivered and extended to the region through the annual MAC Field Day, SARDI Eyre Peninsula Farmer meetings, various crop walk events and seminars and this publication. At the 110 Year SARDI Minnipa Agricultural Centre celebration dinner several MAC staff were recognised for their contributions and service to the industry including Nigel Wilhelm, Amanda Cook, Wade Shepperd, Leala Hoffman and John Kelsh.

We would like to thank project funders and collaborators including the Grains Research and Development Corporation (GRDC), the South Australian Grain Industry Trust (SAGIT), Ag Innovation & Research Eyre Peninsula (AIR EP), Buckleboo Farm Improvement Group (BFIG), the Australian Government (National Landcare Program, Rural R&D for Profit, Soil CRC, Future Drought Fund, SA Discovery Farms and SA Drought Hub), NSW Department of Primary Industries (NSW DPI), Department of Primary Industries and Regional Development (DPIRD), Adelaide University, University of South Australia, Flinders University, Landscape Board, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and plant breeders for their contribution to the Eyre Peninsula for research, development and extension and for enabling us to extend our results to all farm businesses on the EP and beyond in other low rainfall areas. Current projects and contracted research conducted by SARDI Minnipa Agricultural Centre (MAC) are listed in Table 1.

Staff

In 2025, there were new additions and staff leaving the MAC team. The new staff welcomed in 2025 were Tammie Mullen and Julian Post, appointed as Agricultural Officers, Rebecca Ramsey as Project Management Support Officer with Nicole Baty being on leave, and Jo Rynne as the MAC Administration Officer. Cayley Gray completed her Certificate III in Agriculture school-based apprenticeship, hosted by MAC and working with both the Agronomy and Farm teams. Craig Midgley is the Principal Regional Advisor (Eyre and Western) role with PIRSA, based at MAC.

We farewelled Dr Buddhi Chaudhary after 18 months with MAC Agronomy team as a Research Officer and thank him for his contribution to SARDI MAC. He expressed his appreciation of learning more about Australian agricultural farming systems and the practical aspects of field research and operating machinery while on Eyre Peninsula. Fiona Tomney also finished her role as the EP SA Drought Hub Co-ordinator with the Hub removing Nodes across the state.

We farewelled Kym Zeppel after harvest 2025, with four years as an Agricultural Officer at SARDI MAC delivering research trials for the growers of Eyre Peninsula. We wish him all the best for his future endeavours and travelling. We also said goodbye to Tansy O'Brien, Craig Standley, Julian Post, Adele Shepperd and Gabbie Curry and we thank them for their contributions to the MAC team.

SARDI also farewelled Rhiannon Schilling who has been the Program Leader of Agronomy at SARDI since 2020, managing a large team undertaking complex trial and project operations across the state, with extensive engagement with Ag Bureau groups and Farming Systems Groups to keep research relevant to growers. She has led several very successful bids including the initial SA Drought Hub and recently the Long Term Trials 'Discovery Farms' project (funded by DAFF through Flinders University). She managed a broad range of research projects supporting farmers across SA. SARDI MAC sincerely thank Rhiannon for her contributions, experience and help and wishes her all the best at Flinders University. Brian Dzoma has also pursued a new role with Adelaide University based at Roseworthy.

Projects

Ongoing projects of significance delivered by the SARDI MAC teams are the GRDC national variety trials, the national GRDC project led by CSIRO Soils II: Management to sustain production potential in the low to medium rainfall environments of the Southern cropping region (CSP2403-017RTX).

This research project seeks to understand the spatio-temporal dynamics of crop responses to the amelioration of sandy soil profiles so that growers can better predict where, when and how to ameliorate the sandy soil profile and then how to best manage the crop in the ameliorated profile to maximise sustainability and profitability of the new system.

The SA Discovery Farms, led by Flinders University, is focused on developing new innovations to increase climate resilience and brings together a consortium of 39 partners including leading South Australian farmers, farming systems groups, agribusinesses, Rural Research and Development Corporations (RDCs), Landscape Boards, advocacy groups, plant breeding companies and university/State Government researchers. Four SA Discovery Farms (Minnipa Agricultural Centre, Loxton Research Centre, Struan Research Centre and Turretfield Research Centre), along with over 35 Innovator Sites have been established in the first year across the State.

Research trials at MAC were implemented in 2025 for a GRDC project led by NSW DPI on *Geospatial analytics to predict the impact of residual herbicides on establishment and yield* (DPI2306-013RTX). This project aims to quantify the impacts of residual activity on establishment and yield more accurately so that more profitable decisions on crop choice and variety (herbicide tolerance or not) can be made. It will do that by coupling on-farm geospatial data with models of herbicide bioavailability, soil water infiltration, and crop toxicity thresholds to produce maps of plant-risk based on bioeconomic thresholds.

Visitors and Extension Activities

In 2025 SARDI Minnipa Agricultural Centre hosted the South Australian Consultants Group facilitated by Andy Bates on 19 August. Topics presented and discussed included Geospatial herbicide residues, N cycling and volatilisation losses in current cropping systems of Australia with Nigel Wilhelm and Elijah Luo, K deficiency in the cropping zone of south-eastern Australia and Managing Fe deficiency in pulses (Nigel Wilhelm). Cathy Paterson gave a summary of the LTT Barley Biomass research and other projects at MAC. The GRDC Southern Panel visited SARDI Minnipa Agricultural Centre on 2 September to discuss current research with Rhiannon Schilling and other staff and see the MAC facilities. Research presented included N cycling and volatilisation losses in current cropping systems of Australia (Nigel Wilhelm and Elijah Luo), LTT Barley Biomass research presented by Rhiannon Schilling, Brendan Kupke and Cathy Paterson funded by the SA Discovery Farms. Nigel Wilhelm and Brian Dzoma presented the Novel Phosphorus sources research at Port Kenny on a grey calcareous soil.

MAC held numerous successful extension activities in 2025, including the 110 year MAC Field Day, SARDI EP Farmer Meetings and the SARDI/GRDC Lentil Check Grower Group meetings which were all extremely well supported by growers and industry. During the year SARDI MAC researchers presented research projects and outcomes at the GRDC Research Update Adelaide, SARDI EP Farmer Meetings, 110 year MAC Field Day and EP Sticky Beak Days. Details of events held by or presented at by MAC staff are listed below in Table 2.

Minnipa Agricultural Centre staff attended Low Rainfall RD&E Committee meetings during 2025.

Thank you all for your continued support at farmer meetings, field days, agricultural events and sticky beak days. We are grateful for the strong farmer involvement and support and will continue to ensure our research is aligned to on ground priority needs. SARDI staff across the state will continue to work closely with primary producers to develop relevant research programs and ensure excellence in our program delivery, industry and regional engagement. We look forward to seeing you throughout 2026 and wish you all the best for a productive and profitable season.

To contact us at the Minnipa Agricultural Centre, please call **8680 6200.**

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

MAC Staff and Roles 2025

Amanda Cook	MAC Senior Research Scientist (Agronomy)
John Kelsh	MAC Farm Manager
Zhaohan (Elijah) Luo	Research Officer (Agronomy)
Cathy Paterson	Research Officer (Agronomy)
Dr Buddhi Chaudhary	Research Officer (Agronomy)
Jessica Gunn	Research Officer (Livestock)
Nicole Baty	Project Management Support Officer (Agronomy)
Rebecca Ramsey	Project Management Support Officer (Agronomy)
Wade Shepperd	Senior Agricultural Officer (MAC Farm)
Kym Zeppel	Senior Agricultural Officer (Agronomy)
Marina Mudge	Senior Agricultural Officer (NVT)
Tammie Mullen	Senior Agricultural Officer Agronomy
Julian Post	Senior Agricultural Officer Agronomy
Ricca Moyse	Agricultural Officer (MAC Farm)
Leala Hoffmann	Administration Officer
Tansy O'Brien	Administration Officer
Jo Rynne	Administration Officer
Craig Midgley	PIRSA Principal Regional Advisor (Eyre & Western)
Fiona Tomney	Node Coordinator for the SA Drought Hub (Minnipa & Port Augusta)
A/Prof Rhiannon Schilling	Program Leader of Agronomy
Dr Nigel Wilhelm	Senior Research Scientist (Agronomy)
Brian Dzoma	Research Officer (Soils)
Katrina Brands	Casual Field Assistant
Rebbecca Tomney	Casual Field Assistant
Gabrielle Currie	Casual Field Assistant
Adele Shepperd	Casual Field Assistant
Cayley Gray	School Based Apprentice

Table 1. Research projects delivered by SARDI Minnipa Agricultural Centre in 2025.

Project name	Funder	Summary
SARDI Projects		
SA Discovery Farms	Australian Government's Future Drought Fund, Flinders University and SARDI	The SA Discovery Farms, led by Flinders University, is focused on developing new innovations to increase climate resilience and brings together a consortium of 39 partners including leading South Australian farmers, farming systems groups, agribusinesses, Rural Research and Development Corporations (RDCs), Landscape Boards, advocacy groups, plant breeding companies and university/State Government researchers. Four SA Discovery Farms (Minnipa Agricultural Centre, Loxton Research Centre, Struan Research Centre and Turretfield Research Centre) along with over 35 Innovator Sites have been established in the first year across the State. Trials at Minnipa Agricultural Centre: • Optimising barley biomass • Stripper stubble systems • Heat and drought tolerance • Soil microbiome • Water quality for livestock End: June 2028
Soils II: Management to sustain production potential in the low to medium rainfall environments of the Southern cropping region	GRDC (CSP2403-017RTX)	This research project seeks to understand the spatio-temporal dynamics of crop responses to the improvement or amelioration of sandy soil profiles so that growers can better predict where, when and how to ameliorate the soil profile and then how to best manage the crop in the ameliorated profile to maximise sustainability and profitability of the new system. End: June 2028
Effective control of brome grass in the southern and western cropping zones	GRDC (UOA2303-006RTX)	GRDC, Adelaide University and SARDI brome grass 4-year cropping × weed management research on improved management of brome grass with strategies based on crop sequences and herbicides. Trials located at Poochera and Cowell (AIR EP). End: March 2028
Eyre Peninsula Farming Systems Summary	SAGIT (SAR 02424)	This project supports the printing of the Eyre Peninsula Farming Systems Summaries 2024, 2025 and 2026, enabling continued distribution of this important summary to all growers, industry representatives, researchers and consultants on Eyre Peninsula and other regions. End: June 2027

Project name	Funder	Summary
Integrated management strategies for Net Form Net Blotch in low, medium, and high rainfall zones	GRDC (DAQ2304-008RTX)	This investment will develop and deliver cost effective IDM strategies for NFNB across all rainfall zones of the Northern and Southern regions by: • Determining the impact of NFNB by measuring the yield and quality loss incurred in response to the different IDM strategies. • Investigating the decline of NFNB inoculum levels of stubble over time and in different growing environments. • Developing integrated disease management strategies and determine the cost benefit for implementing IDM strategies in each rainfall zone. • Developing and delivery of an extension strategy to drive grower adoption. End: May 2027
Stopping seed set of barley grass on the upper Eyre Peninsula	GRDC (UOA2403-011RTX)	This investment will further investigate management tactics that may delay flowering in barley grass making it feasible to spray-top effectively without damaging medic seed set or alternatively to manipulate barley grass emergence to make the flowering window of all cohorts more synchronised. This investment also aims to demonstrate and validate how different crop and pasture sequences change weed density in mixed-farming systems on the upper EP and provide further extension activities for growers to increase their confidence to implement recommended management strategies to drive down barley grass populations. End: April 2027
Lentil check discussion groups to maximise profitability of lentil production in the Upper Eyre Peninsula	GRDC (UOA2303-007RTX)	This project aims to deliver four peer to peer learning groups to assist agronomic decision making around lentil production on the Upper Eyre Peninsula. In addition to the facilitated peer to peer learning groups, one herbicide matrix trial will be conducted at each of two sites to evaluate the efficacy and profitability of both current and newly available herbicide technologies to drive discussion with the groups. Trials will be within close proximity to two of the peer groups with other groups leveraging existing GRDC and industry trial activities. End: March 2027
Geospatial analytics to predict the impact of residual herbicides on establishment and yield.	GRDC (DPI2306-013RTX)	This project aims to allow growers to quantify the impacts of residual activity on establishment and yield more accurately to make more profitable decisions on crop choice and variety (herbicide tolerance or not). It will do that by coupling on-farm geospatial data with models of herbicide bioavailability, soil water infiltration, and crop toxicity thresholds to produce maps of plant-risk based on bioeconomic thresholds. End: February 2027
Predicting Nitrogen Cycling & Losses in Australian Cropping Systems - Augmenting Measurements to Enhance Modelling	GRDC (UOQ2204-010RTX)	The project will quantify the dynamics of nitrogen (N) cycling and losses across a diverse range of soil and environmental conditions representative of the Australian grains industry. End: June 2027
Impact of stripper front and straw length on harvest efficiency, summer weed control, soil moisture retention and pest populations in the Upper Eyre Peninsula	GRDC (UOA2303-013RTX)	This investment is designed to evaluate the potential benefits and challenges of stripper front use in a disc seeder system on the Upper Eyre Peninsula, specifically the impact of stubble height on harvest efficiency, efficacy of summer weed control, soil moisture retention/fallow efficiency and its resultant impact on yield and pest populations including weeds, snails, insects and mice. End: April 2026
National Variety Trials	GRDC	Yield performance of cereal and break crop varieties at various locations across upper EP.
SAGIT SA Drought Hub AIR EP SARDI Intern	SAGIT SA Drought Hub Australian Government's Future Drought Fund AIR EP (AEP 00525)	Eyre Peninsula internship in applied grains research 2026. End: June 2027

Derisking the sowing program on EP in 2025	SA Drought Hub Australian Government's Future Drought Fund AIR EP	This project's key objective is to demonstrate practices to reduce herbicide toxicity and increase plant establishment in early sowing situations. End: May 2026
Improving crop phosphorus supply on highly calcareous soils using novel sources	High Performance Soils CRC, GRDC and the Australian Government's Future Drought Fund Long Term Trial Project	A joint investment by the High Performance Soils CRC, GRDC and SA Discovery Farms is aiming to develop solutions for more efficient delivery and uptake of P by crops growing in highly calcareous soils. Ends: June 2027
Impact of soil herbicide residues on crop performance in challenging soil types	GRDC (project code: OA2501-005RTX)	Several National Grower Network forums identified herbicide residues as a concern for growers, especially in low rainfall regions. Due to the complexity of the interaction between herbicide types, soil, crop types and environment, many growers lack confidence in the relevance of crop type selection and plant back periods. This work will guide growers in making better-informed decisions with regards to in-crop and pre-emergent chemistry applications, thereby reducing plant-back issues and improving crop growth and yield. Ends: June 2027
SA Drought Hub	Australian Government's Future Drought Fund	The South Australian Drought Resilience Adoption and Innovation Hub ('SA Drought Hub') aims to enhance adoption of drought resilient practices. The SA Drought Hub will develop an innovation and adoption 'infrastructure' consisting of a network of grower groups, universities, government agencies, indigenous partners, agribusinesses, RD&E partners and industry organisations. The initial focus will be to co-design and deliver demand driven activities across regional nodes of pastoral, low, medium and high rainfall mixed farming to demonstrate and increase adoption of drought resilience practices, implement social resilient and wellbeing strategies and leverage future investments for drought innovation and adoption initiatives. The SA Drought Hub will increase preparedness and transition mixed farming towards a future climate with less rainfall. The SA Drought Hub will link to all industry sectors to provide broad resilience and innovation support across the state.
Crop Improvement Trials	Various	Various trials including; ARC Linkage - AIR EP. End: December 2026. LongReach Plant Breeders Variety Trial.

Completed project delivery		
Epidemiology and management of Rhizoctonia in low and medium rainfall zones	GRDC (DAW2206-006RTX)	Investigate disease management strategies to minimise the impact of Rhizoctonia in the LRZ and MRZ of the Southern and Western regions and SW NSW. An integrated and cost-effective approach of cultural, chemical and biological management strategies need to be developed as genetic solutions do not exist for Rhizoctonia. End: June 2025
De-risking the seeding program. Adoption of key management practices for the success of dry early sown crops.	Australian Government's Future Drought Fund AIR EP (DN1 25 02)	This project's key objective is to help growers make informed decisions on the strategies they can employ when early/dry sowing that will maximise seed germination and financial and environmental resilience. End: June 2025
Break crops across the landscape	Australian Government's SA Drought Hub AIR EP (DN3 24 07)	This project aims to provide an opportunity for growers to understand the benefits and risks of having different break crops across different soil types through grower implemented demonstration sites. End: May 2025

Table 2. Minnipa Agricultural Centre events in 2025.

Event	Topics	Attendance
GRDC Update Adelaide 5 February	Unlocking the value of strip and disc systems GRDC (UOA2303-013RTX) - Amanda Cook (presentation)	500-558 growers and industry representatives
SARDI Farmer Meetings Minnipa, Wirrulla, Port Kenny, Ceduna, Lock, Rudall, Cowell and Kimba. 26 February - 6 March	• GRDC Strip and Disc Systems - Amanda Cook • GRDC Barley Grass - Amanda Cook • GRDC Herbicides in Lentils - Dr Navneet Aggarwal • GRDC Nitrogen volatilisation - Zhaohan Luo • GRDC Brome grass - Dr Buddhi Chaudhary • SA Drought Hub Break crops across the landscape - Dr Buddhi Chaudhary • Future Drought Fund De-risking the Seeding Program - Zhaohan Luo • Hybrid disc seeders - Jack Desbiolles; University of South Australia and Belinda Cay; AgCommunicators (Minnipa and Wirrulla) • Farm Business Resilience - Andy Bates; Bates Agricultural Consulting and Barry Mudge; Barry Mudge Consulting	129 growers and industry representatives attended.
Eyre Peninsula Farming Systems Summary March-April	Compiling and printing 1000 copies of the annual Eyre Peninsula Farming Systems Summary for distribution to all EP growers, industry representatives, researchers and consultants on Eyre Peninsula and other regions. Amanda Cook, Nicole Baty and SARDI staff	1000 growers, industry representatives, researchers and consultants
GRDC Lentil Check Discussion Groups Kimba, Mudamuckla, Mt Damper and Lock. 8-9 April 4-5 September	Facilitated by Andy Bates; Bates Agricultural Consulting supported by local agronomists and consultants Jake Hull; West Coast Ag, Leigh Davis; Nutrien Ag, James Cant; AGRA Independent Agronomy and Bella Heron; Elders, four lentil check groups met twice in 2025. Topics discussed during the April meetings were: • herbicide safety • seed quality • inoculation tips • paddock preparation • time of sowing • nutrition Topics discussed during the September meetings were: • cutting edge agronomy • seeding systems • managing sandhills • herbicide residues	144 growers and industry representatives attended and 10 SARDI staff attended. Dr Navneet Aggarwal, Andy Bates, Jason Brands, Nicole Baty, Elijah Luo, Buddhi Chaudhary, Cathy Paterson.
110 MAC Field Day Celebration Minnipa Agricultural Centre 11 September	• MAC Farm Update – John Kelsh • Herbicide use practices: Managing herbicide residues, soil and plant tissue testing for herbicides - Dr Lukas Van Zwieten, NSW DPI • Pest Management Tactics: Minimising the impact of snails - Dr Kym Perry. • SA Discovery Farms Barley Biomass trial - Brendan Kupke • Predicting nitrogen cycling and losses in Australian cropping systems - Dr Nigel Wilhelm and Elijah Luo • Crop safety and weed management in lentils - Dr Navneet Aggarwal • Panel Session: Agronomy of growing lentils in the LRZ - Andrew Bates, Larn McMurray, Kevin Dart and Leigh Davis. • Carbon Farming: Rotations and emissions intensity - Nick Paltridge • Water for primary production, regional farm water usage, water budgeting and water quality - Josh Telfer • SA Discovery Farms: Residual phosphorous (P) long term trial - Dr Sean Mason • NVT Variety Trials - John Kelsh and plant breeders • Geospatial Herbicide Risk – Dr Buddhi Chaudhary	146 growers, plant breeders and industry representatives attended.
Sticky Beak Days - Eyre Peninsula August to October	SARDI MAC Research Officers Elijah Luo, Cathy Paterson and Dr Buddhi Chaudhary presented at a series of grower crop walks organised by local Agriculture Bureau Groups across the Eyre Peninsula.	Over 200 people: mostly growers

SARDI Technical Officers meeting 14-15 October	SARDI Technical officers meeting and discussion of research trial management, visits and equipment at Port Lincoln attended by Kym Zeppel, Tammie Mullen, Marina Mudge and Julian Post.	12 SARDI staff
2nd Global Conference on Sandy Soils Shifting Sands to Sustainable Solutions Perth, WA. 21-24 July	Elijah Luo and Nigel Wilhelm attended the Sandy Soil conference held in Perth WA. N Wilhelm presented "Understanding Crop Development and Yield Responses to Mitigate High Soil Strength in Australian Soils".	Elijah Luo, Nigel Wilhelm and Buddhi Chaudhary

Save the date

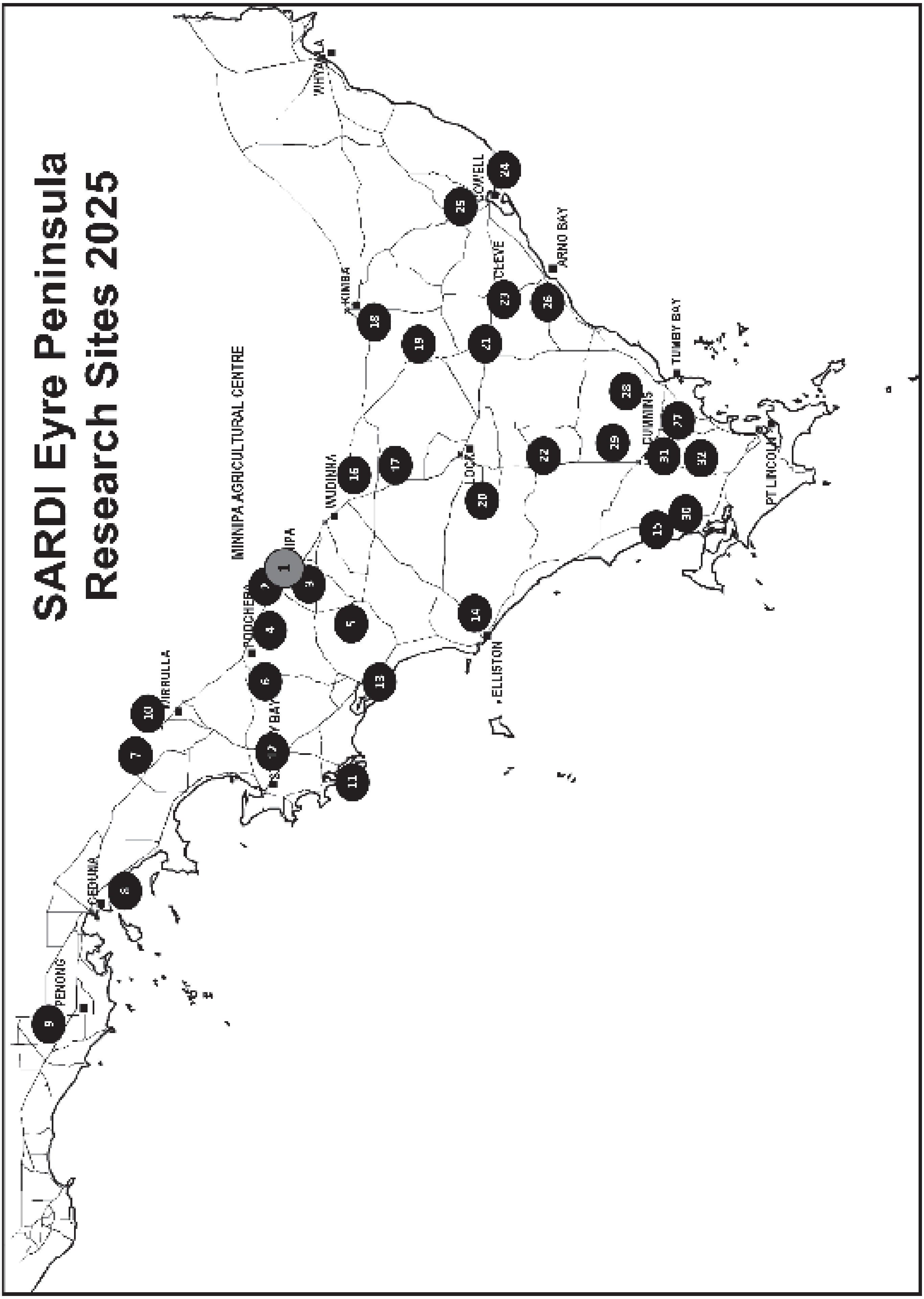
Minnipa Agricultural Centre Annual Field Day

Wednesday, 9 September 2026

Minnipa Agricultural Centre
EYRE PENINSULA

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE


SARDI Eyre Peninsula
Research Sites 2025
MINNIPA AGRICULTURAL CENTRE
COWELL
ARNO BAY
CLEVE
KIMBA
TUMBY BAY
CUMMINS
WUDINNA
ELLISTON
WIRRULLA
CEDUNA
PENONG

Eyre Peninsula agricultural research sites 2025 map references.

Map reference	Location	Trials
1	Minnipa	NVT wheat and early break wheat, barley, field peas, and IT, RR and TT canola. Vetch breeding. Herbicides and nutrition in lentils. Barley grass management. ARC Linkage Silicone. Geospatial Herbicide Risk. Nitrogen cycling. SA Discovery Farms Soils. SA Discovery Farms Optimising Barley Biomass. SA Discovery Farms Wheat Germplasm for Heat Stress tolerance. SA Discovery Farms Stripper Stubble.
2	Minnipa	Strip and Disc.
3	Minnipa	Longreach Plant Breeding.
4	Condada	Break crops across the landscape.
5	Mount Damper	Sandy Soils. NVT lentils.
6	Poochera	Brome grass. SA Drought Hub De-risking the seeding program.
7	Nunjikompita	NVT wheat and oats.
8	Ceduna	Herbicides and nutrition in lentils.
9	Penong	NVT wheat.
10	Wirrulla	Herbicide Residue
11	Calca	Net form of Net blotch.
12	Piednippie	NVT wheat and barley. Rhizoctonia management.
13	Port Kenny	Novel Phosphorus sources.
14	Elliston	NVT barley, Metribuzin residue trial.
15	Mount Hope	NVT canola (IT, TT).
16	Kyancutta	Sandy Soils.
17	Warramboo	NVT wheat.
18	Kimba	NVT wheat and Lentil. Lentil disease.
19	Darke Peak	NVT barley.
20	Lock	NVT canola (IT, TT, RR) Lentil Nutrition and Lentil Disease.
21	Rudall	NVT wheat.
22	Murdinga	NVT Field Peas and Lentils.
23	Cleve	Strip and Disc.
24	Mitchellville	NVT wheat.
25	Cowell	Brome grass.
26	Wharminda	NVT Wheat and barley.
27	Koppio	Potassium deficiency.
28	Ungarra	NVT lupins. Break crops across the landscape.
29	Yeelanna	NVT faba beans, lentils and canola (IT, TT, RR).
30	Coulta	Herbicide Residue.
31	Cummins	NVT wheat and barley.
32	Wanilla	NVT wheat and barley.

Agricultural Innovation & Research Eyre Peninsula (AIR EP) update 2025

Bill Long and Naomi Scholz

Vision

Our vision is for farming systems on the Eyre Peninsula that are productive, profitable and fit for the future.

AIR EP's work is underpinned by our core values of relevance, independence, collaboration and innovation, ensuring our activities remain locally driven, scientifically robust, and focused on long-term outcomes for Eyre Peninsula farmers.

Seasonal Conditions and Regional Resilience

The 2025 season presented significant challenges for farming communities across South Australia. Eyre Peninsula experienced the driest start to a season on record, placing pressure on cropping and livestock systems due to limited moisture. The extended dry spring, summer and autumn period, coupled with a later seasonal break, created ongoing concerns around crop establishment, early growth, and feed and water availability for livestock producers. Despite the challenges, and with some welcome rainfall in winter, yields were quite good in many parts of the region, however profitability remains a high concern heading into 2026.

AIR EP continues to support growers through RD&E programs that address both immediate seasonal variability and long-term sustainability priorities.

Research Impact and Innovation

AIR EP strengthened its focus on farmer-driven research in 2025, working closely with growers, advisors, industry and government partners to ensure research remains locally relevant and scientifically robust.

Key highlights included:

- Negotiation of the DAFF Sustainable Agriculture Program with the Eyre Peninsula Landscape Board
- Completion of the Soil CRC EP Landholder Survey, identifying farmer priorities for soil health in dry and variable conditions
- Continued legume research, particularly lentils, refining cropping practices on challenging soil types
- Delivery of the GRDC RiskWi$e Project, using focus paddocks and discussion groups to reduce risk and capitalise on opportunities
- Ongoing collaboration with universities and research bodies exploring climate-smart rotations and carbon farming

AIR EP's success lies not only in generating trial data with our highly valued research partners, but in translating knowledge into practice through field days, workshops and peer learning networks.

We sincerely thank all past and present members and associates of the Low and Medium Rainfall RD&E Committees for their ongoing commitment, guidance and leadership in supporting Eyre Peninsula farming systems. Their collective expertise and regional knowledge play a vital role in identifying RD&E priorities, as well as emerging issues and challenges across the diverse farming regions of the Eyre Peninsula.

Extension and Knowledge Sharing in 2025

Extension remains central to AIR EP's mission. Over the past year, more than 1,300 participants attended AIR EP events across the region, highlighting strong grower engagement and the value of farmer-to-farmer learning.

Key events delivered across Eyre Peninsula during 2025 included:

- AIR EP Pre-sowing Member Days in Wirrulla, Kimba and Ungarra
- Saline Soils and Variable Rate Technology (VRT) Workshops across Kimba, Wudinna and Ceduna
- RiskWi$e Discussion Groups supporting decision-making and risk management
- Franklin Harbour Soil Pit Session exploring soil constraints and management strategies
- Introduction to Carbon Farming Workshops held across multiple EP locations
- Young Farmer Bus Tour and leadership development activities
- AIR EP/ GRDC / SARDI Lentil Field Day, Lock
- DAFF Sustainable Agriculture Tour of EP
- AIR EP Lower EP Crop Walk
- ARLF Changemaker Workshops delivered in Tumby Bay, Cummins, Streaky Bay and Wudinna

AIR EP continues to prioritise both large-scale grower events and smaller focused discussion groups that deliver meaningful practice change at farm business level.

Strategic Direction and Targets Ongoing (2026–2030)

In October 2025, AIR EP adopted a new Strategic Plan for 2026–2030, providing a clear roadmap to strengthen farmer-led RD&E and extension across the region.

The strategy identifies five key priorities that will guide AIR EP's ongoing work:

- Farmer Focus - ensuring projects and investments are shaped by local farmer needs, priorities and leadership
- Extension - translating research into practice change through peer learning, trusted experts and locally delivered events
- Partnerships - building strong, mutually beneficial relationships with research, advisor and industry partners aligned with Vision EP 2050
- Funding and Resources - securing sustainable, diversified investment to support extension capacity and organisational resilience
- Marketing and Communication - enhancing awareness of AIR EP as the 'go to' organisation for applied agricultural RD&E on Eyre Peninsula

Together, these priorities position AIR EP to deliver farming systems improvements that support long-term productivity, profitability and future readiness across Eyre Peninsula agriculture.

Looking Ahead

With a strong strategic foundation in place, AIR EP enters 2026 focused on expanding its extension reach, strengthening partnerships, and continuing to deliver farmer-driven innovation that supports resilient and sustainable farming systems for the future.

AIR EP thanks its members, collaborators, sponsors, staff and 'most importantly' the farmers and landholders who trust the organisation to work on their behalf toward a more resilient and prosperous agricultural future.

For more information or to find out about coming events, connect with AIR EP via the following:

Website: www.airep.com.au

Facebook: @aginnovationep

Instagram: @ag_eyre

X (formerly Twitter): @AIREP

Subscribe to our newsletter and become a member via the AIR EP website.

With thanks to our valued EP research delivery partners SARDI and EPAG Research, plus the various funding bodies and other organisations and individuals we have the opportunity to work with. And many thanks to our 2025 Sponsors for their invaluable ongoing support of our organisation.

GOLD SPONSORS

BRONZE SPONSORS

2025 SUPPORTERS

CPH Accounting

Centre State Exports

Many thanks to the valuable support from our 2025 sponsors

Eyre Peninsula Seasonal Summary 2025

Joshua Telfer and Catherine Paterson
SARDI

The 2025 season was a genuine roller coaster across Eyre Peninsula, beginning with extremely dry conditions following the drought of 2024. The region received no significant summer rainfall in 2024/25, leaving soil profiles exceptionally dry heading into autumn (Figure 1). Feed reserves were depleted after 2024, resulting in widespread destocking, and some areas experienced ongoing challenges in maintaining adequate livestock water supplies. Significant volumes of hay and fodder were brought in from across South Australia and interstate once local supplies were exhausted.

Most of South Australia-and the whole of Eyre Peninsula-remained very dry through to late May, with only a few isolated pockets (including Verran, Wirrulla, and areas west of Edillilie) receiving mid autumn rainfall. June rainfall was limited across the region, occurring in small 5–10 mm events. While modest, this rainfall was enough to trigger the emergence of many dry sown crops, although germination occurred into extremely dry soil profiles. Strong winds early in the growing season resulted in some crops getting sandblasted, in some cases more than once that set back yield potential. Pastures germinated well in 2025, and once established many producers could stop supplementary feeding.

Substantial rainfall finally arrived in July, falling on crops that in many cases were only just emerging. The Elliston, Wudinna, Streaky Bay, and Cummins districts recorded above average July rainfall, which provided valuable stored soil moisture that became critical for shorter-season crops. Eastern Eyre was not as wet at this time, with totals remaining below 100 mm; however, these districts went on to experience a comparatively wetter spring. By the end of the season, eastern and western areas were in a similar position despite the differing rainfall patterns.

Spring conditions were generally dry from mid to late season, but moderate temperatures allowed crops to finish well. This resulted in around average yields across Streaky Bay, Wirrulla, Wudinna, Kimba and Cleve. The areas that received the mid-autumn rainfall saw above average yields. The far west and Cowell areas were average to below average depending on soil type. The lower Eyre Peninsula generally achieved above average outcomes.

The expansion of the EP lentil production area continued strongly in 2025 (table 1). Growers from Mitchellville to Coulta, and from Minnipa further west, have steadily improved their lentil agronomy, enabling the crop to become well established in rotations across eastern, central, and western EP, with an increasing presence on lower EP. Although lentil prices were lower than in previous seasons, the crop appears to have secured a long term role in many rotations.

Wheat and barley performed well overall; however, lack of September rainfall limited the top end yield potential in both crops. Despite this, final yields were generally solid given the challenging start to the season. Lower prices for cereals compared to previous seasons put pressure on returns for farm businesses.

Canola again performed strongly on lower EP, returning above average yields for many growers. However, significant discounts for GM canola continue to influence grower decisions. Some are reassessing whether non-GM varieties might be feasible where ryegrass pressure is manageable through careful agronomy. Farmers that kept canola in their rotation saw good returns with strong prices.

2025 saw an increase in the value of livestock and wool despite pressures earlier in the season with a lack of feed and, in some areas, water, leading to destocking in parts of the EP. This was driven by strong global demand and restocker interest across the country (agriculture.gov.au). Wool prices rose steadily across 2025, mainly due to a surge in demand from China (woolnews.net) and a reduction in flock size across Australia. Beef saw an increase in saleyard prices in 2025. This was supported by global demand, reduced supply in competing countries and the low Australian dollar (mla.com.au).

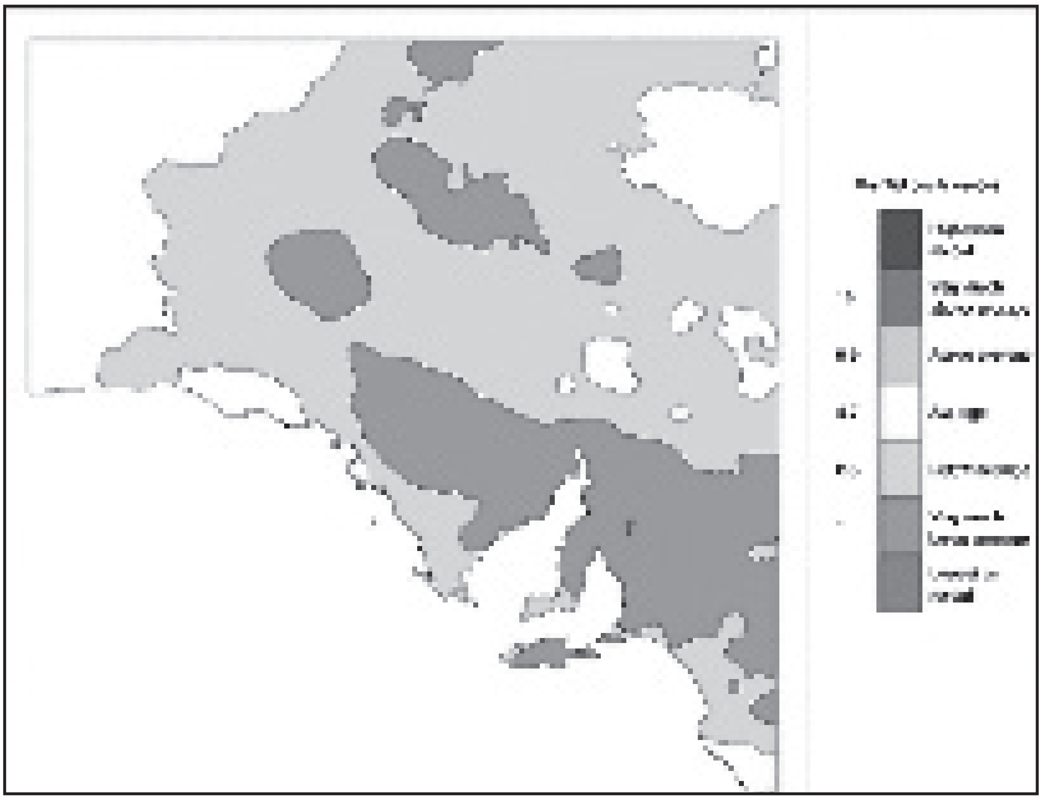


Figure 1. Rainfall for 1 December 2024-28 February 2025, as deciles calculated from long term averages.

Table 1. Estimated crop area and total tonnage for season 2025.
(source PIRSA Crop and Pasture Report South Australia 2025-26)

Crop		Western EP	Lower EP	Eastern EP
Wheat	ha	380,000	145,000	370,000
	t	532,000	551,000	740,000
Barley	ha	70,000	50,000	70,000
	t	112,000	200,000	168,000
Lentils	ha	75,000	55,000	80,000
	t	67,500	137,500	96,000
Canola	ha	4,000	80,000	9,000
	t	3,200	208,000	11,250

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

MAC Farm Report 2025

John Kelsh
Farm Manager
SARDI, MAC

Location
Minnipa Agricultural Centre
Rainfall
Av. Annual: 330 mm
Av. GSR: 244 mm
2025 Total: 281 mm
2025 GSR: 228 mm

Key outcomes

- **Hay production showed highest gross margins.**
- **Crop yields varied from 40 to 86% using a modified French/Schultz potential yield.**
- **Sheep flock numbers to gradually increase after hard cull in 2024.**

Background

The performance of the Minnipa Agricultural Centre (MAC) farm is a core component in the delivery and extension of relevant research & development projects in Eyre Peninsula farming systems. The aim of the MAC farm team is to showcase how the effective use of research findings, agronomic improvements, and new technologies can be applied on a broad scale and to demonstrate best-practice farming on Eyre Peninsula.

Examples of this include the introduction of our hybrid disc seeding system, which will continue to contribute to broadacre demos and trial sites on-centre. The introduction of a stripper front, which is intended to contribute to a similar extent in both broadacre demonstrations and targeted trials.

On the technology front we have made significant changes to the livestock operation, renewing the sheep yards a number of years ago, followed by the shade structure construction and the introduction of an all-electric auto-drafter. More recently we have adopted genomic testing for parentage and selection based on genetic merit. These changes haves simplified the livestock operation somewhat and negate the need to go catching lambs in the freezing cold winter morning conditions.

Other advances in technology on the farm include increasing the density of automatic rain gauges and weather stations, we now have more rain gauges on farm that rainfall data can be gathered from. Insights provided by the now concluded AgTech Demonstration program fuelled this to a degree due to the large variability we were seeing across sensor sites within that program. We also now host an NTRIP RTK base-station that forms part of the AusCORS network – this provides RTK corrections over the internet for any connected devices to enable high accuracy positioning services.

Targeted soil sampling and variable rate starter fertiliser has also been a farm project, trying to find the right balance of zoning, rate and yield potential within our paddocks. Currently largely based on previous yield maps and EM38 data to determine soil depth. We haven't found the answer to this yet, but it would be good to have protein maps to feed into this decision tree and help identify paddock scale protein deficiencies/excesses.

The MAC farm team will continue to strive to provide a site where these sorts of ideas are tested and investigated, while hosting numerous small plot trials – in 2025 we had 20 trial sites at MAC.

What happened?

Weather

Following the below average yield outcomes of 2024, and little stored moisture carried over into the start of the season, the 2025 outlook was similar to the year previous - dependant on a significant autumn opening rainfall event for good prospects. On 20 March, a significant rain event (18 mm) was a little too early to begin seeding. We waited through all of April and most of May before a sign of any more rainfall was to come. Our opening rain finally arrived on 27 May when we received 4 mm, though a significant follow-up didn't appear to be on the horizon. June delivered a good amount of rain with a total of 51 mm. By the end of July optimism was at its peak, having received another 95 mm. A few top-up showers were welcomed in August before the tap turned off at the end of that month. In September, our most critical month for setting up high yields through grain fill, we recorded a mere 4 mm, effectively capping our yield potential. Late rains in October (35 mm) just served to bring harvest on quicker and disrupt hay operations. While rain in November (30 mm) only disrupted harvest.

Table 1. Minnipa Agricultural Centre historical Merino flock joining data summarised.

	Ewes joined	Lambs scanned	Lambs marked	Scanning rate %	Marking rate %	Conception rate %	Survival at marking %
2014	349	442	386	127	111		87
2015	424	555	437	131	103		79
2016	422	532	502	126	119		94
2017	366	428	361	117	99		84
2018	335	434	294	130	88		68
2019	342	486	434	142	127		89
2020	367	543	464	148	126		85
2021	398	625	485	157	122		78
2022	366	620	519	169	142	95	84
2023	410	661	517	161	126	92	78
2024	422	662	496	157	118	94	75
2025	352	550	362	156	103	95	66
Av.	379	545	438	143	115		81

**2014, 2015, 2016, 2017 all had 1 x sire failure.*

Cropping

This year our seeding program commenced on 22 May, with some dry sowing of oats, followed by Clearfield barley. We switched to lentils on 3 June, then swapped to wheat on 5 June. Seeding continued, in between showers, until we finished with field peas on 16 June. Seeding conditions were generally good, and the new disc bar performed very well with minimal issues. We weren't as lucky with the tyne system snapping a lift ram within the first 10 ha of the season, so seeding with that machine stopped. For the second year running, canola was left out of the rotation due to a lack of early moisture. Seed rates were determined based on germination tests and target plants/m^2.

Our fertiliser regime this year was Granulock Z, which was sown just below the seed, with the remainder top-dressed on paddocks that either didn't have a full rate of fertilizer at seeding or would have had sheep turned out on them if required later in the season. The extra fertiliser was top-dressed at a rate of approximately 50 kg/ha. No extra nitrogen was applied during the season. Foliar ZMC was applied to wheat paddocks with the broadleaf weed control spray. Both fertiliser and seeding rates are in Table 2, below.

During May we had heard reports of native budworm and other insects on the wing coming from the north, particularly affecting farmers west of Minnipa and on the northern side of the Eyre highway. As a precaution we added 50 mL/ha Alpha-cypermethrin to our pre-emergent herbicide pass to keep them at bay. No significant incursions were noted during the season subsequently.

Lessons learned by our team this year were that; the soil throw of our hybrid-disc system isn't enough to make trifluralin an effective weed control strategy; extra care needs to be taken when adjusting sowing depth on the new disc seeding system as small adjustments seem to have a large effect; we successfully, though unintentionally, delayed senescence in a medic pasture test strip and need to investigate this further.

The distribution of our arable areas was as follows:

- 29% Wheat - 308 ha (Calibre, Tomahawk CL, Shotgun)
- 27% Barley - 286 ha (Maximus CL, Combat)
- 5% Peas - 54 ha (PBA Butler)
- 8% Oats - 84 ha (Archer)
- 5% Lentil - 60 ha (GIA Thunder)
- 26% Pasture - 276 ha (regenerated annual medic)

An observation of note was that the Shotgun wheat in South 4, while developmentally behind, looked very healthy the whole year. Soil tests indicated that this paddock had a nitrogen limited yield potential of 3.36 t/ha and therefore limiting factors would be either; moisture, phosphorus availability (DGT-P of 41), or sodicity. Despite those constraints it looked like the best paddock on MAC all year and that was reflected in the yield results (Table 2).

Harvest commenced on 30 October with lentils, and concluded on 8 December. Grain yields were slightly above our long-term average, with minimal screenings (<2%) and wheat test weights around 80 kg/hL - showing an inverse relationship between test weight and protein. All hard wheats went H1 or H2, while Tomahawk CL achieved APW or ASW grades. All our barley was transferred to Struan Research Centre for their use as stock feed.

The addition of a prime-mover and semi-tipper combination made a significant difference to our harvest, enabling the prompt removal of grain, allowing the harvester to operate longer before stopping due to lack of storage capacity. The new combination carries 28 tonnes and it allows reversing up to a stack to tip off, where with the truck and dog we were required to queue for a drive-over stacker.

Livestock

Another successful year for the MAC Merino flock with 352 ewes joined and 550 foetus' scanned (156%) resulting in 362 lambs marked (103%), full details in Table 1, below.

Recently our flock breeding objectives were refined slightly to emphasise more on wool quality than previous, the target was to bring our fibre diameter down to an 18.5-micron average and target bright white fleeces. At the time we were producing adult fleeces of about 19.6 micron. We are slowly making progress in this endeavour with our average fibre diameter from last year's fleeces down to 18.8 micron. Once this target is achieved the breeding objectives will be fine-tuned again to focus on fertility and mothering ability whilst maintaining the fibre diameter and other wool metrics.

Current flock numbers are; 374 flock ewes, 359 mixed lambs and 8 rams.

Acknowledgements

SARDI Research Support staff: Wade Shepperd, Ricca Moyse, Leala Hoffmann and Joanne Rynne

MAC Farm harvesting lentil.

Table 2. Cropping results table for 2025, Minnipa Agricultural Centre.

Paddock	Rotation					Crop	Variety	Sown	Area (ha)	Seed Rate (kg/ha)	Fert Rate (kg/ha)	Harvested	Margin ($/ha)	Yield (t/ha)	pY (F&S)* (t/ha)	WUE (%)
	21	22	23	24	25											
AP Highway	W	W	M	W	W	Wheat	Tomahawk CL	7-Jun	65.7	79	50	20-Nov	128	1.74	3.52	49%
AP MAC	B	P	W	B	L	Lentil	Thunder	3-Jun	37.3	49	50	30-Oct	211	1.03	2.36	44%
AP Town	W	P	W	B	L	Lentil	Thunder	3-Jun	17.0	49	50	30-Oct	227	1.08	2.36	46%
Barn	M	T	M	O	P	Field Pea	Butler	17-Jun	7.6	85	30	8-Nov	108	0.94	2.36	40%
Minnipa Hill	M	W	P	W	W	Wheat	Tomahawk CL	9-Jun	38.1	79	50	21-Nov	189	1.86	2.99	62%
North 1	W	M	C	M	W	Wheat	Calibre	14-Jun	64.6	71	50	25-Nov	267	2.05	2.99	69%
North 3	P	W	B	M	O	Oats	Archer	23-May	30.6	65	50+50	8-Dec		1.47	-	-
					B	Barley	Maximus CL	23-May	20.5	53	50+50	9-Nov		1.98	3.52	56%
North 4	M	W	P	W	O	Oats	Archer	22-May	53.6	65	30+50	Cut for hay	350	2.37	-	-
North 5 S	M	M	C	W	B	Barley	Combat	27-May	31.4	55	50		875	3.62	-	-
North 6	W	M	M	W	B	Barley	Maximus CL	30-May	73.6	53	50	11-Nov	199	1.95	3.36	58%
North 8	W	B	M	M	W	Wheat	Calibre	11-Jun	58.7	71	50	26-Nov	256	1.98	3.52	56%
North 10	B	B	W	P	W	Wheat	Tomahawk CL	10-Jun	41.9	79	50	3-Dec	279	2.48	3.52	70%
North 12	P	W	B	O	L	Lentil	Thunder	4-Jun	23.0	49	50	30-Oct	269	1.19	2.36	50%
South 3	W	B	P	W	B	Barley	Combat	28-May	69.5	55	50	13-Nov	213	2.03	3.52	58%
South 4	O	W	T	P	W	Wheat	Shotgun	6-Jun	39.3	70	50	27-Nov	370	2.89	3.36	86%
South 7	M	W	W	M	B	Barley	Maximus CL	2-Jun	41.0	53	50	5-Dec	310	2.50	3.74	67%
South 8	M	C	W	B	P	Field Pea	Butler	16-Jun	46.3	85	30	6-Nov	137	1.10	2.36	47%
South 9	B	M	M	W	B	Barley	Combat	29-May	49.9	50	50	15-Nov	235	2.02	3.90	52%

M = medic, P = field pea, W = wheat, B = barley, O = oats, C = canola, T = triticale, L= Lentil

** Calculated based on rainfall at the closest rain gauge using a modified French & Schultz with water supply as 30% of summer rain (Dec-March) + GSR, evaporation of 65 mm for wheat and barley, and 75 mm for lentil and pea, and a transpiration efficiency of 22 for wheat and barley, and 15 for pea and lentil.*

Understanding trial results and statistics

Interpreting and understanding replicated trial results is not always easy. We have tried to report trial results in this book in a standard format, to make interpretation easier. Trials are generally replicated (treatments repeated two or more times) so there can be confidence that the results are from the treatments applied, rather than due to some other cause such as underlying soil variation or simply chance.

The average (or mean)

The results of replicated trials are often presented as the average (or mean) for each of the replicated treatments. Using statistics, means are compared to see whether any differences are larger than is likely to be caused by natural variability across the trial area (such as changing soil type).

The LSD test

To judge whether two or more treatments are different or not, a statistical test called the Least Significant Difference (LSD) test is used. If there is no appreciable difference found between treatments then the result shows "ns" (not significant). If the statistical test finds a significant difference, it is written as "$P \leq 0.05$". This means there is a 5% probability or less that the observed difference between treatment means occurred by chance, or we are at least 95% certain that the observed differences are due to the treatment effects.

The size of the LSD can then be used to compare the means. For example, in a trial with four treatments, only one treatment may be significantly different from the other three - the size of the LSD is used to see which treatments are different.

Results from replicated trial

An example of a replicated trial of three fertiliser treatments and a control (no fertiliser), with a statistical interpretation, is shown in Table 1.

Table 1. Mean grain yields of fertiliser treatments (4 replicates per treatment)

Treatment	Grain Yield (t/ha)
Control	1.32 a
Fertiliser 1	1.51 a,b
Fertiliser 2	1.47 a,b
Fertiliser 3	1.70 b
Significant treatment difference	$P \leq 0.05$
LSD (P=0.05)	*0.33*

Statistical analysis indicates that there is a fertiliser treatment effect on yields. $P \leq 0.05$ indicates that the probability of such differences in grain yield occurring by chance is 5% (1 in 20) or less. In other words, it is highly likely (more than 95% probability) that the observed differences are due to the fertiliser treatments imposed.

The LSD shows that mean grain yields for individual treatments must differ by 0.33 t/ha or more, for us to accept that the treatments do have a real effect on yields. These pairwise treatment comparisons are often shown using the letter as in the last column of Table 1. Treatment means with the same letter are not significantly different from each other. The treatments that do differ significantly are those followed by different letters.

In our example, the control and fertiliser treatments 1 and 2 are the same (all followed by "a"). Despite fertilisers 1 and 2 giving apparently higher yields than control, we can't dismiss the possibility that these small differences are just due to chance variation between plots. All three fertiliser treatments also have to be accepted as giving the same yields (all followed by "b"). But fertiliser treatment 3 can be accepted as producing a yield response over the control, indicated in the table by the means not sharing the same letter.

On-farm testing - Prove it on your place!

Doing an on-farm trial is more than just planting a test strip in the back paddock, or picking a few treatments and sowing some plots. Problems such as paddock variability, seasonal variability and changes across a district all serve to confound interpretation of anything but a well-designed trial.

Scientists generally prefer replicated small plots for conclusive results. But for farmers such trials can be time-consuming and unsuited to use with farm machinery. Small errors in planning can give results that are difficult to interpret. Research work in the 1930's showed that errors due to soil variability increased as plots got larger, but at the same time, sampling errors increased with smaller plots.

The carefully planned and laid out farmer un-replicated trial or demonstration does have a role in agriculture as it enables a farmer to verify research findings on his particular soil type, rainfall and farming system, and we all know that "if I see it on my place, then I'm more likely to adopt it". On-farm trials and demonstrations often serve as a catalyst for new ideas, which then lead to replicated trials to validate these observations.

The bottom line with un-replicated trial work is to have confidence that any differences (positive or negative) are real and repeatable, and due to the treatment rather than some other factor.

To get the best out of your on-farm trials, note the following points:

- Choose your test site carefully so that it is uniform and representative - yield maps will help, if available.
- Identify the treatments you wish to investigate and their possible effects. Don't attempt too many treatments.
- Make treatment areas to be compared as large as possible, at least wider than your header.
- Treat and manage these areas similarly in all respects, except for the treatments being compared.
- If possible, place a control strip on both sides and in the middle of your treatment strips, so that if there is a change in conditions you are likely to spot it by comparing the performance of control strips.
- If you can't find an even area, align your treatment strips so that all treatments are equally exposed to the changes. For example, if there is a slope, run the strips up the slope. This means that all treatments will be partly on the flat, part on the mid slope and part at the top of the rise. This is much better than running strips across the slope, which may put your control on the sandy soil at the top of the rise and your treatment on the heavy flat, for example. This would make a direct comparison very tricky.
- Record treatment details accurately and monitor the test strips, otherwise the whole exercise will be a waste of time.
- If possible, organise a weigh trailer come harvest time, as header yield monitors have their limitations.
- Don't forget to evaluate the economics of treatments when interpreting the results.
- Yield mapping provides a new and very useful tool for comparing large-scale treatment areas in a paddock.

The "Crop Monitoring Guide" published by Rural Solutions SA and available through PIRSA offices has additional information on conducting on-farm trials. Thanks to Jim Egan for the original article.

Some useful conversions

Area

1 ha (hectare) = 10,000 m² (square 100 m by 100 m)

1 acre = 0.4047 ha (1 chain (22 yards) by 10 chain)

1 ha = 2.471 acres

Mass

1 t (metric tonne) = 1,000 kg

1 imperial tonne = 1,016 kg

1 kg = 2.205 lb

1 lb = 0.454 kg

A bushel (bu) is traditionally a unit of volumetric measure defined as 8 gallons.

For grains, one bushel represents a dry mass equivalent of 8 gallons.

Wheat = 60 lb, Barley = 48 lb, Oats = 40 lb

1 bu (wheat) = 60 lb = 27.2 kg

1 bag = 3 bu = 81.6 kg (wheat)

Volume

1 L (litre) = 0.22 gallons

1 gallon = 4.55 L

1 L = 1,000 mL (millilitres)

Speed

1 km/hr = 0.62 miles/hr

10 km/hr = 6.2 miles/hr

15 km/hr = 9.3 miles/hr

10 km/hr = 167 metres/minute = 2.78 metres/second

Pressure

10 psi(pounds per sq inch) = 0.69 bar = 69 kPa (kiloPascals)

25 psi = 1.7 bar = 172 kPa

Yield

1 t/ha = 1000 kg/ha

Yield Approximations

Wheat 1 t = 12 bags	1 t/ha = 5 bags/acre	1 bag/acre = 0.2 t/ha
Barley 1 t = 15 bags	1 t/ha = 6.1 bags/acre	1 bag/acre = 0.16 t/ha
Oats 1 t = 18 bags	1 t/ha = 7.3 bags/acre	1 bag/acre = 0.135 t/ha

Section Editor:
Josh Telfer
SARDI

Section 1

Soils

Integrating Spatial Data and Soil Phosphorus tests for Improved Phosphorus Management within Paddocks

Buddhi Chaudhary[1,2,3] Sean Mason[4], Sam Trengove[5], Stuart Sherriff[5], Sarah Noack[5], Amanda Cook[1,2,3] and Rhiannon K Schilling[1,2,3]

[1]SARDI; [2]Adelaide University; [3]Flinders University; [4]Agronomy Solutions; [5]Trengove Consulting

Location
Mount Damper
Rainfall
Av. Annual: 330 mm
Av. GSR: 244 mm
2025 Total: 281 mm
2025 GSR: 228 mm
Paddock History
2024: Lentil
2025: Tomahawk CL wheat
Soil type
Calcareous grey sandy loam
Soil test
pH $CaCl_2$: 7.83-7.86, PBI: 39-133, % $CaCO_3$: 1.4 – 9.3%
Plot size
12 m x 2 m x 3 reps
Trial design
RCBD
Yield limiting factors
High pH calcareous soil

Key messages

- **pHnNDVI tool, combining soil pH mapping with NDVI, provides an effective guide for variable rate phosphorus (P) fertiliser application within paddocks. Soils with high pHnNDVI values require high P application rates compared with neutral soils to achieve optimal crop performance.**
- **High P application rates in high pH soils significantly improved crop vigour (NDVI) by enhancing P uptake compared to lower P application rates.**
- **Increased P rates can lead to higher grain yield; however, the economic viability of these yield gains must be evaluated through gross margin analysis to ensure that additional fertiliser costs are justified.**

Why do the trial?

Phosphorus (P) can be highly reactive leading to fixation by carbonate in alkaline soils. Variability in rainfall coupled with high fertiliser costs, particularly P, has resulted in often conservative fertiliser management. This approach risks an imbalance of reserved soil P and availability to plants if application rates are below replenishment levels. Consequently, P deficiency still causes yield losses in many environments and soil types across South Australia (SA). In contrast, there are many areas where crop response to applied P is minimal due to higher soil P availability and optimising gross margins can be achieved with little or no P fertiliser application (Trengove et al., 2021).

The use of pH mapping has become common practice to identify areas within a paddock of low pH to improve lime application efficiency.

While generating pH maps and comparing these with Normalised Difference Vegetation Index (NDVI) derived from satellite imagery, it has been observed on many occasions that high soil pH can correlate with low crop vigour and severe P deficiency (Trengove et al. 2021 & 2025) (Figure 1). This finding resulted in the development of the P sufficiency index. The P sufficiency index has been given the acronym pHnNDVI as it is the soil pH value divided by NDVI normalised to the paddock average using the formula below.

pHnNDVI = soil pH / (NDVI/paddock NDVI average).

Areas of a paddock with high soil pH (>7.5 water) and low relative normalised NDVI (<0.9) result in a high pHnNDVI value and are likely to be highly responsive to applied P (for example, site A and B in Table 1 and Figure 1). Areas with lower pH (<6.5) and high relative NDVI (>1.1) result in a low pHnNDVI value and are likely to be unresponsive to applied P. This data layer can then be used to generate P application maps for variable rate seeding operations. High pHnNDVI zones have been associated with calcareous soils with high relative Phosphorus Buffering Index (PBI) and low P availability (as measured by DGT P).

Most of the validation work has been performed in the mid-North and Yorke Peninsula regions, of SA and therefore warrants expansion in testing on the Eyre Peninsula, SA where calcareous soils are present and cause within paddock variability.

How it was done

A focus paddock was selected south of Minnipa on the western side of Mt. Damper Road with background soil pH data allowing for a paddock map of pHnNDVI to be produced (Figure 1). A new soil pH map of the paddock will be undertaken in 2026. From the variation in pHnNDVI, four locations were chosen (A, D, E and G) to place replicated P response trials in a Randomised Complete Block Design (RCBD) to assess variation of P requirements of wheat across the paddock. Pre-sowing soil P test results were in line with previous work where the highest pHnNDVI values were the lowest in soil P (site A) and lowest pHnNDVI having the highest soil P (site G) (Table 1).

Each response trial was sown with Tomahawk CL wheat on 22 May into a dry seed bed. Different P rates were set up at seeding through addition of MAP at 0, 7.5, 15, 22.5, 30, 50, 90 kg P/ha below the seed with each treatment balanced with nitrogen (N) through varying additions of urea.

Plant establishment was assessed and vigour (NDVI) at different plant growth stages were recorded. Phosphorus content in leaf tissue was analysed by sampling the Young fully Emerged Blades (YEB) at Z24-31. Crops were more advanced in low pHnNDVI sites as compared to the high pHnNDVI sites. The crop stage was also higher in the higher P rates within the trial.

The trials were harvested on 12 December 2025 after pre-harvest assessments.

What happened

Crop establishment

Crop emergence was very different between sites, being driven by soil type and very low rainfall post sowing. However, there were no significant differences in plant numbers between rates of P at any sites. A small rainfall event (4 mm) on 27 May was sufficient to germinate sites D, E and G but germination of site A did not occur until more significant rainfall on 6 June. The differences in emergence between sites was most evident in late June where sites D, E and G were at Z12-13, but site A was still emerging.

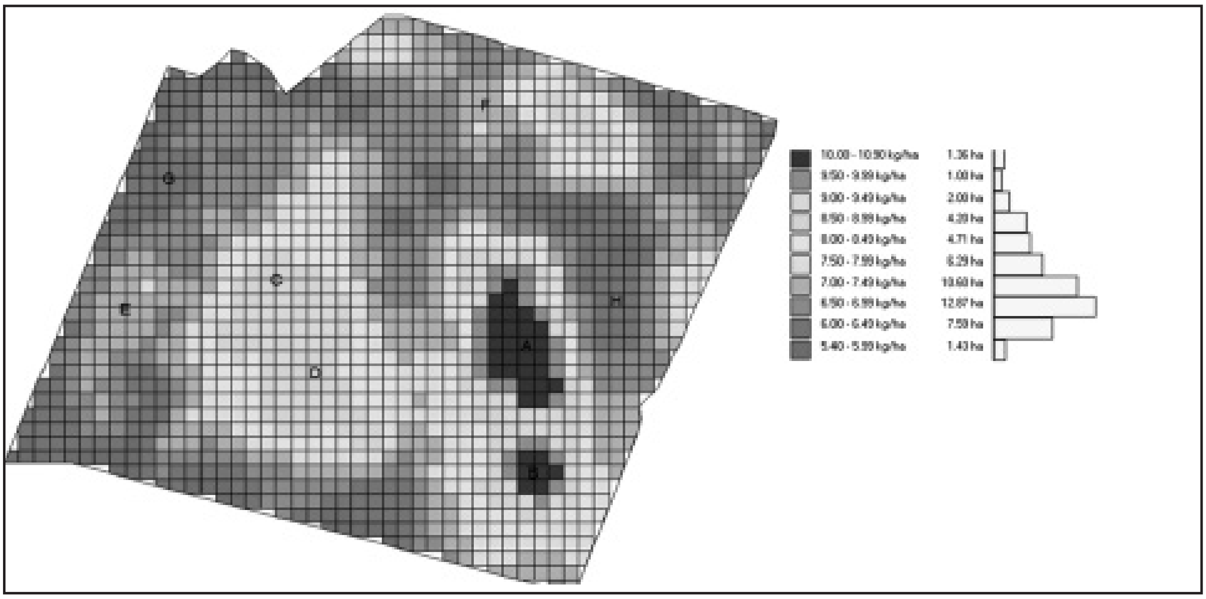


Figure 1. Variation in approximated pHnNDVI across a paddock south of Minnipa in 2025 and location of 4 P response trials.

Table 1. Basic site characteristics (0-10 cm) and P availability indices for each location of P response trial and expected P response.

Site	pH $CaCl_2$	Colwell P (mg/kg)	PBI	Colwell P/ PBI	DGT-P (mg/kg)	% $CaCO_3$	pHnNDVI	Predicted Response
A	7.83	51	133	0.38	27	9.3	10.5	High
D	7.85	40	101	0.40	56	5.3	9	Moderate
E	7.78	35	82	0.43	48	4.5	7.75	Moderate
G	7.86	22	39	0.57	101	1.4	6	Low

*Table 2. Mean NDVI measurements on 5 August for each applied P rate (kg/ha) across 4 sites (A, D, E and G). and calculated relative responses. **Linear response doesn't does not allow for calculation of NDVI maximum. Different letter indicates statistical significance at P = 0.05.*

P applied (kg/ha)	Site A	Site D	Site E	Site G
	NDVI (Z22-24)	NDVI (Z22-24)	NDVI (Z31)	NDVI (Z31-32)
0	0.18[ab]	0.25[a]	0.33[a]	0.57[a]
7.5	0.18[ab]	0.26[ab]	0.33[a]	0.61[ab]
15	0.19[ab]	0.28[ab]	0.41[ab]	0.65[ab]
22.5	0.23[abc]	0.33[abc]	0.43[b]	0.68[bc]
30	0.22[abc]	0.30[bc]	0.40[ab]	0.69[bc]
50	0.20[abc]	0.37[cd]	0.54[c]	0.75[c]
90	0.28[c]	0.41[d]	0.58[c]	0.76[c]
Relative NDVI (%)	62**	52	48	74
LSD (F prob = 0.05)	*0.02*	*0.04*	*0.06*	*0.06*

Crop vigour: NDVI and P concentrations in YEBs

Current in season growth assessments via NDVI have shown a pattern of relative responsiveness in line with soil P tests and the pHnNDVI prediction with careful consideration of different growth stages at each site (Table 2). The highest rate of P (90 kg P/ha) significantly increased crop vigour (NDVI) at all sites as did 50 kg P/ha, except site A, compared to zero P. The minimum rate of P to increase NDVI from the nil was 90 P, 30 P, 22.5 P and 22.5 P for trial sites A, D, E and G, respectively (Table 2).

P responses at site A up to 90 kg P/ha may be driven by the earlier growth stage because of later emergence of this site compared to other sites. Sites D and E with expected moderate responses have high P requirements (optimal P of 50 kg P/ha) and almost doubled the NDVI through additions of P. The least responsive site was still showing signs of response to applied P but with a lower relative NDVI and lower optimal P requirements compared to the higher responsive sites (Table 2). The NDVI of untreated at site G was equivalent to the highest NDVI recorded at all other sites in response at 90 kg P/ha (Table 2).

Plant P concentrations in the YEB were in line with predicted range of P deficiency and varying P requirements across this paddock with values increasing from the most deficient site A through to the least responsive site G. YEB P increased with increasing rate of applied P (Table 3).

Grain yield

Grain yield was significantly higher in 90 P as compared to 0 P at site A, D and E (Table 4). Furthermore, in site D all treatments yielded significantly higher than 0 P. However, there was no significant yield difference between 50 P and 90 P (Table 4). The non-responsive site G had no significant yield difference with applied P.

Partial gross margin analysis for fluctuating fertiliser and grain prices

In addition to soil factors determining P availability, site yield potential is an important factor influencing optimal P rates (Table 4). Sites with lower yield potential can have shallow yield response curves, making it difficult to cover additional P costs despite being responsive to P. A partial gross margin analysis below is based on the current fertiliser and wheat grain pricing (Table 5).

Table 3. Plant P concentrations of wheat YEBs across the four different sites at Minnipa in 2025 for selected P rates. Critical guidelines for YEB P are 0.35% at Z22-24 (Site A/D) and 0.3% at Z30-31 (Site E/G).

P applied (kg/ha)	YEB P (%)			
	Site A	Site D	Site E	Site G
0	0.25	0.26	0.28	0.30
7.5	0.26	0.29	0.27	0.28
22.5	0.30	0.30	0.29	0.32
50	0.30	0.34	0.32	0.36
90	0.36			

Soils

Table 4. Mean grain yield for different applied P rates across the 4 sites for wheat at Minnipa in 2025. Different letters indicate statistically difference between values at each site.

P applied (kg/ha)	Yield (t/ha)			
	Site A	Site D	Site E	Site G
0	2.20[a]	2.38[a]	3.55[a]	4.66
7.5	2.28[a]	2.66b	3.49[a]	4.80
15	2.35[a]	2.72[b]	3.66[a]	4.97
22.5	2.55[ab]	2.79[b]	3.79[ab]	4.95
30	2.51[ab]	2.80[b]	3.90[ab]	5.10
50	2.71[ab]	3.10[c]	3.91[ab]	5.15
90	3.00[b]	3.24[c]	4.28[b]	5.16
LSD (F prob = 0.05)	*0.30*	*0.14*	*0.30*	*ns*
Relative Yield (%)	63	72	70	90

Table 5. Partial gross margins estimated based on 2025 wheat and MAP price.

P rate (kg P/ha)	Partial Gross Margin ($/ha)			
	Site A	Site D	Site E	Site G
0	659	713	1064	1398
7.5	643	758	1007	1399
15	622	735	1016	1408
22.5	642	714	1014	1363
30	590	676	1006	1351
50	541	656	900	1271
90	406	482	791	1056
Wheat at $300/t	MAP at $1200/t			

As with the current price scenario, gross margins were generally highest at low or zero P inputs, although small increases in margin were observed at moderate P rates (e.g., 15 kg P/ha) in some sites (Table 5). In every trial, margins declined progressively at higher P rates (≥50 kg P/ha), indicating that under the prevailing price conditions, fertiliser costs outweighed any yield benefits from additional P input. However, several data layers are available to assist with identifying areas where P rates can be safely cut back and those that will still return a profit with increased grain yields through adequate P applications.

What does this mean?

Seasonal conditions have an impact on soil P dynamics, crop access to residual soil P reserves and reliance on fertiliser P inputs. This in turn is an important consideration for all decision support tools including soil P tests and newly developed indices (pHnNDVI).

The newly developed pHnNDVI tool for guiding variable rate P application may be suited to calcareous soils in low rainfall regions of the EP. Sites characterised by high pHnNDVI values showed strong responses to higher P fertiliser rates, as reflected by improved crop vigour (higher NDVI) and increased P concentrations in YEB leaf tissue. Differences between higher and lower P application rates, particularly in high pHnNDVI soils, were visually apparent and were also supported by statistical analysis.

Higher rates of P responses in terms of NDVI, YEB, and grain yield generally followed a linear progression. NDVI at the non responsive site (e.g., G) was comparatively higher than the responsive sites. Notably, at site G, the NDVI at 0 P was mostly higher than the NDVI at 90 P in other responsive sites (e.g., A and D). This clearly indicates utilisation of residual P resulting from early germination and crop establishment.

Higher rates of P application increase grain yield, particularly at responsive sites (those with high pH and low NDVI). At the Minnipa sites, the highest P rate (90 kg P/ha) produced the greatest grain yield, which was significantly higher than the nil. However, at the non responsive site (e.g., site G with low pH and high NDVI), there was no significant yield difference among the different P rates, despite this site producing the highest overall yield compared with other sites. Late sowing and late emergence place a greater reliance on fertiliser P inputs because root exploration of residual P pools is slow or limited (McLaughlin & McBeath, 2011; Heuer et al., 2017). These findings highlight the importance of precise application of costly fertiliser based on paddock pH mapping at variable rate strategies to optimise gross margins.

The gross margins analysis evaluated the profitability of each unit of P applied by comparing yield responses against current grain and fertiliser market prices. Partial Gross Margins (PGM) at higher P application rates are strongly influenced by the relative yield potential of each paddock. A declining PGM with increasing P rates, apart from occasional exceptions, such as the 15 kg P/ha treatment, indicates that the additional yield was insufficient to offset fertiliser costs under current price conditions. While there is some success in spatially predicting P responses, for most sites the yield gains do not recover the cost of P fertiliser at existing grain and fertiliser prices. Therefore, variable-rate P application informed by pHnNDVI is required to improve gross margins in paddock level.

References

Heuer, S., Gaxiola, R., Schilling, R., Herrera-Estrella, L., Lopez-Arredondo, D., Missuwa, M, Delhaize, E., and Rouched, H. (2017). Improving phosphorus use efficiency: a complex trait with emerging opportunities. The Plant Journal, 90: 868-885.

McLaughlin, M.J., McBeath, T.M., Smernik, R., Stacey, S., & Ajiboye, B. (2011). The chemical nature of P accumulation in agricultural soils – implications for fertiliser management and design: an Australian perspective. Plant Soil, 349:69-87.

Trengove, S., Sherriff, S., Bruce, J. & Mason, S. (2021). An informed approach to phosphorus management in 2022. Eyre Peninsula Farming Systems Summary 2021, pp 66-71.

Trengove, S., Sherriff, S., Nock, S., Bruce, J., Anderson, D. & Mason, S. (04 Feb. 2025). Integrating spatial data and long-term strategies for improved phosphorus fertiliser management. GRDC Update Papers, accessed 23 Jan. 2026, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2025/02/integrating-spatial-data-and-long-term-strategies-for-improved-phosphorus-fertiliser-management

Acknowledgement

We would like to thank Jerel Fromm for access to his paddock. This SA Discovery Farms project is funded from the Australian Government's Future Drought Fund through the Long-term Trials of Drought Resilient Farming Practices Grants. We would also like to acknowledge previous projects that have helped form the basis of this trial funded by SAGIT and GRDC.

Improving crop phosphorus supply on highly calcareous soils using novel sources

Nigel Wilhelm[1,2], Andong Shi[1,2] and Brian Dzoma[2]
[1]SARDI, [2]Adelaide University

Location
Port Kenny
Farmer: Simon Guerin
Rainfall
Av. Annual: 343 mm
Av. GSR: 270 mm
2025 Total: 294 mm
2025 GSR: 264 mm
Paddock History
2024: Volunteer pasture
Soil type
Grey highly calcareous sandy loam
Plot size
1.5 m x 20 m

Key messages

- **P nutrition was an important driver of wheat performance on a highly calcareous grey sandy soil at Pt Kenny in 2025.**
- **Highest yields were obtained with phosphoric acid as the P source.**
- **Carbon coated mineral performed well but it appeared that was due to the added phosphoric acid.**
- **Lacing biochars with phosphoric acid performed no better than applying phosphoric acid alone.**
- **Wheat grew poorly when supplied only with biochar.**

Why do the trial?

Phosphorus (P) has a vital role in ensuring crop vigour and grain yields, including tolerance to abiotic stressors like heat and drought. Highly calcareous soils present many challenges for crop production and P uptake is a major limitation. Current methods of supplying P in these soils are inefficient, but a lack of more effective P sources make it difficult to increase P levels in plant tissue and boost crop productivity.

A joint investment by the High Performance Soils CRC, GRDC and SA Discovery Farms is aiming to develop solutions for more efficient delivery and uptake of P by crops growing in highly calcareous soils. Alternative P sources are being examined to see if they can improve crop tolerance to P stress in dry years and increase productivity and profitability. An Innovator Site has been established on a highly calcareous soil at Pt Kenny. The trial will run for two seasons and will investigate the importance of the P component in a carbon coated mineral (CCM, which is a processed biochar, enriched with P). CCM will be compared to several other biochars to which phosphoric acid has been added, and also to other P sources including phosphoric acid and DAP. Crop biomass, NDVI, plant tissue P, grain yield and grain quality are being measured to assess crop responses. Soil testing will be conducted post-harvest to monitor the impact of these various P sources on soil reserves.

Rate response trials are also being run with CCM, in pot trials in the greenhouse using soil from the UEP trial site as well as at Pt Kenny to determine agronomic thresholds for CCM.

How was it done?

Two replicated field trials were established on a grey calcareous sandy loam (Colwell P in top 10 cm was 21 mg/kg and PBI, 229) at Port Kenny in 2025. Both trials were sown to Calibre wheat @ 60 kg/ha on 12 June 2025 into a moist seed bed. N was applied mid-season to both trials to ensure N deficiency was not a constraint to crop performance in any treatment.

Trial 1 (Carbon-coated mineral rate response) was set up with 8 CCM rates (2000, 1000, 750, 500, 350, 250, 100 kg/ha) and a granular DAP control at 38 kg/ha, to match P in 500 kg CCM/ha. This trial is investigating the impact of decreasing rates of CCM on crop growth on a very highly calcareous soil of the upper EP to identify an optimal rate of CCM for wheat performance. CCM is a granulated material which was banded below the seed. A maximum of 350 kg CCM/ha was banded in the seeding pass. For rates higher than 350 kg CCM/ha, passes were made prior to seeding to place the extra CCM at banding depth and below the future seed row. Trial design is a randomised complete block design (RCBD) with four replicates. DAP plots also received 30 kg urea/ha at seeding and all CCM plots received 50 kg urea/ha at seeding.

Trial 2 (Phosphorus sources) was set up with 9 treatments/sources of phosphorus which included pine-based biochar, almond-based biochar, CCM, triple super phosphate, DAP, and fluid P as phosphoric acid (summarised in Table 1). DAP and triple super were included as current practice options, CCM @ 500 kg/ha is the treatment frequently used in previous research, and pine and almond-based biochars were applied at the same rate as CCM. Pine-based biochar, which is very low in P, was also laced with phosphoric acid to supply the same total rate of P/ha as the other treatments (7.5 kg P/ha) and this was applied as a separate treatment. The P content of almond-based biochar was the same as CCM, so a phosphoric acid laced product was not required. In addition, there were 3 treatments, where only phosphoric acid was used at the same rate of kg P/ha as CCM, pine-based or almond-based biochar at 500 kg/ha.

The trials assessed the impact of CCM on crop P status and productivity against the other P sources. Trial design is a randomised complete block design (RCBD) with three replicates.

Table 1. P source treatments at Port Kenny, in 2025.

Treatment	Rate of P product (kg/ha)	Phosphoric acid added	Total rate of P applied (kg P/ha)
DAP	38	No	7.5
Triple super	38	No	7.5
Pine biochar	500	No	0.6
Almond biochar	500	No	7.5
CCM	500	No	7.5
Pine biochar+phos acid	500	Yes	7.5
Phos acid/pine	-	Yes	0.6
Phos acid/almond	-	Yes	7.5
Phos acid/CCM	-	Yes	7.5

What happened?

CCM response

Crop establishment was not affected by increasing rates of CCM and averaged 103 plants/m2. Early growth of wheat improved with high rates of CCM (Figure 1). The highest rate of CCM more than doubled shoot biomass compared to DAP. Plants at low CCM rates and with DAP, were pale, lacked vigour and had tillered poorly. CCM was a superior source of P than DAP because rates as low as 100 kg/ha of CCM resulted in wheat with similar biomass at Z32 to DAP at 38 kg/ha even though it supplied much less P per ha than DAP. CCM at 100 kg/ha delivers 1.5 kg P/ha compared to 7.5 kg P/ha with DAP at 38 kg/ha.

The benefit of increasing rates of CCM continued through to grain yield. Grain yields nearly doubled from the lowest to the highest rate of CCM (Figure 1). Low rates of CCM performed well compared to DAP, resulting in similar yields to DAP but with lower application rates of P/ha. Grain yields continued to increase at even the highest rates of CCM which suggests that P deficiency may not have been fully corrected, even at 2,000 kg CCM/ha.

Grain quality was not affected by increasing rates of CCM; protein averaged 10.1% for the trial, screenings 4.8% and grain size averaged 38 g per 1,000. Consistent grain proteins of 10% across all treatments suggest that N nutrition was not a major driver of crop performance.

P sources

Crop establishment was not affected by treatments and averaged 100 plants/m^2. Phosphoric acid applied at seeding improved crop growth early in the season, increasing shoot dry matter at second node stage by more than 50% compared to DAP or Triple super (Table 2). There was no benefit of delivering phosphoric acid in combination with a biochar (CCM, pine-based or almond-based biochar) in early wheat growth. This pattern continued to crop maturity. P delivered as phosphoric acid alone resulted in the highest wheat yields, approximately 400 kg/ha more than DAP or triple super, all of which supplied the same kg P/ha (Table 2). CCM @ 500 kg/ha also performed well, resulting in yields similar to phosphoric acid alone. Wheat yields with biochars alone were lower than with DAP or triple super. Treatments had little impact on grain quality with protein averaging 10.3% which suggests that N nutrition was not a major constraint to wheat performance (Table 2).

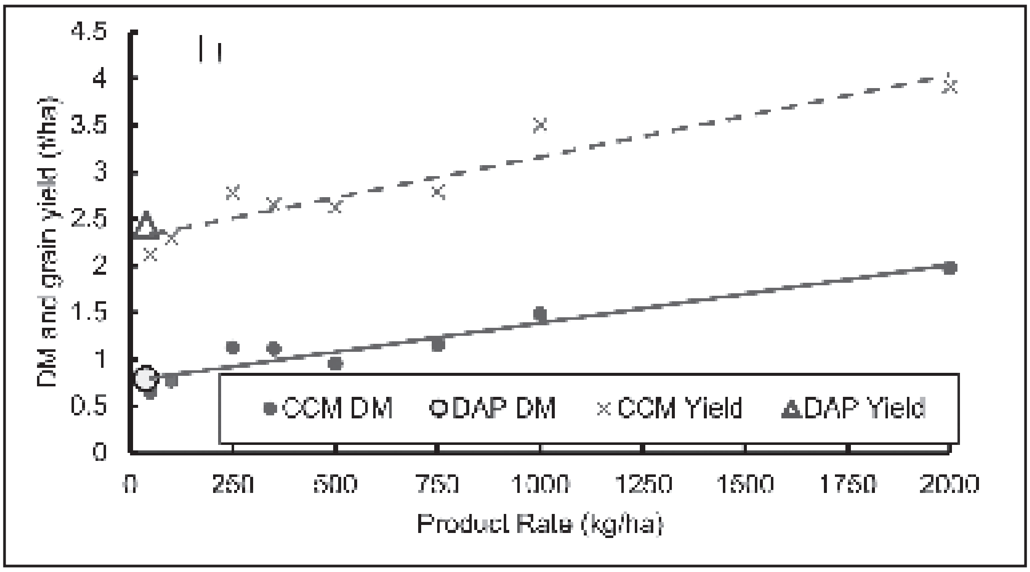


Figure 1. Effect of increasing rates of CCM on shoot growth at second node stage (DM) and grain yield of wheat at Pt Kenny, in 2025. Hollow symbols are wheat treated with DAP @ 38 kg/ha at seeding (same amount of P as applied with 500 kg/ha of CCM). The left-hand vertical bar is the treatment LSD (P=0.05) for shoot DM and the right-hand bar is for grain yield.

Table 2. Impact of P source treatments on growth and grain yield of wheat at Port Kenny, in 2025.

Treatment	Shoot DM at Z32 (kg/ha)	Grain yield (kg/ha)	Grain protein (%)
DAP	747	2154	10.1
Triple super	735	2206	10.4
Pine biochar	383	1918	10.8
Almond biochar	535	1951	10.3
CCM	1,033	2696	10.3
Pine biochar+phos acid	813	2420	10.3
Phos acid/pine	1,106	2703	10.3
Phos acid/almond	1,137	2634	10.1
Phos acid/ccm	1,132	2637	10.1
LSD (P=0.05)	*132*	*220*	*0.3*

What does this mean?

P nutrition was a major driver of wheat production because increasing the rate of CCM increased grain yields substantially. It was the phosphoric acid component of CCM which appeared to produce these production increases. High rates of phosphoric acid (@ 7.5 kg P/ha) also produced higher grain yields than DAP or triple super at the same rate of P/ha and phosphoric acid is well known as a better P fertiliser than DAP or triple super on this soil type.

While CCM was a better source of P than DAP, producing similar wheat yields to DAP at lower rates of applied P/ha, lacing two other biochars (pine-based and almond-based) with phosphoric acid had no impact on crop performance. At the same rate of P/ha, phosphoric acid alone and phosphoric acid added to biochar (and to CCM) produced the same yields.

The primary purpose of the CCM response trial was to investigate whether rates of CCM could be decreased from the rate we had frequently used in previous trials (500 kg/ha), and which had showed strong promise as an alternative source of P for crops on highly calcareous soils, but still maintain crop productivity. However, at Pt Kenny in 2025 with wheat, decreasing rates of CCM below the “standard” of 500 kg/ha resulted in progressively poorer crop production, which suggests that rates of CCM to boost crop production substantially on these difficult soils, will need to be high relative to the granular high analysis fertilisers currently used. For example, 213 kg CCM/ha was required to produce the same wheat crop as 38 kg/ha of DAP. This suggests that CCM would have to cost no more than $260/t if it were to replace DAP as a source of P at the same cost. And this ignores the cost and inconvenience of having to apply 6 times more material per ha.

Another valuable aspect of CCM as a novel P fertiliser is that it has shown residual benefits to the crop after the year of application in previous trials. These two trials will be re-sown in 2026 to assess residual benefits of all P sources. If CCM continues to show residual benefits, then the economics of its use could improve substantially.

Acknowledgements

The authors would like to acknowledge the significant contributions of growers through both trial cooperation and the support of the High Performance Soils CRC, GRDC and the Australian Government’s Future Drought Fund Long Term Trial Project for this project (Improving crop phosphorus supply on highly calcareous soils using novel sources, 4.2.007). The authors would also like to thank Simon Guerin for hosting the trials.

Setting up for success - reaching and sustaining yield potentials in ameliorated sands

Therese McBeath[1], Melissa Fraser[2], Kenton Porker[1], Michael Moodie[3], Sam Trengove[5], Zhaohan (Elijah) Luo[5], Brett Masters6, Chris Saunders[7] and Jack Desbiolles[7].

[1]CSIRO Agriculture and Food; [2]Soil Function Consulting; [3]Frontier Farming Systems; [4]Trengove Consulting; [5]SARDI; [6]EPAG Research; [7]Adelaide University.

Location
Warramboo
Farmer: Jake Sampson
Rainfall
Av. Annual: 309.5 mm
2025 Total: 306 mm
2025 GSR (Mar-Oct): 274 mm
Paddock history
2025: Calibre wheat
2024: Highland XT lentils
2023: Calibre wheat
Soil type
White siliceous sand over reddish-brown sandy loam
Plot size
15 m x 20 m
Trial design
Split-plot

Key messages

- **We have developed simple and plausible benchmarks for yield potential in ameliorated sands.**
- **Yield gaps in sandy soils can be closed through a combination of soil amelioration (deep tillage) and matching inputs to yield potential adjusted for early season conditions.**
- **Loosening (through deep ripping) that increases access to deep soil water during the critical period is the primary driver of improved yield and water-use efficiency.**
- **Nutrition responses were generally additive to the deep tillage response, with higher fertility inputs delivering consistent yield gains across a range of tillage treatments.**
- **Responses to amelioration are likely to be smaller or more variable at sites with limited stored soil water following dry fallows or where winter rainfall is insufficient to recharge deeper soil layers ahead of the critical period.**
- **Readily available management inputs and amelioration (tillage) treatments can achieve these new yield potentials. These concepts can be applied across regions and different types of sands.**

Why do the trial?

After a decade of deep tillage research in the sandy soils of the southern region, we have repeatedly demonstrated that high soil strength and water repellence are often constraining crop productivity and that management actions, such as deep ripping, that loosen the soil profile and mixing through spading and ploughing (diluting repellent layers) lead to substantial yield improvements. To ensure a successful outcome, growers and consultants need to diagnose all underlying soil constraints to be able to select the best method of deep tillage. A recent analysis of crop water use in ameliorated sands has shown that cereal crops are able to yield at upwardly revised water-limited yield frontiers (slope of 26 kg/ha/mm and evaporation term of 46 mm) (Porker et al. 2025) in low to medium rainfall environments compared with the previously reported benchmarks of 25 kg/ha/mm and 45 mm evaporation (Harries et al. 2022), and 22 kg/ha/mm and 60 mm evaporation (Sadras and Angus 2006) (Figure 1). Leaving sands unmodified resulted in water use less than 21 kg/ha/mm and evaporation of up to 40% of growing season rainfall (GSR). Recent work also indicated that several experiments examining the response to deep tillage have been nitrogen-limited, in part due to the underprediction of the new yield potential. In 2025, a series of experiments was established to understand how to best feed the new crop yield potential in ameliorated sands to realise the full benefits of soil amelioration.

How was it done?

A series of three field experiments was established in 2024 and a further four field experiments were established in 2025. This paper will focus on the first-year responses in the experiments established in 2025, where the treatments tested combinations of tillage type and nutrient inputs to match to the new frontier of water limited yield. The sites are based at Annuello, Bowmans, Bute and Warramboo where all experiments will run for a total of three years. Key details of the site soil constraints and crop type are shown in Table 1, while the fallow and growing season rainfall are shown in Figure 2.

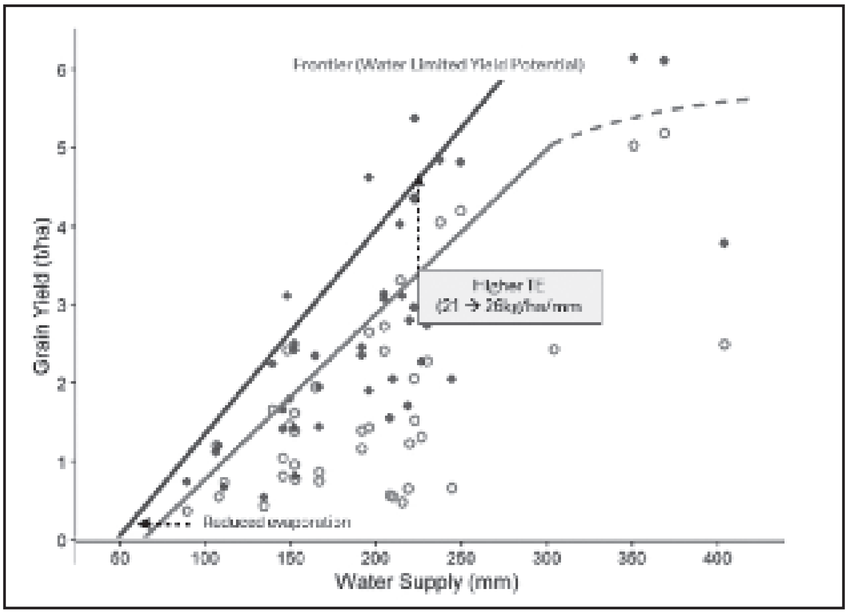


Figure 1. Shift in the sandy-soil yield–water supply frontier with amelioration. Points show observed grain yield across environments and treatments, with untreated/current practice (open red circles) and best deep tillage response (filled blue circles). Solid lines illustrate the relative water-limited yield frontiers: amelioration reduces teh non-productive evaporation (60 mm → 45 mm intercept in the x-axis) and increases the transpiration efficiency (from solid red line with 21 kg/ha/mm → solid blue line with 26 kg/ha/mm slope). Dashed segments indicate a conceptual upper limit at higher water supply. Data are from Ouzman et al. (2024) where water supply was calculated as 0.25 × summer rain + growing-season rain.

Table 1. Site characteristics for the 2025 growing season.

Site, region, state	Key soil constraints	Crop type and cultivar
Annuello, Victorian Mallee, VIC	Low fertility, high soil strength, marginal acidity	Barley (Titan AX[A])
Bowmans, Adelaide Plains, SA	High soil strength, moderate repellence.	Barley (Commodus[A])
Bute, Upper Yorke Peninsula, SA	Low fertility, high soil strength, moderate repellence.	Barley (Maximus[A])
Warramboo, Upper Eyre Peninsula, SA	Low fertility, high soil strength, moderate repellence.	Wheat (Tomahawk CL Plus[A])

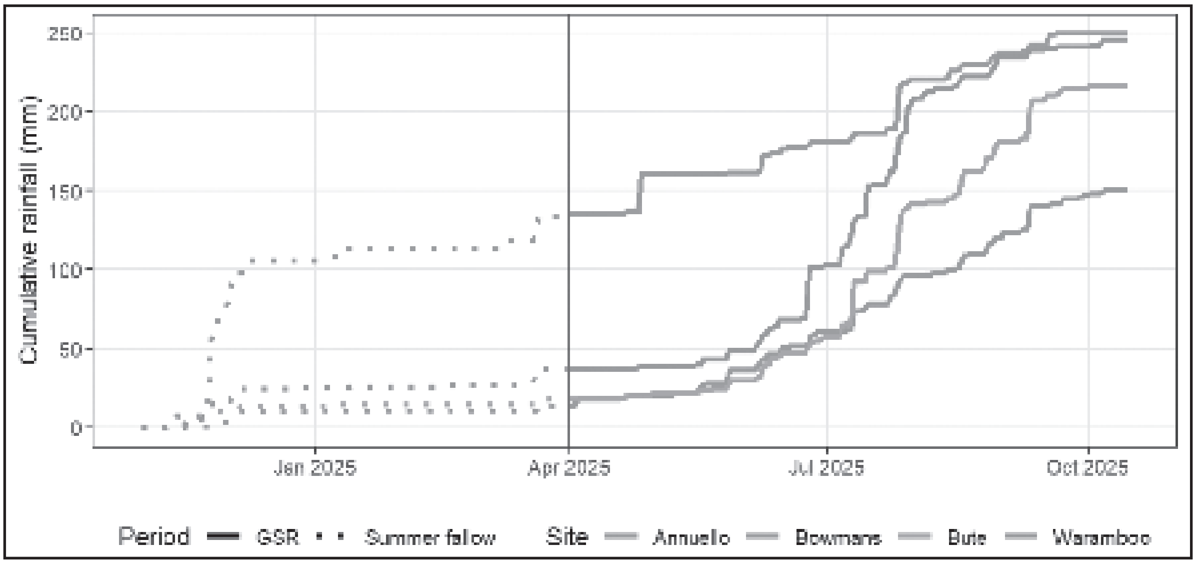


Figure 2. Cumulative rainfall across the 2025–26 season showing summer fallow (dotted) and growing-season rainfall (solid) for Annuello, Bowmans, Bute and Warramboo. The vertical line indicates 1 April, separating summer rainfall contributing to starting soil water from in-season rainfall driving crop water supply.

To ameliorate soil constraints to a level sufficient to establish a new yield potential, three tillage treatments were implemented, in addition to a no-tillage control. The baseline deep tillage treatment consisted of maximised deep ripping with minimal surface disturbance. This was achieved using Agrowplow® No. 9 shanks fitted with Agrowplow winged tips to ensure effective soil loosening. Ripping was performed to a depth of 550 mm using three tynes spaced at 600 mm, allowing the full plot width to be loosened. The second deep tillage treatment involved the addition of high-capacity inclusion plates. These were fitted to the same Agrowplow tynes, operating at the same depth and spacing and retaining the winged tips. The inclusion plates were 150 mm wide and 390 mm high, with the top edge set at a nominal depth of 100 mm below the original soil surface. The plates extended 600 mm behind the ripper tyne, to allow high volumes of inclusion. As high-capacity inclusion ripping displaced substantial surface soil and created large furrows behind each tyne, a pair of small concave discs were mounted at the rear of the ripper frame to backfill the furrows and level the plots. The final tillage treatment comprised deep ripping followed by spading. The ripping operation was identical to that used in the baseline treatment and was followed by a 2.1 m wide Farmax spader operating at an approximate depth of 350 mm. To assist post-amelioration management, both the ripping-only and inclusion treatments were followed by a rolling pass using an open-bar cage roller with an additional 600 kg of ballast to aid consolidation and seedbed preparation. All tillage operations were conducted at 5 km/h, with rolling carried out at 3 km/h.

Starting water supply was estimated as 30% of November–April summer fallow rainfall, providing a consistent and robust estimate of plant-available water at sowing across sites. The baseline yield potential was then calculated using results from the 'Sandy Soils 1' investment (CSP1606-008RMX-CSP00203 - *Increasing production on sandy soils in low and medium rainfall areas of the South*), assuming a transpiration efficiency of 20 kg/ha/mm. Evaporation was not treated as a fixed value but instead adjusted to 40% of GSR, reflecting site-specific seasonal conditions. The 'New frontier' treatment targeted 80% of yield potential (Figure 1). This target was based on an increased transpiration efficiency of 26 kg/ha/mm and an evaporation term defined as a proportion of in-season rainfall, rather than a fixed loss. Under typical conditions of ~200 mm GSR, this approach equated to approximately 45 mm of evaporation at most sites. The 'High' treatment targeted 100% of yield potential, using the same transpiration efficiency and evaporation assumptions as the 'New frontier' treatment. High-input treatments were designed to maintain an additional 40 kg N/ha in the system as a fertility buffer (for example, 4.1 t/ha × 40 kg N/t = 164 kg N/ha demand, plus a 40 kg N/ha buffer).

Nitrogen and phosphorus inputs were altered to meet the demand of the three yield targets – a contrast of synthetic and organic (chicken manure) nutrient forms was included in the 'High' yield treatment. Sulphur was added to balance the baseline and frontier plots, and higher rates were added to balance between the 'High synthetic' and 'High Organic' treatments. Potassium was applied to all synthetic treatments with a basal application of 14–18 kg K/ha per site, noting the organic treatment is inherently high in K. Trace elements were applied to all plots in season.

Across sites in 2025, yield targets ranged from 2.0t /ha to 5.8 t/ha, reflecting differences in yield potential derived from treatment-based decision rules and local climate conditions assessed at sowing (for P) through to late tillering (for N top-dressing). Yield targets, and the associated input requirements, were revised in-season in response to seasonal conditions assessed in early June and again in early July. An example of how nutrient inputs were adjusted according to yield targets at Annuello is shown in Table 2.

Table 2. Example of nutrient inputs for the site based at Annuello, in 2025.

Nutrition	Yield target	Nitrogen supply (kg/ha) (min. N plus fertiliser N)	Phosphorus input (kg/ha)
Baseline	2.0	104	9
New frontier	3.3	128	18
High synthetic	4.1	225	62
High organic (as chicken manure)	4.1	204*	63

**assumed 50% of N applied available in the year chicken manure was applied.*

What happened?

In line with previous experience, the responses to deep tillage were significant (P<0.001) and substantial (Figure 3) at all sites and tillage doubled and tripled yield compared to the no tillage control at our most responsive sites. The addition of high-capacity inclusion plates achieved similar or greater yield response above ripping alone at all sites, most notably at Bute and Warramboo, particularly when extra nutrition was supplied (Figure 3). The 2024–25 fallow was one of the driest on record which delayed the establishment of crops in no tillage control plots and changed water dynamics. At Bute, this was exacerbated by the deposition of eroded sand onto the standing residue in the control plots. Access to water below 40 cm was a key driver of yield responses in 2025 (data not shown). Early root growth and vigour remain important for reducing evaporation, but their relationship with yield is variable and seasonally dependent. Poor early growth did not necessarily result in poor yield, provided crops were able to access water and nutrients during the critical period. For example, at Bowmans, inclusion treatments improved rainfall infiltration and early water use, however a lack of water at depth for the critical period meant a flat response to tillage, and signs of haying off (high pre-anthesis biomass, low harvest index, small grain and high protein).

The response to nutrient inputs varied across sites. At Warramboo and Annuello, the yield response to nutrition was additive to, rather than interactive with, the response to deep tillage (Figure 3). Bute was an exception, showing a significant ripping × nutrition interaction (P<0.01). In this environment, the no-tillage treatment showed little or no response to additional nutrients, whereas strong nutrient responses occurred only where deep tillage was applied. This indicates a co-limitation by soil physical constraint and fertility, with nutrients unable to be converted into yield without prior constraint alleviation. Such responses were rare across the 'Sandy Soils 1' project dataset and highlight a dual limitation of water capture and nutrient access that warrants further investigation. There was no response to the nutrient additions at Bowmans, which was both the lowest rainfall site and a sand that had adequate levels of nutrition in the soil testing. There were symptoms of 'haying off' where substantial early biomass responses (pre-flowering) translated into similar or lower yield (in some scenarios), from low harvest index, small grain and high protein.

At three of the four sites, there were increased yields with increasing level of nutrient input, but the difference between the moderate ('New frontier') and high ('High synthetic' and 'High organic') was not substantial/economic and should be evaluated after a 2–3 year crop cycle to test our hypothesis that increased fertility will maintain yield potential and the amelioration benefit over time.

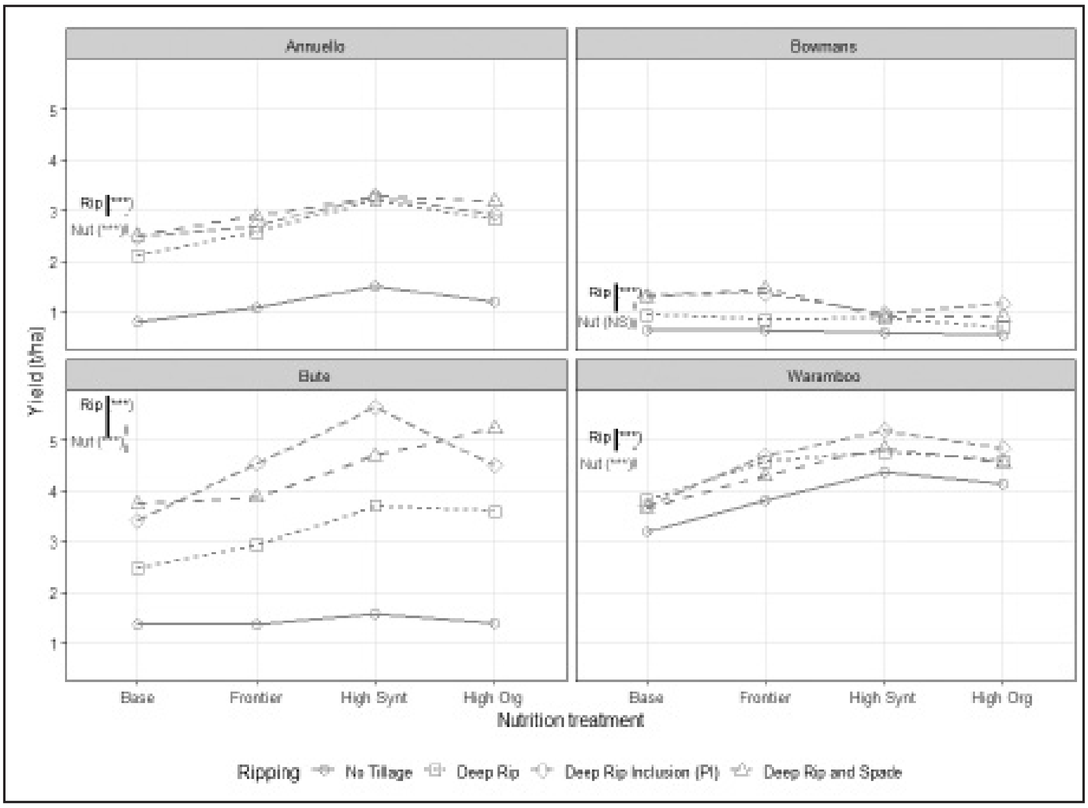


Figure 3. First year grain yield responses to tillage and nutrition treatments at sites established in the 2025 growing season. Vertical bars represent least significant difference (LSD) and significance of ripping and nutrient factors, with a non-significant interaction. Bute had a significant tillage x nutrition interaction (P<0.01, LSD 0.8 t/ha).

What does it mean?

Soil loosening that enabled greater access to deep water during the critical period (August) was the dominant driver of yield response in 2025. Sites that had inadequate stored water from a long, dry fallow and/or a lack of winter rainfall showed a reduced magnitude of response to both tillage and nutrition. Nutrition responses were generally additive, with relatively uniform yield responses across soil treatments.

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 (GRDC project code: CSP2403-017RTX), the authors would like to thank them for their continued support. We thank the technical teams who deliver the experimentation for our projects. GRDC project CSP2403-017RTX is a collaboration between CSIRO, Adelaide University, Frontier Farming Systems, EPAG Research, Trengove Consulting, Soil Function Consulting, South Australian Research and Development Institute and University of Sydney.

References

Harries M, Flower KC, Renton M, Anderson GC (2022) Water use efficiency in Western Australian cropping systems. Crop and Pasture Science **73**, 1097-1117.

Ouzman J, McBeath T, Fraser M, Desbiolles J, Azeem M, Llewellyn R, Moodie M, Saunders C, Wilhelm N, Whitworth R (2024) Yield responses to amelioration treatments that improve the productivity of sandy soils in the Southern Australian Cropping Region. CSIRO Data Access Portal (https://data.csiro.au/collection/csiro:57681)

Porker K, McBeath T, Manson J, Masters B, Ware A, Giles J, Sadras V, Cossani M, Moodie M, Wooding K (2025) Achieving water-limited yield frontiers more profitably. GRDC Updates, Adelaide.

Sadras VO, Angus JF (2006) Benchmarking water-use efficiency of rainfed wheat in dry environments. Australian Journal of Agricultural Research **57(8)**, 847-856.

Optimising nutrient management packages on sand ameliorated with different deep tillage strategies

Zhaohan Luo[1,2], Therese McBeath[3], Amanda Cook[1,2,4] and Kym Zeppel[1]
[1]SARDI; [2]Adelaide University; [3]CSIRO [4]Flinders University

Location
Mount Damper
Farmer: Kev Brands
Rainfall
Av. Annual: 325 mm
2025 Total: 293 mm
2025 GSR (Apr-Oct): 246 mm
Paddock History
2025: Razor CL Plus wheat
2024: Calibre wheat
2023: Medic pasture
Soil type
White siliceous sand over reddish-brown sandy loam
Plot size
1.5 m x 10 m x 3 reps x 3 blocks
Trial design
Multi-environment

Key messages

- **Deep tillage was able to increase the yield potential, but extra nutrition was required to maximise the productivity.**
- **Extra nutrition did not increase grain yield in unameliorated soils at the Mount Damper site in 2025.**
- **Wetter application alone did not have a positive impact on grain yields in 2025 at the Mount Damper site.**
- **More data will be gathered in future seasons for a comprehensive understanding of the nutrition package required in different deep tillage treatments, as the site was only established in 2025.**

Why do the trial?

Production constraints on sandy soils can be overcome with strategic deep tillage and the application of soil amendments. However, yield responses from amelioration tend to decrease with time likely due to deficiencies in nitrogen (N), phosphorus (P), other nutrients and possibly recompaction. This indicates that ameliorated soils require a sustained supply of nutrition to maintain the high productivity resulting from soil amelioration. The aim of the work reported here is to update crop management guidelines for post-amelioration management. This will help growers maximise returns on their soil amelioration investment over the years by identifying the right source, placement, and rate of nutrient inputs to extend the benefits of amelioration. This work is part of a 4-year program in the Mt Damper district that has been supported through previous and current GRDC funded sandy soils research.

Year 2025 was the second season of this project. For details of the first season results, see the article in the EPFS Summary 2024, p. 28.

How was it done?

The 2025 trial was set up on top of a sand hill. The A horizon is a bleached silicious sand from 0-10 cm, which is severely to mildly repellent. The B horizon is a reddish-brown sandy loam from 20-40 cm. The C horizon ranges from reddish-brown to brown sandy loam to clay loam from 40-100 cm with high soil strength. The trial area consisted of 3 blocks with a different tillage treatment on each. The first block did not receive any tillage (No tillage), the second block was in an area which had been ameliorated with a plozza plough to 40 cm at the end of 2023, along with the rest of the paddock. The third block was delved to 80 cm (in dry conditions) in 2025 in addition to the previous plozza-ploughing. The delving operation was done with a 3-tine delver with 1 m spacing, delved at 45 degrees angle to the shank (Figure 1) at 7 km/hr on 29 April 2025. After the delving was finished, the block was rolled, followed by a mixing tillage to approximately 10 cm with offset discs, then rolled again.

There was approximately 66 kg/ha of nitrate N in the top 60 cm of soil and 13 kg/ha of Colwell P in the top 10 cm, which was sufficient to support 1.64 t/ha of wheat, assuming wheat requires 40 kg/N/t grain. Within each amelioration block, 10 nutrition treatments were implemented during and post-seeding aiming to achieve target yields ranging from 2 (district practice) to 4 t/ha based on inputs adjusted for pre-sowing soil N. The amount of P input (Table 2) at seeding was calculated based on an estimated P requirement of 7 kg/ha per tonne of wheat (GROWNOTES, GRDC, 2016).

Figure 1. Delver used to implement tillage treatment on the Plozza + Delving block.

Table 2. Nutrition treatments implemented within each tillage treatment block.

Nutrition	Nutrition Description (Yield Target)	Total nutrition Requirement	Nutrition Application at seeding	Nutrition Application post-seeding
1	Nil control	None	None	None
2	Nil control + wetter	None	Wetter (SE14 at 3L/ha in-furrow)	None
3	District practice (2 t/ha)	14 kg/ha P + 22 kg/ha N	50 kg/ha MAP + 33 kg/ ha urea with seed + 15 kg/ha MAP below seed	None
4	Extra N + P (3 t/ha)	22 kg/ha P + 65 kg/ha N	50 kg/ha MAP + 33 kg/ ha urea with seed + 50 kg/ha MAP below seed	50 kg/ha (4 July) + 37 kg/ ha urea (21 July)
5	Extra N + P (3 t/ ha) + S	22 kg/ha P + 65 kg/ha N + S (SOA – 70% urea + 30% SOA blend)	50 kg/ha MAP + 33 kg/ ha urea banded + 50 kg/ ha MAP banded 3 cm	50 kg/ha urea (4 July) + 45 kg/ha SOA (21 July)
6	Extra N + P (3 t/ha) + S + TE	22 kg/ha P + 65 kg/ha N + S (SOA – 70% urea + 30% SOA blend) + ZMC	50 kg/ha MAP + 33 kg/ ha urea with seed + 50 kg/ha MAP below seed	50 kg/ha urea (4 July) + 45 kg/ha SOA (21 July) + 800 g/ha ZMC (6 August)
7	Extra N + P (4 t/ha)	29 kg/ha P + 111 kg/ha N	50 kg/ha MAP + 33 kg/ ha urea with seed + 80 kg/ha MAP below seed	50 kg/ha urea (4 July) + 50 kg/ha urea (21 July) + 80 kg/ha urea (21 August)
8	Extra N + P (4 t/ ha) + S	29 kg/ha P + 111 kg/ha N + S (SOA – 70% urea + 30% SOA blend)	50 kg/ha MAP + 33 kg/ ha urea with seed + 80 kg/ha MAP below seed	50 kg/ha urea (4 July) + 60 kg/ha SOA (21 July) + 80 kg/ha urea (21 August)
9	Extra N + P (4 t/ha) + S + TE	29 kg/ha P + 111 kg/ha N + S (SOA – 70% urea + 30% SOA blend) + ZMC	50 kg/ha MAP + 33 kg/ ha urea with seed + 80 kg/ha MAP below seed	50 kg/ha urea (4 July) + 60 kg/ha SOA (21 July) + 800 g/ha ZMC (6 August) + 80 kg/ha urea (21 August)
10	Extra N + P (4 t/ha) + S + TE + Wetter	29 kg/ha P + 111 kg/ha N + S (SOA) + ZMC +Wetter	Wetter sprayed at seeding + 50 kg/ha MAP + 33 kg/ha urea with seed + 80 kg/ha MAP below seed	50 kg/ha urea (4 July) + 60 kg/ha SOA (21 July) + 800 g/ha ZMC (6 August) + 80 kg/ha urea (21 August)

The trial was sown on 4 June 2025, with 80 kg/ha Tomahawk CL® sown at 1 cm deep. Wetter was banded with seeds. To avoid fertiliser toxicity, no more than 33 kg/ha of urea and 50 kg/ha of MAP was banded with the seed. The rest of any fertiliser was banded 3 cm below the seed. The rest of the N required to achieve the yield target was top-dressed as urea or SOA during the season. The trace element solution (ZMC) was foliar sprayed just prior to first node (Z31).

Baseline soil sampling was done on 23 April. Plant establishment counts were conducted on 10 July. NDVI measurements were taken on 10 July, 22 August and 22 October. Penetrometer readings into wet soil profiles were taken on 6 August within each block (readings were taken both on the delve line and off the delve line on the delved block). Z31 biomass cuts were done on 19 August. The trial was harvested on 11 December.

What happened?

Soil Strength

Soil strength measurements which were taken in wet soil profiles (Figure 2) demonstrated that soil strength at 30 cm with no strategic tillage was approx. 2250 kPa which is close to but not exceeding the threshold for limiting root growth. Both delving and plozza-ploughing had reduced soil strength at the same depth down to approx. 1100 kPa and 2000 kPa, respectively. Overall soil strength in the delved block remained relatively low across the soil profile down to 70 cm, whereas soil strength of the plozza-plough block gradually increased and levelled with the un-ameliorated block past the depth of 30 cm.

Crop Establishment

Due to a dry summer in 2024/25, there was very little moisture in the topsoil. In addition, a very strong wind event on 23 June filled in crop rows with sand and caused significant damage to the seedlings. As a result, crop establishment in all three tillage treatment blocks was below the target of 198 plants/m^2. The No Tillage treatment block had a plant establishment of 77 plants/m^2, the Plozza-ploughed block had 94 plants/m2 and the Plozza + delving block had a plant establishment of 83 plants/m^2.

NDVI

The Minnipa region experienced above average July and August rainfall. On 10 July, nutrition treatment 3 t/ha + S had a significantly higher NDVI value than the two Nil Control treatments within the No Tillage block. There was no significant difference between nutrition treatments for the Plozza and Plozza + Delving block. Overall, the No Tillage block appeared to have had better early vigour than the ameliorated blocks. As the crops developed into tillering, the difference in nutrition treatments became more prominent in the No Tillage and Plozza + delving block, where nutrition treatments with higher yield target and nutrient inputs had higher NDVI values than the nil control + wetter. The overall advantage in early vigour measured in the control block have diminished at tillering. This trend remained in the No Tillage block to the end of flowering, whereas the differences between nutrition treatments were not significant for the other tillage blocks. Even though the No Tillage block seemed to have had an overall higher NDVI value towards the end of the season, this data is confounded by the number of weeds present in the block because spraying was delayed to allow wheat seedlings that had been sown in the buffer areas of the trial to provide as much cover as possible.

Biomass

At Z31 (Table 3), in contrast to the NDVI values, different nutrition treatments were similar in shoot biomass in the No Tillage block. A response was only seen in the highest nutrition input, Treatment 9 (4 t/ha + S + TE), in the plozza plough block. However, plant biomass increased significantly with extra nutrition targeting yield higher than 2 t/ha in the plozza + delving block. Where the difference in biomass is significant, the nil control with the addition of wetter underperformed in comparison to crops that received extra nutrition. On average, the block that was plozza-ploughed alone had an average biomass of 1801 kg/ha, and the plozza + delving block had an average biomass of 1650 kg/ha, which is 500 kg/ha or 349 kg/ha benefit from tillage treatments.

Yield & Protein

Average yield for the No Tillage block was 1.9 t/ha, while the plozza and plozza plus delved blocks both achieved an average yield of approximately 3 t/ha, demonstrating the higher yield potential and quality for blocks that had received strategic deep tillage.

The yields from the No Tillage block were not responsive to the addition of extra nutrition, although the yield quality was significantly increased (Figure 3). The Plozza Block (Figure 4) and Plozza + Delving Block (Figure 5), however, had around 1 t/ha increase in yields with nutrition input targeting 4 t/ha in comparison to district practice and nil nutrition input. Wetter addition did not change yield or quality.

Overall, there was approximately 1 t/ha of yield reward for soil amelioration alone. When nutrition package is introduced after amelioration, the yield increase can range from 1 - 2 t/ha based on yield targets, in comparison to the nil control without any strategic deep tillage.

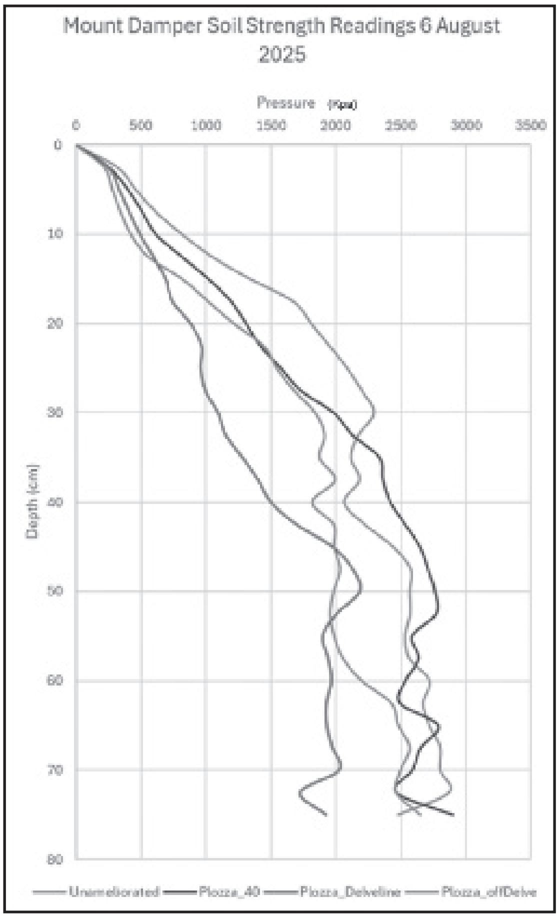


Figure 2. penetrometer readings taken on the No tillage block, Plozza block and Plozza + Delving block (both on and off the delving lines) on 6 August 2025 at Mt Damper.

Table 3. Average NDVI values for each nutrition treatment within each tillage treatment block on 10 July (Z13), 22 August (Z30) and 22 October (Z75), and Z30 biomass (kg/ha) of wheat in each nutrition treatment within each tillage treatment block on 19 August. Within a tillage treatment, a different letter represents a difference in biomass. Within a tillage treatment, a different letter represents a difference in NDVI.

Treatment	10 July			22 August						22 October		
	No Tillage	Plozza	Plozza + Delv	No Tillage		Plozza		Plozza + Delv		No Tillage	Plozza	Plozza + Delv
				NDVI	Biomass (kg/ha)	NDVI	Biomass (kg/ha)	NDVI	Biomass (kg/ha)			
Nil control	0.25 b	0.20	0.15	0.35 ab	1117	0.35	1446 b	0.35 abc	1421 bcd	0.23 ab	0.18	0.18
Nil control + wetter	0.25 b	0.21	0.14	0.26 b	1035	0.34	1502 b	0.26 c	1178 d	0.22 b	0.16	0.16
District practice (2 t/ha)	0.28 ab	0.20	0.14	0.39 ab	1197	0.36	1465 b	0.29 bc	1253 cd	0.22 b	0.17	0.16
Extra N + P (3 t/ha)	0.29 ab	0.20	0.15	0.43 ab	1441	0.46	1929 ab	0.45 ab	1889 a	0.24 ab	0.18	0.22
Extra N + P (3 t/ha) + S	0.32 a	0.20	0.15	0.46 a	1553	0.42	1782 b	0.49 a	1600 abc	0.25 ab	0.19	0.19
Extra N + P (3 t/ha) + S + TE	0.29 ab	0.22	0.14	0.46 a	1409	0.49	2024 ab	0.4 abc	1964 a	0.24 ab	0.19	0.21
Extra N + P (4 t/ha)	0.29 ab	0.21	0.16	0.46 a	1319	0.38	1602 b	0.48 a	1780 ab	0.27 a	0.22	0.21
Extra N + P (4 t/ha) + S	N/A	0.21	0.17	N/A	missing	0.50	1812 b	0.47 ab	1888 a	N/A	0.21	0.20
Extra N + P (4 t/ha) + S + TE	0.27 ab	0.23	0.14	0.46 a	1297	0.48	2426 a	0.42 abc	1655 ab	0.25 ab	0.20	0.21
Extra N + P (4 t/ha) + S + TE + Wetter	0.27 ab	0.21	0.16	0.41 ab	1344	0.52	2024 ab	0.44 abc	1876 b	0.26 ab	0.22	0.22
LSD (F Prob = 0.05)	*0.03*	*ns*	*ns*	*0.1*	*ns*	*ns*	*582*	*0.11*	*389*	*0.03*	*ns*	*ns*
Average	0.28	0.21	0.15	0.41	**1301**	0.43	1801	0.4	**1650**	0.24	0.19	0.2

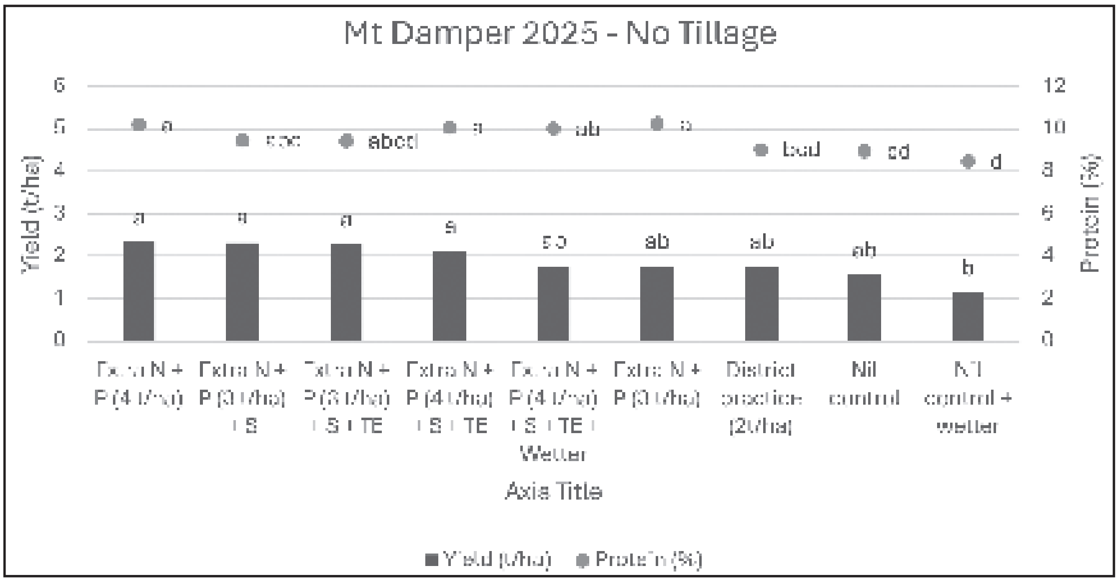


Figure 3. The average grain yield (t/ha) and protein content (%) of the No Tillage Block in Mount Damper in season 2025; The Nil Tillage block did not have Nutrition Treatment 8.

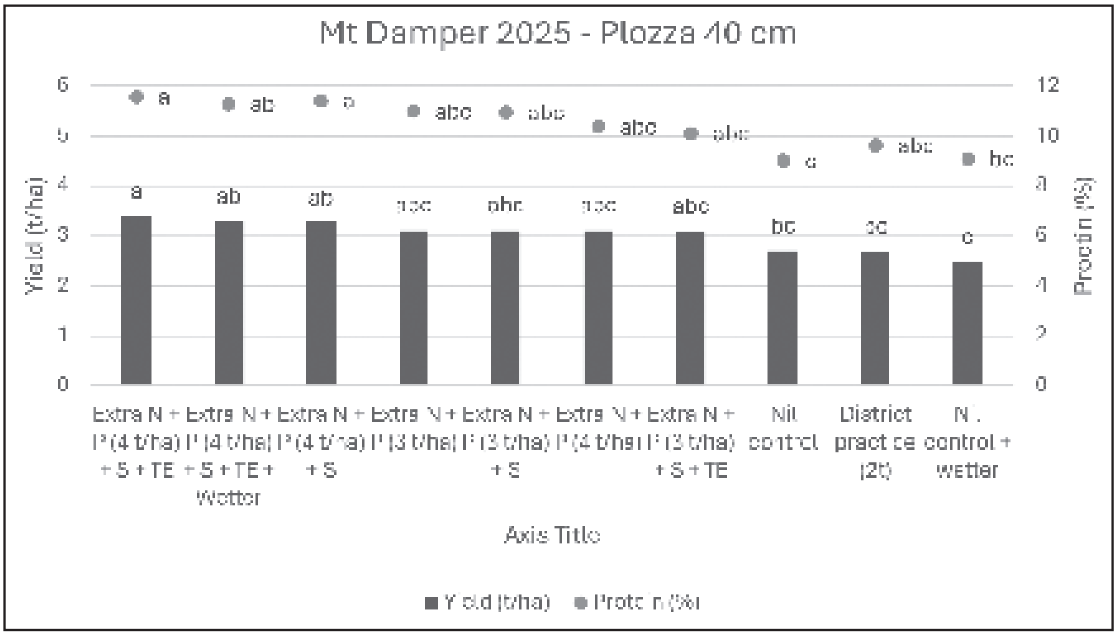


Figure 4. The average grain yield (t/ha) and protein content (%) of Plozza plough at 40cm Block in Mount Damper in season 2025.

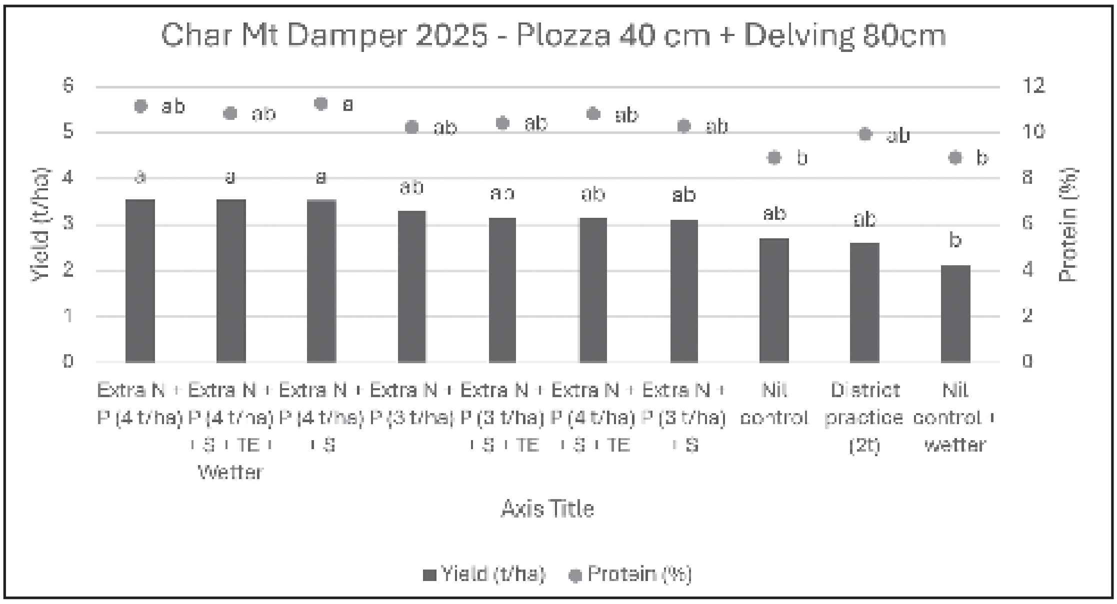


Figure 5. The average grain yield (t/ha) and protein content (%) of Plozza plough at 40 cm + Delving at 80 cm Block in Mount Damper in season 2025.

What does this mean

It was found that while deep tillage increased the yield potential, extra nutrition was needed to maximise the productivity of the Mount Damper site in a season like 2025. This difference in yield in comparison to the Nil block can be partly explained by reduced soil strength in the top 30 cm of soil from plozza ploughing, as plant roots can more easily penetrate through the soil to access water and nutrition (Figure 2). Meanwhile for the plozza plus delving block, some clay has been brought to the surface and nutrients are likely to have been redistributed. The reason why addition of wetter at seeding did not improve crop establishment was unclear.

Dry sowing conditions and an early wind event in 2025 reduced crop establishment. Nutrition packages did not result in any differences in plant establishment at the time of measurement. Even though the site experienced above average July and August rainfall, the NDVI response from nutrition treatments did not show a consistent improvement in either ameliorated block. Early in the season, NDVI readings showed that the delved block had weaker crop vigour than the No Tillage block. This could be partially due to the wind damage the site received earlier in the season as the site was freshly delved and more topsoil might have been lost.

In 2024, there was no significant difference between yields from various in-season nutrition input strategies due to low in-season rainfall (EPFS Summary 2024, p. 28). Nevertheless, at the end of the season in 2025, Figure 3 demonstrated when there was no deep tillage, there was little yield response when nutrition packages were introduced. For ameliorated blocks, there was a 1 t/ha yield increase when the yield target was 4 t/ha, in comparison with district practice. However, when compared with district practice in the No Tillage block, the combination of deep tillage + extra nutrition input resulted in large yield responses that ranged from 1 - 2 t/ha, and an improvement in quality from 8.5% to almost 12% of protein.

Nonetheless, the result from this year needs taking into consideration that it is the first year the interactions between post-amelioration nutrition input and various tillage strategies was investigated in the project in this region, and the soil was recently ameliorated. More data will be gathered in the coming seasons to provide a more comprehensive understanding of the effect of in-season nutrition after amelioration.

Acknowledgement

These trial sites were made possible through CSIRO's leadership to gain support from Grains Research & Development Corporation (GRDC) to improve and maintain sandy soil production across the southern region. The authors would also like to thank the collaborating landholders involved in this project, without whom this project would not be possible. The author would also like to thank MAC Staff Ian Richter (retired), Kym Zeppel, Marina Mudge, Tammie Mullen, Julian Post, Katrina Brands, Rebbecca Tomney for helping throughout the project for its successful delivery. The author would also like to thank Leigh Davies from Nutrien Ag Solutions for provide insights and ideas for this project and helping with rolling, as well as local growers Jerel Fromm for implementing the delving treatment and Nigel Oswald for lending us the delver.

Reference

GROWNOTES, GRDC. (2016, Feburary). Wheat - Section 5 - Nutrition and fertiliser. GRDC GROWNOTES, 5. Retrieved from https://grdc.com.au/__data/assets/pdf_file/0029/373907/GrowNote-Wheat-South-05-Nutrition.pdf

Crops differ in their tolerance to high strength soils

Nigel Wilhelm[1,2], Luke Simpson[1], Brian Hughes[1] and Murray Unkovich[2]
[1]SARDI; [2]Adelaide University

Location
Avon, Mid North of SA
Farmer: Kelvin & Dylan Tiller
Rainfall
Av. Annual: 353 mm
Av. GSR: 256 mm
2024 Total: 255 mm
2024 GSR: 127 mm
2025 Total: 195 mm
2025 GSR: 166 mm
Paddock history
2023: Lentils
Soil type
Deep orange sand
Plot size
1.5 m x 30 m

Key messages

- **Deep ripping a sand with high strength layers improved crop performance in the year of treatment.**
- **Wheat, barley, canola and lupin are tolerant of high soil strength, while lentil, and tillage radish are sensitive.**
- **Dry cropping years (low soil water reserves and low growing season rainfall) can negate the benefits to crop production of reducing high soil strength.**

Why do this trial?

High soil strength (HSS) is a widespread problem on sands which restricts root growth and crop access to soil nutrients and water. While deep tillage can increase yields in HSS sands and increasing areas of sands in the cropping zone of southern Australia are being ripped, the impact of these operations can be inconsistent and short lived. Problems associated with deep tillage, such as cost, effort to implement, and concerns about erosion, persist. Despite considerable research on crop responses to deep tillage, several important questions still remain:

- how can growers readily assess whether they need to loosen the soil
- will all crop species benefit equally from ripping
- can benefits of deep tillage be enhanced by growing crops with greater tolerance to HSS or overcome the need to rip
- can primer crops penetrate HSS better and provide improved rooting environment for subsequent crops?

GRDC commissioned a project in 2023 to investigate these issues and this article reports on a field-based study undertaken in South Australia as part of this project, which is led by the University of Queensland. Similar field experiments were also conducted in Western Australia and in Victoria. The primary aims of these field studies were to assess the relative sensitivity of major crop types to HSS and to examine the potential for primer crops to improve root penetration in HSS profiles to improve productivity of subsequent crops. Deep ripping was used to alleviate HSS in each trial.

How was it done?

A site was chosen at Avon in the mid North region of South Australia on a broad sandhill in 2024. Annual rainfall for the district is 350 mm. This site was chosen because deep ripping on similar sandhills in the area had produced substantial increases in crop productivity and current crop productivity on this sandhill was poor.

The soil is a shallow brown loose sand over a massive yellowish red calcareous loamy sand with softer calcareous yellowish red sand to at least 90 cm. The surface layers are mildly water repellent.

The trial involved four crop types (Anvil CL wheat with low or standard N, 43Y92CL canola, GIA Thunder lentil and Sod Buster tillage radish) which were grown on either ripped or non-ripped plots. Appropriate plots were ripped prior to seeding in 2024 with an Agrisem® Cultiplow® 52 with TCS 750 blades to a depth of 42–45 cm below the surface in a single pass. This operation reduced soil strength substantially to the depth of penetration (Figure 2).

All crops were seeded on the same day in mid-June 2024. Crop growth and soil moisture were monitored throughout the season and grain yields measured at maturity for all crops except tillage radish, which was terminated at early pod formation.

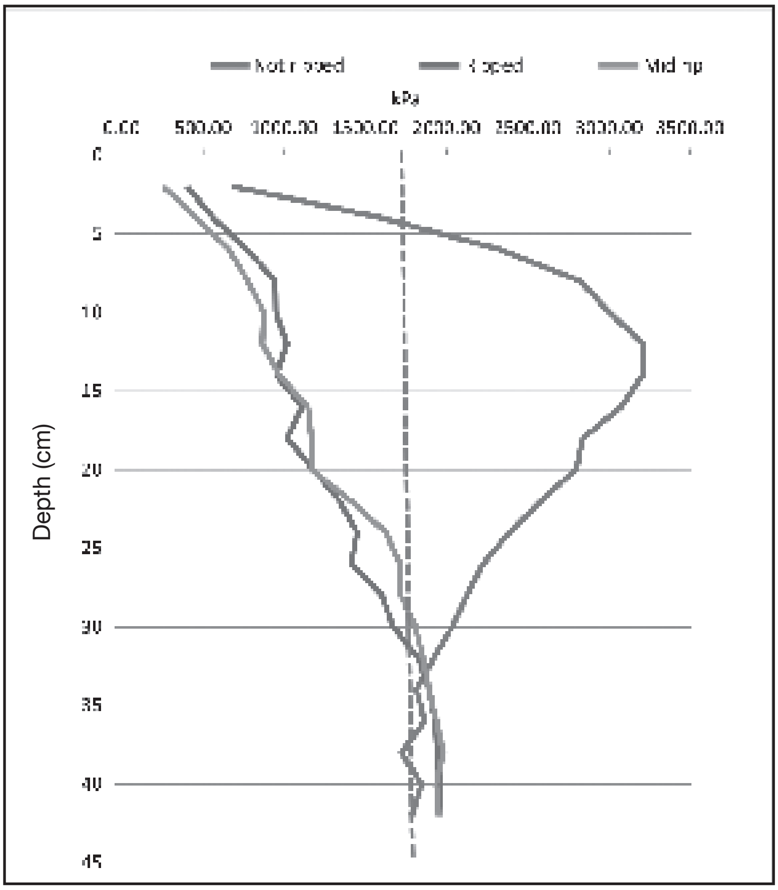


Figure 2. Soil penetration resistance with and without ripping in July 2024 after the profile had wetted up from several rainfall events.

In 2025, all plots were seeded with Anvil CL wheat in mid-June to estimate the impact of previous crop choice in a HSS situation. A luxury supply of N was added to all plots to ensure that any impact of previous crop was not due to differing N supply.

What happened?

2024

Biomass at flowering was assessed in mid-September, 2024 (Table 1). Lentils and tillage radish responded strongly to ripping while canola and wheat were more tolerant of high soil strength. Percentage response of flowering biomass to ripping is a measure of tolerance to high soil strength (high response suggesting sensitivity to HSS and small response suggesting tolerance to HSS). A similar pattern was also measured with grain yields, although tillage radish was not taken through to maturity (sprayed out at flowering to simulate commercial practice). It is interesting to note that reductions in both biomass and grain yield with high strength soil, expressed in kg/ha, were similar for all crops (for example, approx. 900 kg/ha in flowering biomass and nearly 400 kg/ha in grain yield).

2025

The summer of 2024–25 and the following autumn were very dry at Avon. Soil moisture prior to seeding was much lower than in 2024. Prior to seeding in 2024, soil moisture averaged 9% (g/g) over the top 90 cm but in 2025, soil moisture averaged less than 2% for all the grain crops and only 2.4% following tillage radish. Mineral N in the top 80 cm prior to seeding in 2025 was highest following tillage radish (67 kg N/ha), intermediate following lentils (44 kg N/ha) and lowest for low-N wheat (23 kg N/ha). Seeding in 2025 was delayed until 18 June, which was the first occasion for a wet seed bed. Severe wind events post-seeding back-filled seeding trenches and blew sand across the site, especially in those treatments with the least stubble cover, creating reduced, patchy and staggered establishment of wheat. This damage appeared most severe in plots with the least stubble cover (following tillage radish and lentils). Despite these early challenges to development, wheat matured later and yielded better following tillage radish and then following lentils (Table 2). Wheat yields after canola or wheat were relatively poor. It is not yet clear if any of the benefits from preceding wheat in 2025 with tillage radish or lentils in 2024 was due to a ‘primer crop’ effect on soil strength. Ripping in 2024 reduced wheat yields in 2025 if they were following wheat from 2024 but otherwise had little impact on wheat performance in 2025. Prior ripping did not benefit the crop in 2025 because reserves of soil water pre-seeding in 2025 were lower after ripping and there were no major re-charge events to restore soil water reserves.

Table 1. Effect of ripping on flowering biomass and grain yield (kg/ha) of four crop types at Avon, SA in 2024.

Crop type	Flowering biomass (kg/ha)			Grain yield (kg/ha)	
	Not ripped	Ripped	% response to ripping	Not ripped	Ripped
Tillage radish	1550	2838	83	Sprayed out at flowering	
Canola	3788	4588	21	1483e	1760d
Lentil	1152	1853	61	235g	548f
Wheat – low N	3395	4112	21	3300c	3880b
Wheat – high N	4537	5422	20	4088a	4438b
LSD (p=0.05, crop x rip)	*ns, ripping and crop type significant*			*Significant with log transformed data*	

Note: Grain yield of lentils was impacted by severe frosts in late Spring.

Table 2. Effect of prior ripping and crop type on grain yield of wheat at Avon, SA in 2025.

Previous crop type	Grain yield (kg/ha)	
	Not ripped	Ripped
Tillage radish	4175	3983
Canola	2260	2353
Lentil	3208	3438
Wheat - high N	2603	2295
Wheat - high N	2438	2075
LSD (P=0.05, crop x rip)	360 (between crops) 252 (within crops)	

What does it mean?

Deep ripping a HSS sand in a low rainfall cropping environment produced substantial benefits to crop production in the year of amelioration. Wheat and canola were relatively tolerant to HSS at this site compared to tillage radish and lentils. Similar rankings of crop types occurred in the WA and Vic field trials: cereals and canola tolerant of HSS and pulses (lentil and bean) and tillage radish sensitive. Lupin were the exception: in the WA trial, they were tolerant of HSS. Tillage radish is widely promoted as a crop which will improve soil conditions for following crops (a primer crop) so it was a surprise to find that it was so strongly affected by HSS. We have yet to untangle the wheat yield results from 2025 to know whether its benefits to a following wheat crop were due to any primer crop properties.

Our findings suggest that wheat is a good crop choice for situations where HSS is an important constraint because it is tolerant of HSS, relatively easy to establish, quick to provide cover and relatively valuable, rather than canola (while being a crop tolerant of HSS and being valuable, it can be tricky to establish in fragile sands and can be slow to provide cover, or lentil (relatively valuable but sensitive to HSS).

The trial was assessed for soil strength in mid-January 2026 to examine whether crop sequence (and hence any "primer crop" effect) had changed soil resistance to penetration. These data have yet to be collated.

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 through project, UOQ2308-006RTX. The authors would like to thank them for their continued support and to Kelvin and Dylan Tiller for hosting the Avon trial. We also thank Derek Modra and Farm Tech Machinery, Wodonga Vic for the loan of their Agrisem deep ripper.

Key findings over the medium term when overcoming acidity

Brian Hughes[1,2], Andrew Harding [1,2], Nigel Fleming[1], Josh Telfer[1] and David Woodard[1]
[1]SARDI; [2]Adelaide University

Key messages

- **Incorporation of lime was effective where acidity was present deeper than 10 cm only if there were sufficient soil and lime mixing.**
- **Lime quality comparisons showed that purity (neutralising value) is important and related to effectiveness while particle fineness also showed some benefits. No growth differences were observed between dolomites and lime of similar qualities although soil and plant nutrients have been affected.**
- **Trace element levels in plants were affected by liming. Molybdenum is usually increased and manganese almost always decreased. If manganese is marginal it is recommended to apply trace element foliar sprays after liming. Copper, boron and zinc were also occasionally reduced although not to critically low levels.**
- **While alkaline clay has had good pH impacts other alternative products to lime such as manure, gypsum and biochar have shown small to nil response in soil pH over time.**

Why do the trials?

Increases in cropping yields and intensity and higher rates of nitrogen fertiliser application have increased acidification rates and new acid areas are now emerging across much of the Southern Australian cropping zone.

In South Australia (SA) about 2.5 million hectares is considered acid prone and potentially affected by acidity but this estimate is expected to increase to over 4 million hectares in the next few decades (DEW, unpublished).

In an earlier project, from 2019 to 2021 (GRDC project 1905-011RTX), new information was derived on lime movement, treatment options, stratified pH profiles and the value of alternative products over the three years of the project. Components included the establishment of ten long term field trials which were extended in the recent GRDC investment (GRDC project UOA 2206-009RTX) and has provided much needed long-term data from lime experiments across SA and southwest Victoria.

The trial work has enabled a review of acidification rates in topsoils and subsurface layers in soils under current farm practices, including estimates of lime movement down the soil profile. It has provided information to revise lime recommendations, highlighted the issue of subsurface acidity and stratified profiles, investigated acidity management practices, developed extension aids and allowed a review of long-term crop profits for optimised soil pH profiles. It has extended and communicated findings to grain growers.

This paper is structured around common questions raised by farmers and advisers when treating acid soils.

These include;

- Should we incorporate lime
- Comparing Limes - NV, ENV, Ca, Mg, other quality measures
- Impact on trace elements
- Alternative products
- Benefit: Cost

How was it done?

Lime trial sites which were established in SA included one site in 2015, and others from 2019-21. The sites were monitored for growth and yield impacts from various liming practices. Each site had pH by depths assessments every 2-3 years to highlight the impact of various treatments over time. There was one site on Eyre Peninsula, at Brooker. Most sites were monitored until 2024.

Treatments included lime at 2-3 rates, incorporation using various methods, alternative products at some sites and comparison of limes at some sites. At most sites a sulphur treatment was applied to acidify the soil further at a rate to estimate what would happen if no treatment was undertaken in the next five to ten years.

The starting pH profile of SA sites are shown below

Table 1. Initial soil pH ($CaCl_2$) at different soil depths (0-30 cm) of SA trials.

Initial soil pH by SA site										
Site	Kapunda	Koonunga	Mallala	Spalding	Wirrabara	Sandilands	Lameroo	Yumali	Brooker	Bute
Soil Type	SL RBE	SL RBE	Shallow SL RBE	CL RBE	Dark SCL over brown clay	SL over red clay	Sand over clay	Sand over clay	Shallow sand over clay	Yellow sand over clay
Depth										
0-5	5	5.7	4.7	4.5	4.5	4.4	5.6	5	4.5	5.8
5-10	4.7	4.4	4.6	4.1	4.3	4.1	4.5	4.6	4.4	5.3
10-15	4.7	4.3	5.8	4.3	4.7	4.4	4.4	4.6	5	5
15-20	6.3	4.6	6	4.3	4.7	5.1	4.4	4.7	5.3	
20-25		4.5	6.9	5	4.7	6.7	4.5	4.9		
25-30		5.7			5.8	6.7	5.8			
Comment	Prelimed	Prelimed	Not limed	Not limed	Not limed	Not limed	Not limed	Not limed	Not limed	Not limed
				4.5-5.0	≤4.4					

RBE - Red Brown Earth, SL - Sandy Loam, CL - Clay Loam

What happened?

Incorporation of Lime

Lime incorporation produced different results depending on the site and the method.

Understanding the soil pH profile is a key requirement when assessing the possible impact of lime incorporation. We have developed four categories of acidification, and we allocated trials to these categories as follows:

- Surface acidification - 0-10 cm acid, often clay layer at 10 cm (Mallala, Brooker)
- Deeper acidification - 0-15 to 20 cm acid (Sandilands, Spalding, Tungkillo)
- Stratified acidification/ subsurface acid - 0-5 cm slightly acid/ neutral, 5-15 cm acid, (Kapunda, Koonunga-paddocks had been previously limed), sandy 5-25 cm acid (Lameroo, Yumali)
- Subsoil acidification - A horizon slightly acid/ neutral, B horizon acid - not normally an issue in cropping soils.

Understanding the type and depth of incorporation and the effectiveness of mixing helps to determine whether lime incorporation is justified. Several methods have been used in these trials and they are summarised below:

- Tyned cultivator - at Sandilands, Koonunga and Kapunda. Mixed results with slight improvement in the yield in some years and have a slightly improved subsurface pH
- Offset disc to 7.5 cm - at Mallala. Slight benefit only in 2020, while in 2022 when in lentils there were responses to lime but no impact of cultivation.
- Rotary hoe - at Spalding, Yumali, Lameroo and Wirrabara. Provided a good mix to 10 cm, at Yumali better than surface applied lime after five seasons.
- Mouldboard plough - at Koonunga mouldboard ploughing has been better than surface applied lime or tyned incorporation over the last four years when liming has improved crop performance. The impact of different incorporation treatments at this site is shown in Figure 1 and highlights the positive impact of the mouldboard plough and Calciprill (a granulated lime) applied at 125 mm, in increasing pH around 5-15 cm.

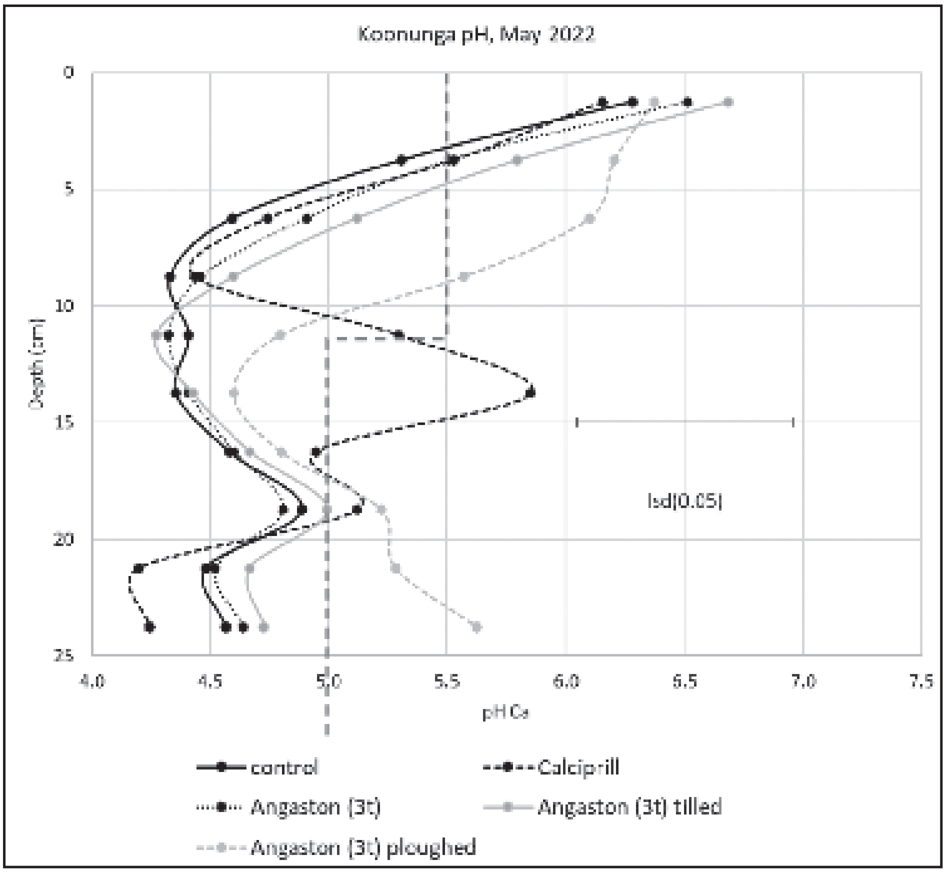


Figure 1. Impact of Angaston or Calciprill lime treatments on pH of profile at Koonunga May, 2022. Control treatment is not limed or cultivated. Tillage was with tyned cultivator or mouldboard plough. Vertical dashed line is target soil pH.

Deep ripping - deep ripping has been undertaken at several sites. At the silicious sand sites at Yumali, Bute and Lameroo, deep ripping alone gave a response to grain yields, while at the sandy loam sites at Sandilands and Mallala, deep ripping gave nil to small responses. Where lime was added prior to deep ripping, yield responses were larger than with deep ripping alone. Sandy soil modification - the use of spading and inclusion plates with and without lime was tested at two sites and was better than not liming. At Lameroo in years three and four, spading with lime was better than spading alone.

The use of clay at Yumali has been one of the highest yielding treatments. This treatment increased soil pH, as well as overcame other sand issues such as severe water repellency and low CEC (see pH impacts of treatments in Tables 2 and 3). Note that little pH change occurs when ripping, spading or using inclusion plates where no clay was added unless lime was also applied.

Impact of Liming on Trace Elements and Other Plant Nutrients

Generally we found that plant molybdenum increases substantially with liming treatments, often from low or deficient levels in legumes to adequate. An example is provided below from the Brooker site when in beans. In addition, plant manganese can be reduced substantially and at this site reductions in zinc, copper and boron were also evident.

Alternative products

A range of alternative products to lime have been used in various trials. Their impact on yield and soil pH has been measured. A summary is provided below:

Clay

Collected from within the paddock of each trial at Yumali and Lameroo. The lime content in the clay was assessed at 3.8% for Yumali and 1.3% for Lameroo. The Yumali clay had increased soil pH in 2023 by similar amounts to a medium rate of cultivated lime (3 t/ha) while the Lameroo clay had increased pH to a level similar to a low rate of cultivated lime (1 t/ha).

In addition, use of clay reduces water repellency, increases soil strength reducing erosion risk, and increases ability to hold more nutrients.

The clay treatments have performed well and have been in the top yields at both sites.

Biochar

The main biochar used was obtained from SA No-Till Farmers Association (SANTFA) and had been imported from USA. It was termed 'cool terra' and described as a good quality char. It was slightly acidic and seemed to be relatively inert in the soil where it was added.

Manure

Three different composted manures were tried at 5 t/ha incorporated using chicken manure at Mallala, cow manure at Spalding and pig manure at Lameroo. Each manure had slightly different contents with the chicken manure containing more nitrogen. Their impacts on soil pH have been very small.

Gypsum

Gypsum had mixed results where applied including some negative and some slightly positive results on yield of crops. The gypsum used had a lime impurity which explains a slight pH rise after it had been applied as the soil received the equivalent of 250 kg/ha of lime when applied at 5 t/ha. It was difficult to determine if gypsum increased yield, either on its own or in combination with lime, and results were not conclusive. At Mallala it seemed to increase soil pH slightly at 7.5-10 cm below the surface in 2023.

Table 2. Treatment impact on soil pH at Yumali (sand over clay) in 2023, 4 years after treatments implemented.

Treatment	Depth (cm)				
	0-5	5-10	10-15	15-20	20-25
Sulphur Cultivate	4.61	4.39	4.27	4.46	4.68
Control	4.97	4.61	4.61	4.57	4.87
Spare 1	5.00	4.66	4.51	4.57	4.51
Spare 2-R	4.96	4.60	4.63	4.76	4.61
Low lime surface 1 t/ha	5.69	4.80	4.69	4.70	4.72
Medium lime surface 3 t/ha	6.42	5.32	4.91	4.92	4.70
High lime surface 5 t/ha	6.77	5.79	5.40	4.68	4.91
Deep rip	4.87	4.56	4.51	4.47	4.49
Cultivate	5.02	4.73	5.15	4.69	4.78
Clay cultivate 100 t/ha	5.80	5.48	5.15	4.83	4.82
Deep rip + cultivate + lime 3 t/ha	6.06	5.39	5.16	4.68	4.80
biochar + lime 3 t/ha + cultivate	6.10	5.61	5.15	5.04	5.06
Medium lime cultivate 5 t/ha	6.06	5.55	4.92	4.91	4.94
High lime cultivate 5 t/ha	6.48	5.77	5.16	4.92	4.88
Lime 2 surface cawtes 3 t/ha	5.80	4.75	4.78	5.46	5.18
Lime 3 surface Henschke 3 t/ha	6.30	5.30	4.79	5.00	4.86
LSD 0.05 = 0.99					

Main lime used Agricola (Robe), cultivation/incorporation using rotary hoe, biochar at 5 t/ha, deep ripped to 30 cm above clay

Table 3. Treatment impact on soil pH at Lameroo, 2023, 3 years after treatments implemented.

Treatment	Depth (cm)					
	0-5	5-10	10-15	15-20	20-25	25-30
Control	5.53	4.71	4.71	4.94	5.41	5.82
Inclusion no lime	5.09	4.74	4.58	4.56	4.68	4.85
Inclusion with lime 3 t/ha	6.32	5.68	5.05	5.08	5.00	5.65
Spader no lime[#]	5.49	4.84	4.59	4.62	4.85	5.22
Spader with lime 3 t/ha	6.24	5.79	5.43	5.13	5.66	6.06
Spader lime 3 t/ha and manure 5 t/ha	6.15	5.59	5.55	5.36	5.43	6.14
Spader manure 5 t/ha	5.44	4.97	4.75	4.55	4.68	5.08
LSD 0.05= 1.14						

[#]*Spader depth approx 30 cm still above clay*

Table 4. Impact of selected treatments on nutrients in young leaves of faba beans at Brooker 2023 (adequate levels from Weir and Creswell, 1994).

Treatment	Nitr-ogen	Sul-pher	Mang-anese	Phos-phorus	Cal-cium	Magn-sium	Alum-inium	Cop-per	Boron	Iron	Molyb-denum	Zinc	Pota-ssium
Lime @ 3 t/ha mixed	5.57	0.27	54.50	0.39	0.69	0.20	31.00	8.78	16.00	99.25	0.27	27.25	1.94
Lime @ 6 t/ha mixed	5.75	0.28	42.75	0.40	0.72	0.20	57.25	8.90	16.00	125.00	0.38	25.50	1.85
Sulphur	2.77	0.54	552.5	0.27	0.75	0.29	165.00	11.00	19.75	100.75	0.03	78.00	2.15
Surface lime @ 6 t/ha	5.47	0.26	54.50	0.37	0.75	0.20	85.50	8.43	16.00	124.75	0.24	26.75	1.91
Untreated control	3.83	0.21	165.25	0.32	0.60	0.26	72.00	10.78	19.25	94.75	0.05	60.50	2.29
Faba bean adequate values	4.3-5		50-300	0.3-0.55	0.6-1.2	0.24-0.5		5-25			0.4-5.5	28-140	2.2-4
Deficient levels / below normal	<1.6-3.6			<0.16-0.24							<0.19		

Table 5. Extra return from best three treatments at Yumali, 2020-24.

Treatment (t/ha)	**Cost of treatment ($/ha)**	**Extra yield above control (t/ha)**	**Extra $/ha Benefit-cost**
Deep Rip + lime 3 t/ha + incorporated with rotary hoe	215	3.1	921
Lime 3 t/ha + incorporated with rotary hoe	170	2.3	746
Clay @100 t/ha + incorporated with rotary hoe	350	2.8	724

Table 6. Extra return from best four treatments at Sandilands, 2020-24.

Treatment (t/ha)	**Cost of treatment ($/ha)**	**Extra yield above control (t/ha)**	**Extra $/ha Benefit-cost**
Kulpara Dolomite 4 t/ha	140	0.9	301
Angaston Lime 6 t/ha	290	1.1	256
Ang Lime 4t/ha + Gypsum 5 t/ha	360	1.1	239
Dalyhead Dolomite 4 t/ha	160	0.9	212

Economics of liming

The economics of liming and other treatments have been assessed for trials at Yumali and Sandilands. For Yumali, the best three treatments were lime @ 3 t/ha incorporated by rotary hoe, clay incorporated by rotary hoe @100 t/ha and deep rip/lime @ 3 t/ha and incorporated by rotary hoe, returning an extra $700–900/ha over 5 crops (up to 3 t/ha of extra grain over the 5 year period) (Table 5).

At Sandilands, the best four treatments were Kulpara lime @ 4 t/ha left on the surface, Angaston lime @ 4 t/ha left on the surface, Angaston lime @ 4 t/ha + gypsum @ 5 t/ha and Angaston @ 6 t/ha left on the surface, each returning close to $300/ha over 5 years. No account has been made of residual amounts of lime applied, as 4 t/ha of lime at Sandilands will possibly account for acidification produced over a at least 15 years (Table 6). At Sandilands while incorporation by cultivator has slightly improved soil pH values no extra yield has been measured.

What does it mean?

These projects have shown the effectiveness of incorporation of lime depends on the soil depth to the acidic layer and the type and effectiveness of incorporation and resulting mixing impact.

Detailed soil monitoring has provided a higher level of information on pH change and the impact of liming treatments than measuring grain yield alone.

To date, differences in lime quality, unless it was large differences in neutralising value and lime fineness, have resulted in small or no differences in yield over time, although soil profile pH and cations are showing more difference.

Consistent impacts occur on plant trace element levels when liming, both beneficial and detrimental, including increased molybdenum and decreased manganese. Decreased copper for livestock is potentially an issue at some sites. Occasional effects on a range of other nutrients was detected as well. Significant reductions in plant aluminium occurred with liming . Plant nutrient changes will show the effect of liming before any yield differences are observed.

Alternative products to lime, apart from clay, have only had small impacts on pH over time. Clay has led to similar pH changes to low and moderate rates of lime in sandy sites.

Other soil amelioration practices, such as ripping, spading and inclusion plates, have caused yield increases on sandy soils for other reasons but have not changed pH profiles unless they have mixed clay or lime.

Economic assessments of responsive sites have shown large and positive returns due to the relatively low cost of lime and its long-term effect. Landholders need to consider a preventative approach to soil acidity by liming before subsurface acidity develops.

Acknowledgements

Acknowledgements are made to the 10 landholders where these trials were undertaken, to various SARDI staff (and former staff) who assisted with the work including L Simpson, N Wilhelm, H Drum, B Armour, B Guidera and B Masters. GRDC for being the primary funder and assisting. Also acknowledged are the various partners including DEW, AgCommunicators, Trengove Consulting, Southern Farming Systems and various Landscape Boards.

See acid soil website for various articles

Acid Soils Southern Region | Amelioration strategies for acid soils

Wheat responds to Potassium at Koppio in 2025

Josh Telfer
SARDI

Location
Koppio
Farmers: Kingsley, Rosso & Derick McDonald
Rainfall
Av. Annual: 522 mm
Av. GSR: 424 mm
2025 Total: 463 mm
2025 GSR: 394 mm
Paddock History
2025: Rockstar wheat
2024: Canola
Soil type
Sandy loam over thick loamy sand with ironstone gravel over clay at > 90 cm

Key messages

- **Potassium deficiency is a concern on the lower EP for certain soil types.**
- **Yield impacts can be severe.**
- **Plant symptoms are often difficult to diagnose and may resemble water stress.**
- **Plant tissue testing can successfully diagnose the issue.**
- **It is important to sample deeper than 0–10 cm to understand potassium (K) reserves in the soil. However, interpreting soil tests remains challenging due to a lack of local critical values for non-sandy soils.**

Why do the trial?

Potassium (K), along with nitrogen and phosphorus (N and P), is one of the three major nutrients often listed first when discussing nutrient limitations to crop performance. However, unlike N and P, most crop and pasture systems on the Eyre Peninsula (EP) rely almost entirely on the natural mineralisation of soil potassium to supply plant needs. Although it is well known that management practices such as repeated hay cutting can remove large amounts of potassium from the farm, and K management is not typically a priority in EP farming systems. There is continual removal of K from soils through agricultural production. Fortunately, most potassium taken up by grain crops is cycled back into the system rather than being exported as grain. Nevertheless, some EP soil types are naturally low in K rich minerals, resulting in limited K supply to crops and pastures. Several soil test methods have been developed to identify K-limited soils. However, when using critical values published in Australian literature, EP soils typically test above these thresholds. Even so, there have been documented cases of K deficiency on the EP since the 1990's, including instances following windrow burning.

The GRDC project (UOQ2503-008RTX) aims to improve the reliability and interpretation of soil tests used to predict crop responses to potassium particularly in the heavier soils seen in Eastern Australia. The trial reported here was conducted as part of this project.

How was it done?

In conjunction with the McDonald family from Koppio, we identified areas suspected to be low in available potassium. In 2025, the McDonalds had begun a potassium fertiliser strategy targeting paddocks where they had previously observed crop symptoms and previous soil and tissue test results suggested K deficiency might be a factor.

The trial was a simple +/- design comparing a high rate of potassium (100 kg/ha) against an untreated control. Soil samples were collected at three depths (0–10, 10–40, and 40–70 cm) prior to seeding to assess surface nutrient status and a range of potassium test methods, including Colwell K, DGT K, and Exchangeable K (see Table 2 below).

K was applied to 4 m x 18 m strips as broadcast muriate of potash (KCl). Treatments were replicated 4 times.

Once the treatments were applied, the farmer sowed 90 kg/ha of Rockstar wheat, with 90 kg/ha of DAP using a DBS seeder. The site was managed the same as the rest of the paddock with regard to nitrogen fertiliser (75 kg/ha of urea & 25 kg/ha of SOA) and weed control. It was sown on 7 May, and emergence was assessed on 13 June. Crop growth was measured on 7 July and 21 August by Canopeo® green cover and Greenseeker® NDVI . Tissue tests were taken of whole shoots in mid-July following observation of visual differences between +/- K strips. Dry matter cuts were taken at flowering on 18 September and nutrient composition of the whole shoots assessed.

Table 1. Plant tissue test, biomass, and grain yields comparing the treatment (100 kg K/ha) against the control at Koppio, in 2025.

Growth Stage	Treatment	Shoot K (%)	Shoot Biomass /Grain Yield (kg/ha)
Tillering (Z16–Z29)	100 kg K/ha	3.03	
Tillering (Z16–Z29)	Control (No K)	1.14	
Heads emerged (Z41–Z57)	100 kg K/ha	1.51	1005
Heads emerged (Z41–Z57)	Control (No K)	0.64	564
Maturity	100 kg K/ha		3403
Maturity	Control (No K)		2108

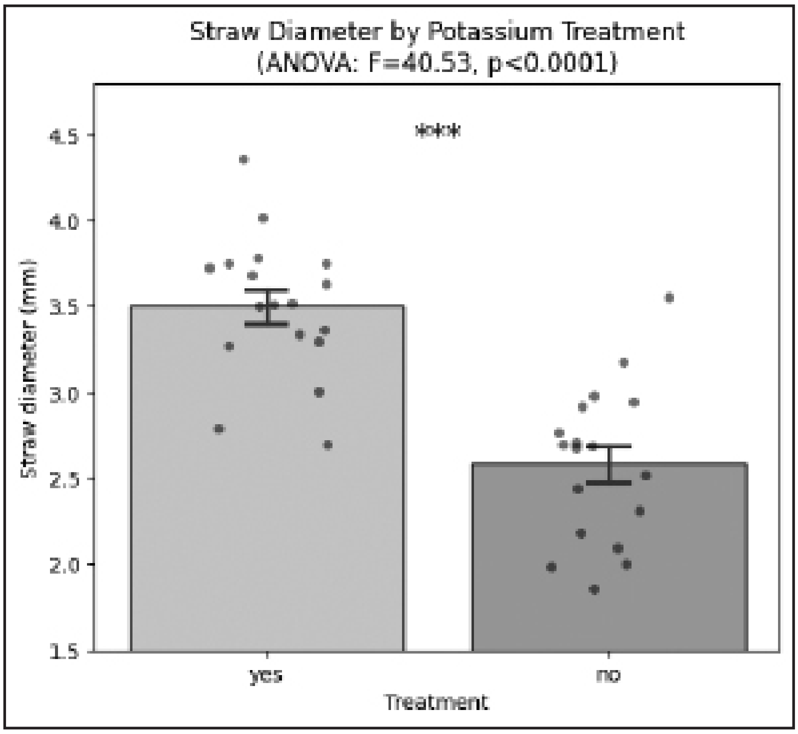


Figure 1. Straw diameter at harvest (mm) based on Potassium Fertiliser status- (100 kg/ha vs 0 kg/ha) at Koppio, in 2025.

What happened?

Emergence and establishment of wheat was not affected by K treatments. However, from early July there were visual differences across the eight strips with the +K strips greener and more vigorous. The early tissue test showed that shoot K concentrations were deficient in the untreated strips and adequate in the +K strips.

Visually, the plots without added K appeared sickly throughout the season, and all measurements such as growth stages, biomass (Table 1), rate of senescence and plant height were all poor.

An observation in spring was that in the control strips, wheat visually looked more vigorous where located over previous harvester rows, indicating the importance of K cycling from previous crop residues, but these were still inferior in height compared to +K strips.

The final yields show a very consistent response over the replicates with a very strong yield signal around improving K nutrition shown (Table 1). It was very obvious throughout the season which plots had been treated with K, and this was also reflected in straw strength and height, and straw diameter (Figure 1) which is exactly the kind of plant changes we would expect with K deficiency based on the scientific literature.

Table 2. Soil potassium results from different testing methods from the trial location at Koppio, in 2025.

Depth	Parameter	Results
0-10	pH $CaCl_2$	6.93
0-10	Colwell K, mg/kg	38
0-10	DGT, K mgL	4.15
0-10	Exchangeable Ca cmol/kg	6.71
0-10	Exchangeable Mg cmol/kg	0.35
0-10	Exchangeable K cmol/kg	0.10
0-10	Exchangeable Na cmol/kg	0.06
0-10	CEC cmol/kg	7.2
0-10	K saturation percent	1.4
10-40	pH $CaCl_2$	6.43
10-40	Colwell K mg/kg	28
10-40	DGT K mgL	1.67
10-40	Exchangeable Ca cmol/kg	3.18
10-40	Exchangeable Mg cmol/kg	0.22
10-40	Exchangeable K cmol/kg	0.07
10-40	Exchangeable Na cmol/kg	0.05
10-40	CEC cmol/kg	3.5
10-40	K saturation percent	2.1
40-70	pH $CaCl_2$	5.57
40-70	Colwell K mg/kg	43
40-70	DGT K mgL	1.02
40-70	Exchangeable Ca cmol/kg	1.02
40-70	Exchangeable Mg cmol/kg	0.11
40-70	Exchangeable K cmol/kg	0.07
40-70	Exchangeable Na cmol/kg	0.04
40-70	CEC cmol/kg	1.23
40-70	K saturation percent	5.3

What does it mean?

This trial shows that potassium deficiency can significantly impact wheat yields on lower EP on a loamy sand over gravel profile. It shows that both soil testing for K, and also tissue test analysis can be used to diagnose likely response to potassium fertiliser.

The soil at the trial site of a loamy sand over deep gravel has very little K reserves and typically has less K at depth than in the surface. A shortage of K delays plant development as well as weakens properties like straw strength, plant height and ultimately crop yield. Because these symptoms are very closely related to soil type, the challenge is to identify zones across the landscape which justify an intervention with K fertiliser. On central Yorke Peninsula, placing K in or under the seed row is much more efficient than broadcasting K (Sam Trengrove, GRDC Update 2026). However, the results seen here showed good performance from early broadcasting of KCl.

Further work will aim to understand which soils don't supply sufficient K to match yield potential, and to develop a precision approach to target these particular soil types, backed up by soil testing (to depth) and tissue testing.

Fire thresholds and rate of spread in Canola Stubble - preliminary results

Simeon Telfer[1,2], Richard Hurley[3] and Rachel Bessell[4]

[1]SA Country Fire Service; [2]RMIT University; [3]CSIRO - Data61; [4]Country Fire Authority, Victoria

Location
Ungarra
Farmer: Issac Telfer
Rainfall
Av. Annual: 410 mm
2024 Total: 374 mm
2024 GSR (Apr - Oct): 234 mm
Paddock History
2024: Canola
2023: Faba beans
2022: Wheat
Soil type
Sandy loam over clay
Plot size
50 m x 50 m x 18 plots
Trial design
18 experimental fires using line ignition in grazed canola stubble

Key messages

- **Fire spreads slower in canola stubble than predicted by current grass fire spread models under moderate to high fire weather conditions.**
- **Continuity of crop residue affects fire spread under moderate to high fire weather conditions.**
- **More trials will be conducted under a wider range of weather conditions.**
- **These results may translate to other non-cereal crops, although validation of this assumption is required.**
- **Improved fire rate of spread modelling will result in more accurate fire danger ratings and fire warnings for the community.**
- **Better understanding of fire spread rates in non-cereal crops can contribute to farmers' risk appreciation and integrate with other farm practice considerations.**

Why do the trial?

The aim of this project is to establish fire spread thresholds and rate of spread models in canola stubble. The SA Country Fire Service (CFS), and all other fire agencies around Australia, currently use a grass fire spread model to predict rate of spread of fire in broadacre agricultural crops (Cheney, Gould, and Catchpole 1998). This model is used for predicting fire spread to warn communities when a fire is reported and also used in the Australian Fire Danger Rating System to derive the hourly Fire Behaviour Index (Kenny et al. 2024). The grass fire spread model was originally developed for pasture grasslands, but has been validated for use in cereal crops by CSIRO (Cruz et al. 2020). This model has shown good agreement with experimental and uncontrolled grass fires in grasslands and cereal crops and provides reliable fire danger ratings for those fuel types.

The grass fire spread model is used for fire spread predictions and fire danger ratings for a range of other fuel types including non-cereal crops as there is not a more suitable fire spread model. This project aims to validate the existing grass fire spread model in canola stubble/ residue, and if it is not suitable, to develop a new fire spread model which can be used for fire spread predictions and fire danger ratings.

Anecdotally, fires ignite and spread differently in cereal, canola and pulse crops. To date, no research has attempted to quantify spread rates and the contributing factors to fire spread in non-cereal crops. In addition to improving fire danger ratings and warnings, this research aims to increase understanding of fire risk for farmers who have a mosaic of crop types such as cereals, canola and pulses.

How was it done?

50 m x 50 m experimental burn plots were established in canola stubble near Ungarra. The paddock had been moderately grazed with sheep creating some areas of bare earth particularly in machinery wheel tracks. An aerial survey of the experimental area was conducted using RedEdge Mx camera mounted on a DJI Matrice 350 remotely piloted aircraft system (RPAS). This imagery was used to create a normalised difference vegetation index (NDVI) map, which showed more crop residue in the area between wheel tracks versus outside the wheel tracks.

Based on this finding fuel loads were sampled separately; 2 samples from between wheel tracks and 2 samples outside wheel tracks for each plot. Standing canola stubble and crop residue were sampled separately. Fuels were destructively sampled using a 1m x 1m quadrat, stored in paper bags, dried in an oven for 24 hours at 105°C before being weighed. Plot fuel loads were calculated by taking the weighted average of fuel loads based on the amount of area between wheel tracks and outside wheel tracks to create an average fuel load equivalent in t/ha.

During the experimental burns fuel moisture was measured by collecting fuel samples from each plot immediately before ignition and stored in a sealed tin. These samples were dried for 24 hours at 105°C and weighed to calculate fuel moisture content (Matthews 2010). Wind speed, temperature, humidity and solar radiation were measured during the burns at 2 m and 10 m using portable weather stations.

Burns were ignited using two simultaneous firelighters to light a 50 m line ignition. DJI Mavic 30T and DJI Mavic 3T were used to capture aerial video footage of the experimental burns. Still frames were extracted for the video footage every 10 seconds (see Figure 1 for example). The extracted aerial images were georeferenced in QGIS using ground control points surveyed with RTK GNSS equipment with minimum 20 mm accuracy. Rate of spread was measured using aerial visual and thermal imagery from RPAS by measuring spread rate of fire against ground control reference plates. Statistical analysis was undertaken in R Studio.

What happened?

The experimental burns resulted in 6 burns failing to propagate 12 m in 12 minutes and were classified as “No-Go”. Twelve burns were classified as “Go” and had an average rate of spread of 620 m/hr with a maximum spread rate of 1640 m/hr. Figure 2 shows a box plot of the weather conditions (a-c), fuel moisture (d) and rate of spread (e) for the experimental burns. Temperature ranged from 18 - 27°C, humidity ranged from 32 - 66%, wind speed (measured at 10 m) ranged from 17 - 40 km/hr and fuel moisture ranged from 6.3 – 13.2%.

Weighted average crop residue fuel loads ranged from 2.7 - 5.7 t/ha. During the experimental burns, the standing stubble was not consumed by the main fire front, instead it burnt at the base and fell over and then smouldered after the main flames had passed. For this reason, the standing stubble was not included in the fuel load calculations.

Observed rates of spread were compared with predicted rate of spread using the “Eaten-out” grass model (Figure 3a) and the “Cut/Grazed” grass model (Figure 3b). Even when considering only fires that actually spread, the eaten-out model overpredicted rate of spread by approximately 3 times and the Cut/Grazed model overpredicted rate of spread by roughly 6–7 times. These numbers are even higher when “No-go” fires are included.

Fire spread was found to be affected by the continuity of crop residue. Wheel tracks and lower fuel areas often stopped the fire spread even under relatively high wind conditions. A method of determining fraction ground cover using satellite and RPAS imagery was trialled, however, there was insufficient data to determine a relationship with rate of spread when considered with wind speed and fuel moisture. Experiments conducted recently in February 2026 (data not yet analysed) in ungrazed canola stubble showed much higher rates of spread, indicating that crop residue continuity strongly influences fire rate of spread and intensity.

Soils

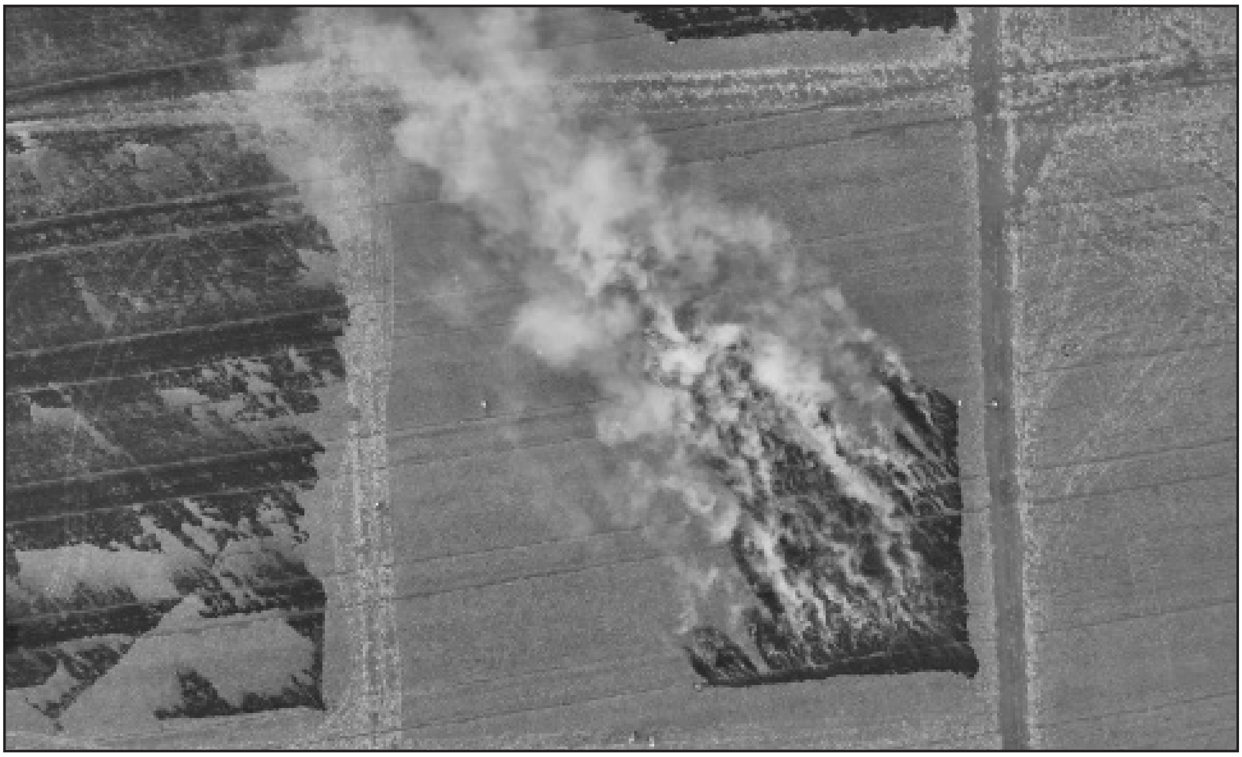


Figure 1. Aerial Image of a 50 m x 50 m experimental burn in canola stubble .

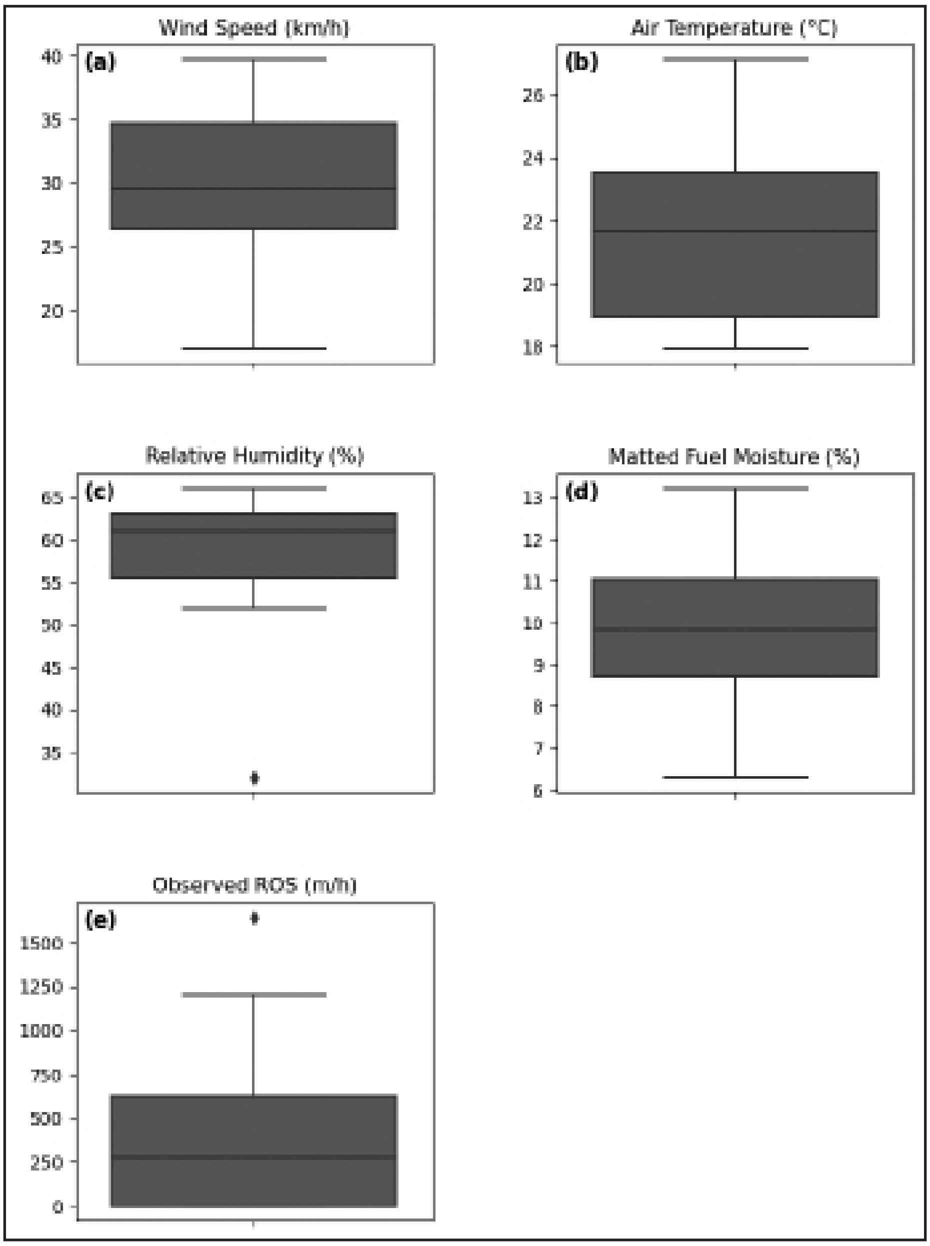


Figure 2. Boxplots of weather, fuel moisture and rate of spread of experimental canola burns. (a) 10-m open wind speed, (b) air temperature, (c) relative humidity, (d) matted fuel moisture content, and (e) observed rate of spread.

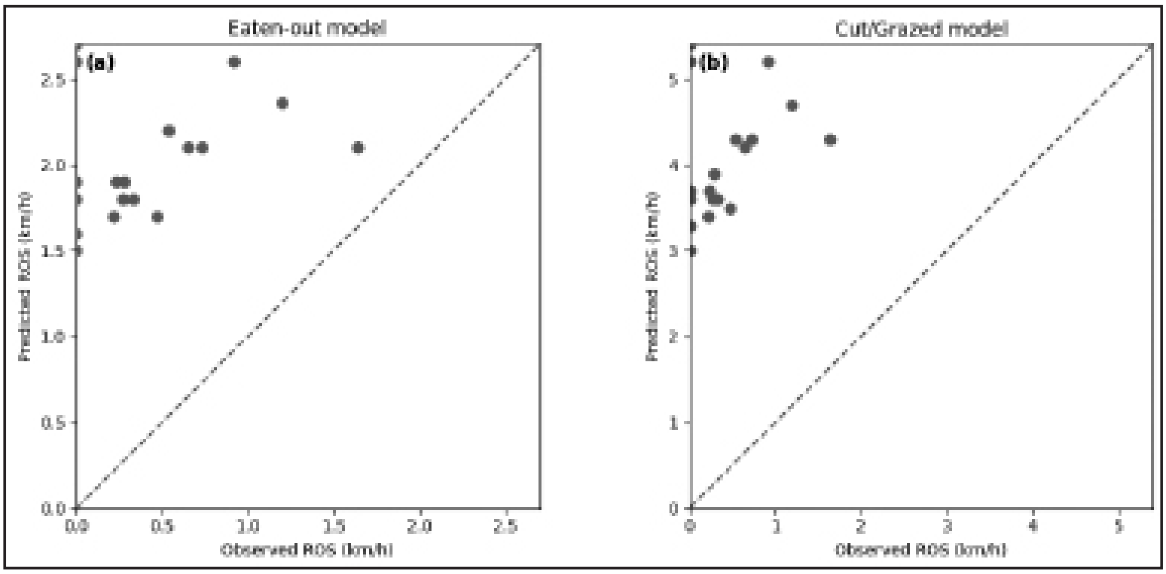


Figure 3. Comparison of observed canola fire and modelled rate of spread for Eaten out grass fire spread model (a) and Cut/Grazed grass fire spread model (b).

When compared with cereal crop stubble of similar fuel load, canola crop residue was not arranged well-enough to allow rapid fire propagation under the weather and fuel moisture conditions in this trial. Given other non-cereal crops like pulses have a similar post-harvest residue arrangement, these results are likely to translate to other crops such as beans and lentils. However, more validation of fire spread in these crop types is required.

What does this mean?

The findings of this study indicate the rate of spread is overpredicted in canola stubble under moderate to high weather conditions when using the current grassland fire spread models. Operationally, the CFS (and other fire agencies around Australia) uses "Eaten-out" rate of spread model to predict fire spread in canola when preparing warning messages for the community. The "Eaten-out" model was shown to match baled wheat stubble, which is generally considered more flammable than non-cereal crop residue (Cruz et al. 2020). This is likely leading to over prediction of fire spread and potentially over-warning communities. While this is more desirable than under-predicting fire, more accurate fire warnings would improve community confidence in warnings.

Likewise, incorporating these findings into the Australian Fire Danger Rating system could lead to more accurate fire danger ratings in areas with a high proportion of canola and non-cereal crop types. This could also include a fractional cover layer to further improve fire spread predictions and fire danger ratings should a relationship between rate of spread and ground cover be established.

These findings also have implications for farmers and land managers in broad-acre agricultural areas. Canola is considered low risk of fire ignitions at harvest (especially direct-headed) and these results indicate it is also lower risk post-harvest. Grazed canola stubble inhibits fire spread compared with harvested and even baled cereal stubble. While retaining more crop residue may have benefits for soil condition, the initial findings from this research indicate that fires which start or spread into more continuous stubbles will spread faster and with more intensity. Farmers can use this information to create lower fuel areas to minimise fire spread through grazing or have a better appreciation of fire risk on their property.

Eighteen additional experimental burns were conducted at the same property in February 2026 in drier conditions with more continuous fuels. The results of these additional burns have not been fully analysed at time of writing; however, they indicate that the fire spread reduction in canola stubble is less under dry windy conditions and with higher crop residue loads.

The results of this trial may also translate to other low residue crops such as legumes. Anecdotally however, crops such as lentils and vetch have a higher instance of fire ignitions during harvest, so further research is needed to assess the overall impact on fire risk as increasing areas move away from grazing towards these alternative crops. The authors would be glad to hear from farmers willing to participate in future studies.

Acknowledgements

This research is funded by the Government of Victoria through the Safer Together program, the Country Fire Authority and through co-contribution by the CSIRO and SA Country Fire Service. The authors offer their sincere thanks to Isaac and Luke Telfer, the volunteers from Lincoln brigade who provided fire cover, and other CFS staff for their support in data collection.

References

Cheney, N. P., J. S. Gould, and W. R. Catchpole. 1998. "Prediction of Fire Spread in Grasslands." International Journal of Wildland Fire 8 (1):1-13. doi: https://doi.org/10.1071/WF9980001.

Cruz, Miguel G., Richard J. Hurley, Rachel Bessell, and Andrew L. Sullivan. 2020. "Fire behaviour in wheat crops – effect of fuel structure on rate of fire spread." International Journal of Wildland Fire 29 (3):258-271.

Kenny, B. J., S. Matthews, S. Sauvage, S. Grootemaat, J. J. Hollis, and P. Fox-Hughes. 2024. "Australian Fire Danger Rating System: implementing fire behaviour calculations to forecast fire danger in a research prototype†." International Journal of Wildland Fire 33 (4):WF23142. doi: 10.1071/WF23142.

Matthews, Stuart. 2010. "Effect of drying temperature on fuel moisture content measurements." International Journal of Wildland Fire 19 (6):800-802.

Section 2

Section Editor:
Dr Nigel Wilhelm
SARDI

Farming Systems

Predicting nitrogen cycling and losses in a mixed farming system at Minnipa

Nigel Wilhelm[1,2], Zhaohan (Elijah) Luo[1,2], Luke Simpson[1] and Kym Zeppel[1]

[1]SARDI; [2]Adelaide University

Location
Minnipa
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2025 Total: 283 mm
2025 GSR: 227 mm
Paddock History
2024: Maximus CL barley
2023: Canola
2022: Medic pasture
Soil type
Calcareous loam
Plot size
1.5 m x 23 m

Key messages

- **A vigorous medic stand in 2022 has supported 3 years of subsequent cropping without the need for additional N to maintain grain yields or grain quality.**
- **Uptake of N by the treated wheat from broadcast urea was poor in 2023 when very little rain fell in the month after application. However, nearly one-half of broadcast N was found in the shoots of the treated crops at the end of the season in 2024, when rainfall events post application were heavier and more frequent than in 2023.**
- **Broadcast N to the previous crop increased grain proteins in the subsequent crop, showing that crops can make use of N from applications in the previous season.**

Why do this trial?

Understanding nitrogen (N) cycling has been and will continue to be an important issue for the Australian agricultural industry. N cycling is a complex process that involves interactions between a wide range of biotic and abiotic factors, and which has important impacts on management strategies on farm. Outcomes from N cycling have direct effects on the environmental impact and financial performance of farming enterprises.

The trial reported here is part of a multi-seasonal, national-wide project which is funded through a GRDC investment - “Predicting nitrogen cycling and losses in Australian cropping systems - augmenting measurements to enhance modelling” (UQ2204-010RTX). This project supports 13 field sites, located in QLD, NSW, VIC, SA, and WA and seeks to understand the characteristics of the N cycle in major Australian cropping regions and more accurately predict N losses under different crop type and management strategies in various environments. The main aims of this project are:

- To provide the grains industry, researchers, regulators, policy makers and the public access to credible information summarising N cycling and N losses from key grain production systems and associated soil types across Australia, and predictions of N losses and their potential environmental impact for the grains industry.
- To use the foundational knowledge of N cycling, losses and recovery by crops developed in this investment to inform improved N management practices to optimise grower returns from investment in N fertiliser.

Table 1. Timing of crop choices and N treatments in three separate sequences at Minnipa, 2022 - 2025.

	Cycle 1	Cycle 2	Cycle 3
2022	Medic pasture	Medic pasture	Medic pasture
2023	Wheat (N treatments applied)	Canola	Canola
2024	Barley	Wheat (N treatments applied)	Barley
2025	Wheat	Wheat	Wheat (N treatments applied)

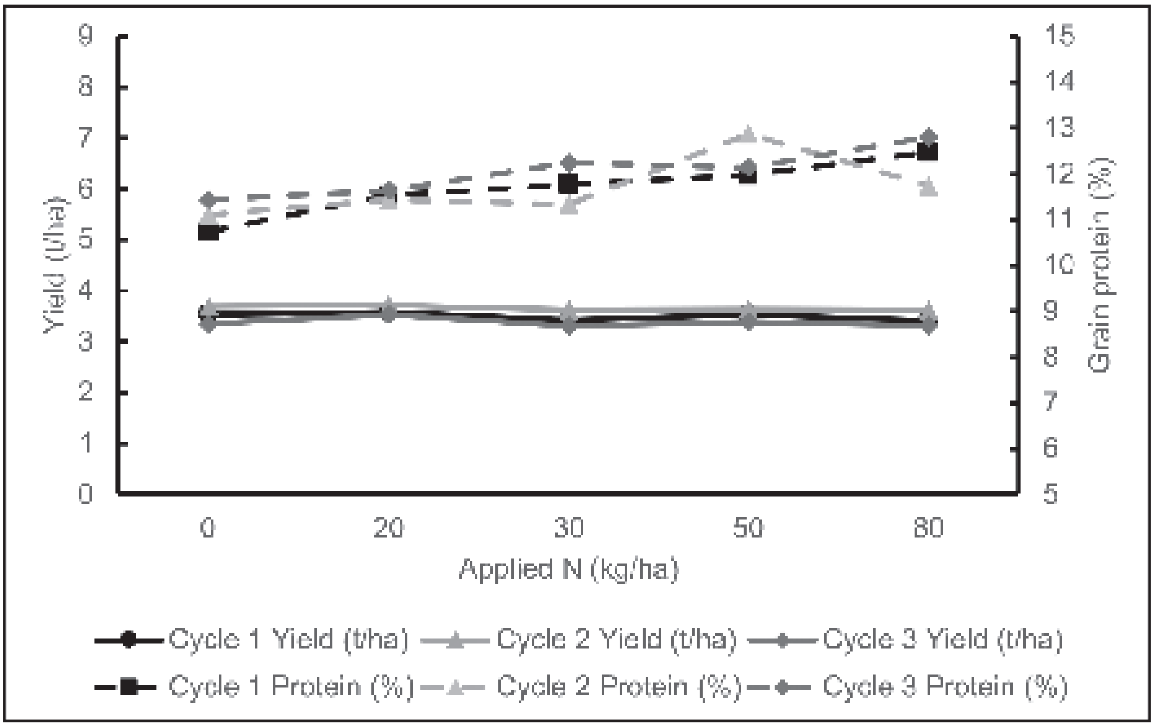


Figure 1. Grain yield and protein of wheat in 2025 in the N cycling trial at Minnipa Ag Centre after 3 seasons of N applications. Cycle 1 was applied in 2023, cycle 2 in 2024 and cycle 3 in 2025.

The trial set up at Minnipa Agricultural Centre is monitoring the cycling of broadcast urea through three crop sequences and for up to 3 years after application. The trial is using 15N-labelled urea to track applied N. This site was chosen on a vigorous medic stand to represent mixed farming systems of upper Eyre Peninsula.

How was it done?

A paddock on Minnipa Ag Centre with a vigorous medic stand in 2022 was chosen as the site for the trial which started in 2023. The purpose of the trial is to monitor the fate of urea broadcast onto wheat through 3 different cropping choices (medic, canola, wheat or barley, see Table 1 for timing of crop types and N treatments), over three seasons and to assess any residual benefits of broadcast N. Urea was broadcast each year onto wheat at mid to late tillering (Z24-Z30) in early July, in front of a forecasted rainfall event. This trial has treatments with 15N labelled urea and with standard urea. The main purpose of the 15N treatments is to track the fate of the applied N through crops and through the soil. There are three 15N rates (control - no N, low rate - 20 kg/ha N and high rate - 50 kg/ha N).

The treatments with standard urea estimate the severity of N deficiency each year (N response) and also monitor residual benefits. There are 6 N response rates (no N, 10, 20, 30, 50 and 80 kg/ha N). In the year of application, and in the following years, treated plots received no basal N applications. In the years preceding the application of treatments, all plots received approx. 50 kg MAP/ha at seeding. Plots received 50 kg triple super/ha at seeding in the year of application, and in the following seasons.

Wheat biomass, yield and grain quality were assessed every year. The primary purpose of the crop and soil sampling was to follow the fate of applied urea into the treated crop, into the soil profile and into following crops. Soil moisture was also measured several times each year.

Table 2. Amount of N from urea broadcast in July in the shoots of wheat at maturity (including grain) over three years, 2022 - 2025 at Minnipa.

Applied N (kg/ha)	N in mature shoots of wheat from urea broadcast at tillering (% of applied N)		
	2023	2024	2025
20	19	46	*43*
50	17	46	*48*

Note: Figures in italics are for wheat one month after application of urea, data from later samplings not yet available.

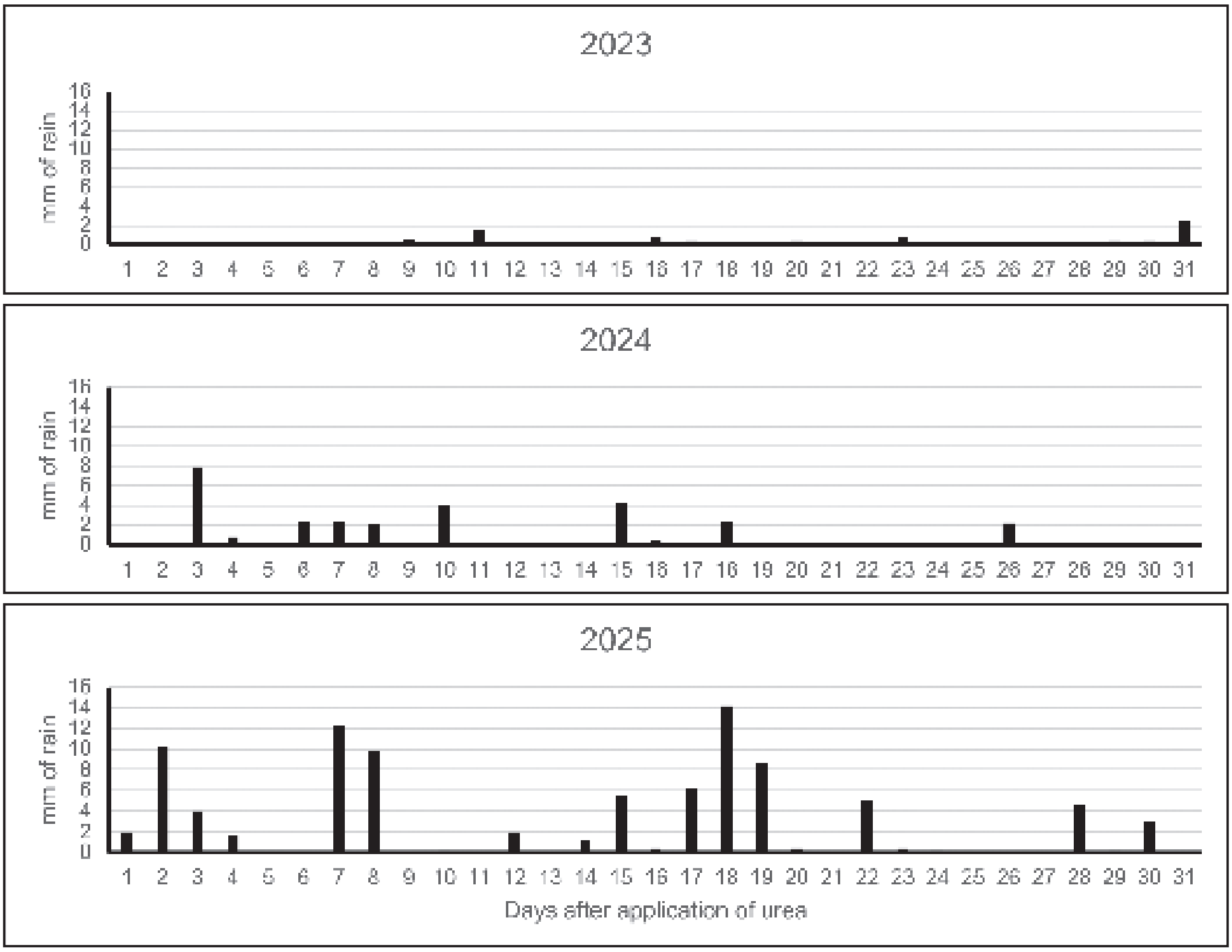


Figure 2. Daily rainfall in the 30 days after broadcasting of urea in the N cycling trial at Minnipa for 3 seasons; 2023, 2024, 2025.

What happened in 2025

This site experienced a very dry summer and autumn prior to seeding in June 2025. However, a well above average June and July substantially improved crop growth and potential. Figure 1 shows grain yield and grain protein of the 2025 crop (the whole trial was seeded to wheat in 2025) and that increasing rates of broadcast urea did not increase grain yield (cycle 3 yields in Figure 1). Previous applications of urea (cycles 1 & 2) also did not change yields. However, applications of urea from all 3 seasons increased grain proteins, suggesting that these previous applications of urea had benefits beyond the year of application.

The lack of response in grain yield of wheat from increasing applications of urea was due to the situation not being deficient in N for wheat in 2025.The medic stand from 2022 had boosted N reserves in the soil to the extent that three years of cropping were sustained without the need for additional N. Grain proteins (%) without added N in 2025 were approximately 11% for all 3 cropping sequences, which indicates N supplies were adequate for normal growth of wheat. This pattern was very similar to results in 2023 and 2024; increasing rates of applied N did not increase grain yields of wheat but increased grain protein. Results and findings from the previous years of this trial can be found in the 2024 and 2023 EPFS Summary. Reserves of mineral N in the top 60 cm were high prior to seeding in all three years of the trial (213 kg N/ha in 2023, 81 in 2024 and 108 in 2025).

The uptake of N from broadcast urea by the crop in the year of application varied greatly between the 3 seasons of the trial (Table 2).

The differences in uptake of N by the treated crop from broadcast urea were due to differing weather conditions after application. In 2023, rainfall events after broadcasting of urea in mid-July were small and infrequent (never more than 3 mm per day for the first 30 days and only a total of 8 mm for the whole period) (Figure 2). This meant that there was little rain to dissolve and move the urea into the root zone and the topsoil was often dry, preventing uptake of nutrients by the crop. Conditions in 2025 contrast with those in 2023; 12 mm of rain fell within the first 2 days after application and there were many rainfall events in the first 30 days, totalling 92 mm for the whole period. Conditions in 2024 were intermediate between 2023 and 2025 with 8 mm falling 3 days after application. The better moisture conditions in 2024 for movement of urea into the root zone and for crops to take up nutrients resulted in nearly one half of the applied N being found in the mature shoots of the treated crop. The pattern in 2025 is on track to match, or exceed, the uptake by crops recorded in 2024.

Our expectation is that most of the N that is not being recovered in the shoots of the treated crop will be found in the soil profile. We have sampled each year to assess the amount of N in soils from broadcast urea but those samples have yet to return from the laboratory in Queensland. These results will be available within the next 6 months. Two sets of interim findings lend support to this expectation. The first is that we have found losses from broadcast urea to volatilisation of ammonia to be relatively low. Trials to estimate ammonia losses from broadcast urea were conducted in 2024 and 2025, nearby to the trial reported here, and they found relatively low losses of urea in both years under similar conditions (21% of the applied urea lost as ammonia in the month after application in 2024 and 14% in 2025). The second set of findings is that there was little N in the shoots of mature wheat in 2024 from urea applied in 2023. If the applied N is not being fully taken up by crops and not a lot is being lost to the atmosphere as ammonia, then the soil seems the most likely place that the balance will be found.

The national set of data being generated by this project, with thirteen trials similar to the Minnipa trial, plus many related activities, will be used to improve the N cycling module of APSIM, a crop simulation model. This will allow us to better simulate scenarios of N nutrition and N fertiliser requirements for any cropping situation in Australia in the future.

Acknowledgement

The authors would like to acknowledge the significant contributions of growers through the support of the GRDC in the current project (UQ2204-010RTX) and also thank MAC Staff for the successful delivery of the trial and processing of its samples.

How much urea N is being lost to volatilisation?

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

[1]Agriculture Victoria, [2]SARDI, [3]Adelaide University, [4]LaTrobe University, [5]NSW Department of Primary Industries and Regional Development

Location
Minnipa
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2025 Total: 283 mm
2025 GSR: 227 mm
Paddock History
2024: Maximus CL barley
2023: Canola
2022: Medic pasture
Soil type
Calcareous loam
Plot size
1.5 m x 23 m

Key messages

- **Most ammonia losses from top-dressed urea occur within the first two weeks after urea application.**
- **Soil type strongly influences losses: heavy soils retain ammonium and reduce volatilisation, while low-clay Calcarosols are more prone to greater losses.**
- **Weather conditions are key: windy periods after application increase NH_3 losses, whereas substantial rainfall after top dressing helps reduce volatilisation.**
- **On sandy or low-clay calcarosols, splitting applications, or using urease inhibitors could be beneficial to reduce losses.**

Why do the trials?

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

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

This work is part of a national GRDC project (UQ2204-010RTX) that aims to track the fate of fertiliser N across key soils and cropping systems nationwide, and to quantify the relative contribution of different loss pathways such as NH3 volatilisation, denitrification, and leaching.

How was it done?

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

Table 1. The physico-chemical properties of soils (0-10 cm) for urea volatilisation studies at Minnipa, SA and Horsham, Vic. CEC = cation exchange capacity.

Site	Soil type	Soil pH (water)	Soil Carbon (%)	Sand (%)	Silt (%)	Clay (%)	CEC (cmol/kg)
Minnipa	Calcarosol (sandy loam)	8.1	1.4	72	11	18	7.9
Horsham	Vertosol (clay)	7.9	1.7	38	17	45	35

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

What happened ?

Figures 1 and 2 show cumulative NH_3 losses from applied urea over each experimental period, daily rainfall and wind speed at the Horsham and Minnipa sites, respectively. Across both seasons, % N of the applied N lost as NH_3 was significantly greater at Minnipa than at Horsham, although N application rate was higher at Horsham (80 kg N/ha vs. 50 kg N/ha). At Horsham, total NH_3–N losses were 6.5 and 7.3 kg N/ha in 2024 and 2025, respectively, equivalent to 8.2% and 9.2% of the 80 kg N/ha applied (Figure 1). In contrast, at Minnipa, % losses were higher, 21.3% and 13.7% of the 50 kg N/ha applied, amounting to 10.6 and 7.4 kg N/ha in 2024 and 2025, respectively (Figure 2). The observed losses align with previous studies from the southern region, which have reported ammonia volatilisation losses of 9.5–26% from surface-applied urea (Turner et al., 2010; Incitec Pivot Fertilisers, 2024). The relatively lower losses recorded at the Horsham site in this study are largely attributable to soil characteristics, particularly the higher clay content (45%) of the Vertosol soil. The corresponding high CEC (35 cmol/kg) results in greater retention of ammonium on the soil (Adhikari et al., 2019). The lower volatilisation rate observed in the Vertosol soil, despite substantial ammonium remaining in the surface soil throughout the measurement period (Figures 3 and 4), provides evidence of this effect. In contrast, the sandy loam Calcarosol at Minnipa has a substantially lower surface soil clay content (18%). Its measured CEC (8 cmol/kg) was lower than that of the Vertosol. Carbonate-rich calcarosols are dominated by Ca^{2+} ions, which strongly compete with ammonium ion for cation exchange sites, resulting in less effective ammonium retention in soil. The presence of free calcium carbonate further buffers the soil against pH decline following urea hydrolysis and neutralises acidity generated during nitrification, thereby maintaining alkaline conditions for longer periods that favour ammonia volatilisation (Fenn and Kissel, 1975). Furthermore, the lower water-holding capacity of the Calcarosol promotes rapid surface drying, a condition that likely further enhanced ammonia losses. Higher wind speeds during the first week after urea application at Minnipa, compared with Horsham in both seasons, may have further contributed to increased losses, as windy conditions promote volatilisation from the soil surface in the absence of a dense crop canopy. Together, these soil properties and higher wind conditions help explain the higher volatilisation losses at Minnipa.

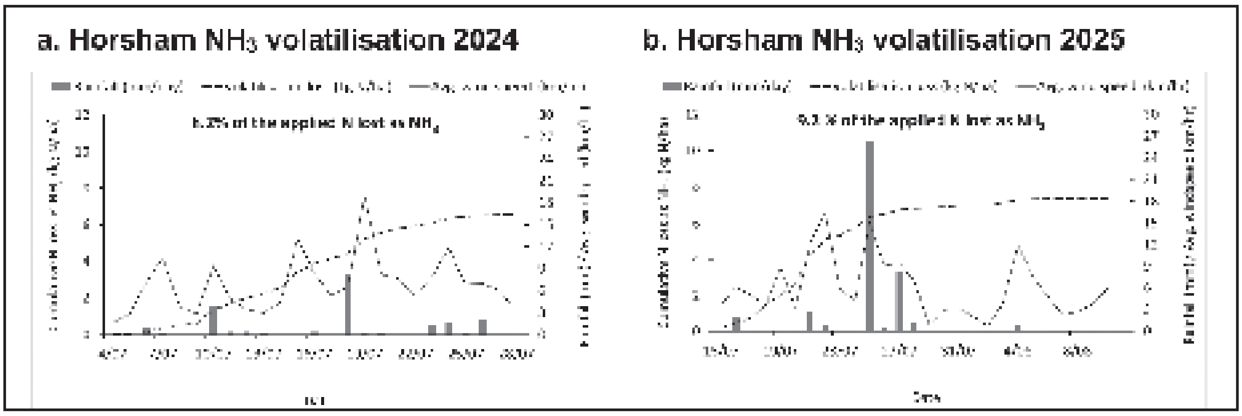


Figure 1. Cumulative NH_3 losses following urea top-dressing over the experimental period, together with daily rainfall and wind speed at the Horsham site during (a) 2024 and (b) 2025.

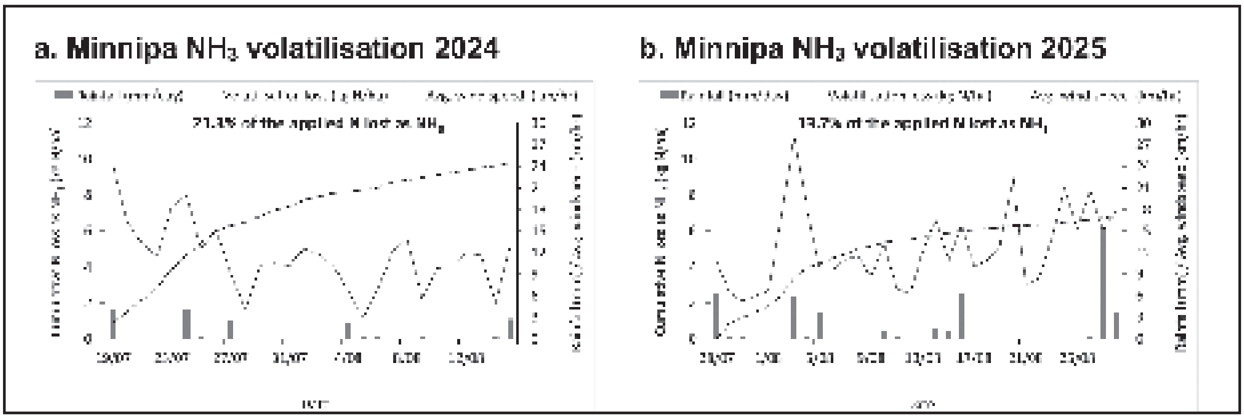


Figure 2. Cumulative NH_3 losses following urea top-dressing over the experimental period, together with daily rainfall and wind speed at the Minnipa site during (a) 2024 and (b) 2025.

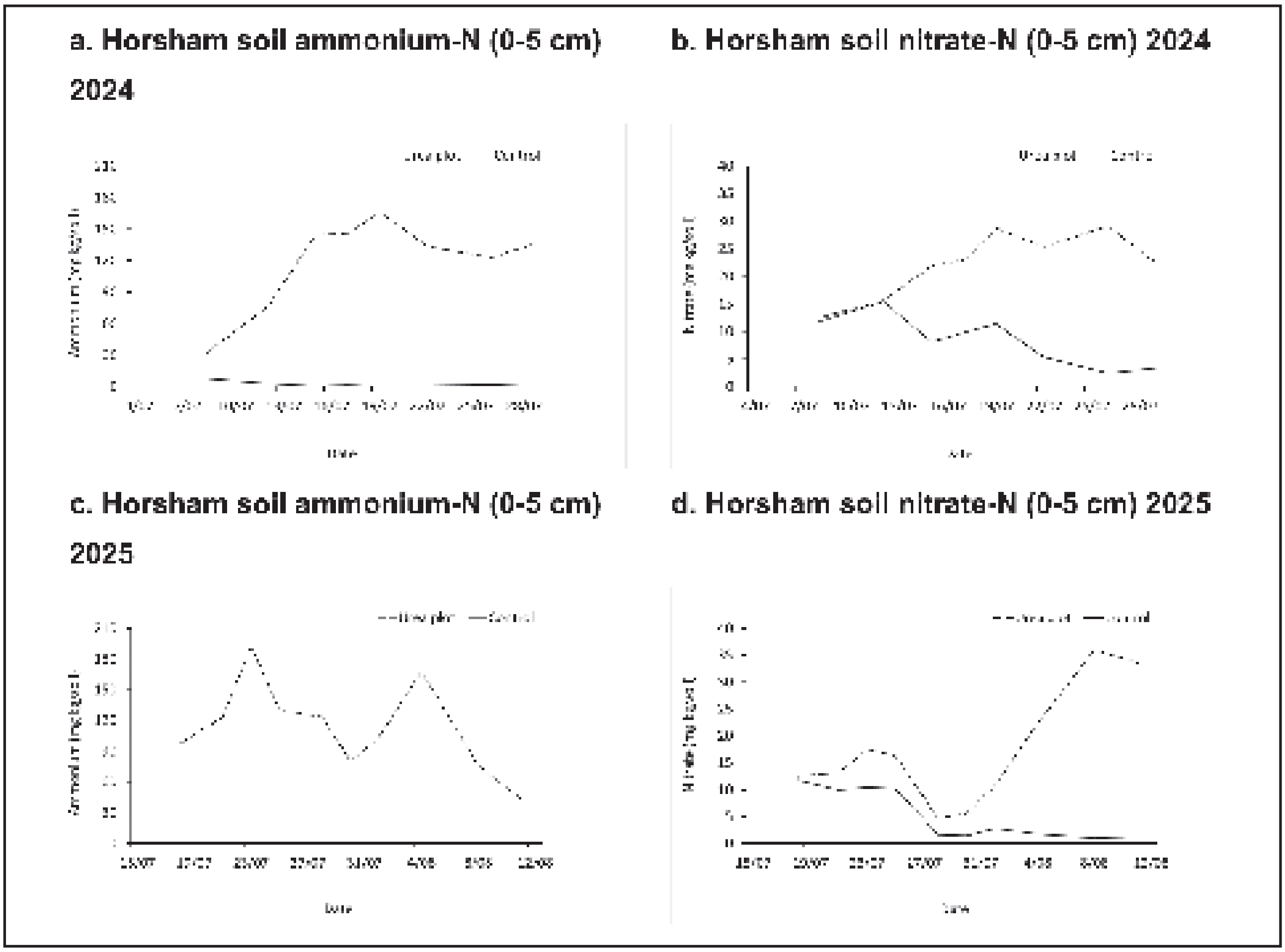


Figure 3. Ammonium-N and nitrate-N in surface soil (0-5 cm) following urea top-dressing over the experimental period at Horsham.

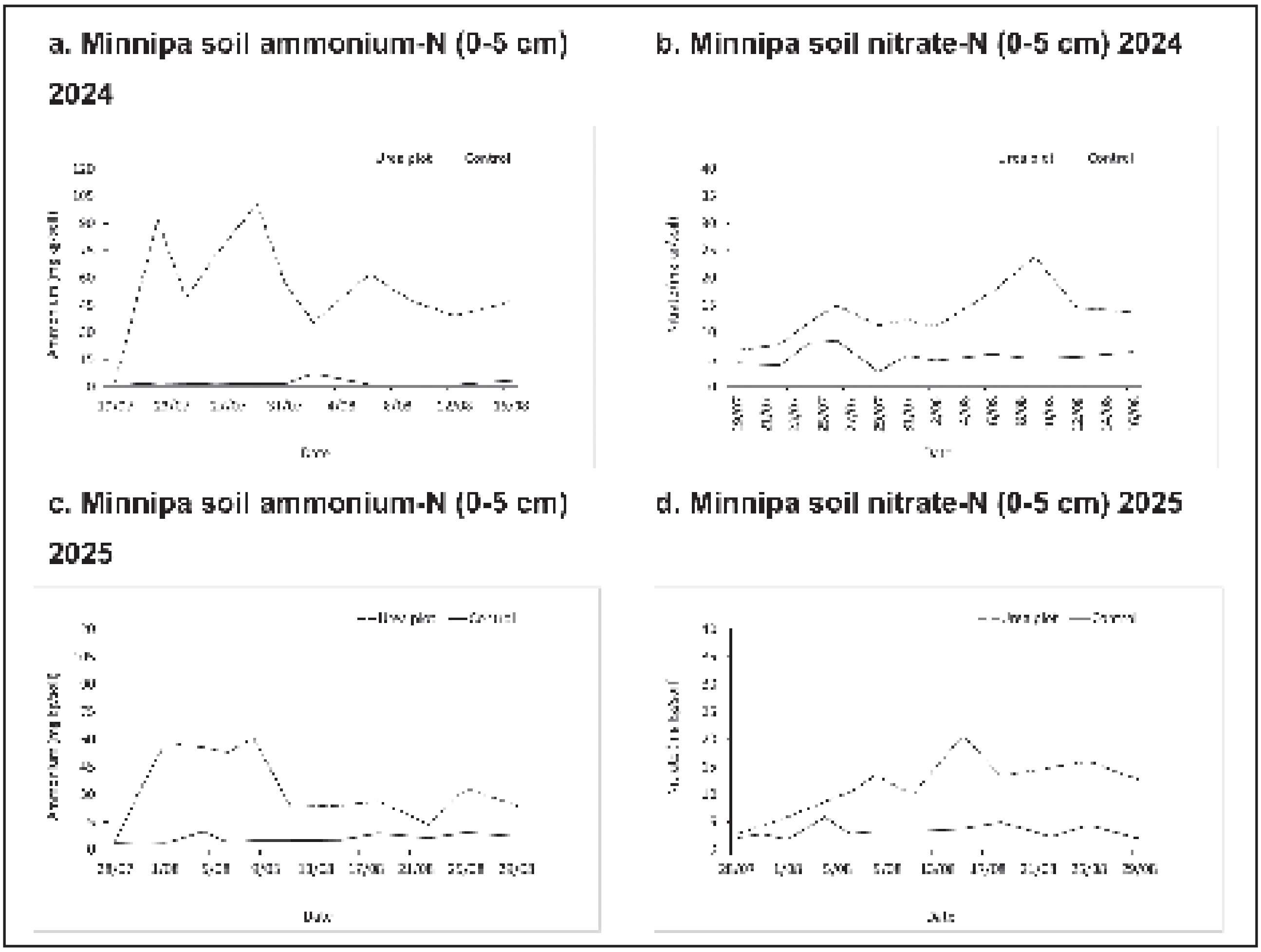


Figure 4. Ammonium-N and nitrate-N in surface soil (0-5 cm) following urea top-dressing over the experimental period at Minnipa.

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

Overall, most NH_3 losses occurred within the first two weeks following urea application, emphasising this as the critical period for volatilisation. Soil ammonium levels in the urea-treated plots corresponded with this pattern, peaking between 10 and 15 days after application-indicating that urea hydrolysis was largely complete by this time-before gradually declining with some fluctuations (Figures 3 and 4). Soil nitrate levels in the urea plots gradually increased throughout the trial as ammonium was converted to nitrate, although this accumulation was moderated by crop uptake. Both ammonium and nitrate levels in the background plots remained relatively low and stable over the sampling period (Figures 3 and 4).

What does it mean ?

Soil characteristics strongly influence ammonia volatilisation losses from top-dressed urea:

- Across both seasons, N lost as NH_3 as a % of the applied N were consistently higher on a Calcarosol (Minnipa) compared with a Vertosol (Horsham), although N application rate was higher with the Vertosol (80 kg N/ha vs. 50 kg N/ha). The lower losses on the Vertosol are largely attributed to its high clay content (45%) and greater CEC. In contrast, low clay (18%) Calcarosol, with the dominance of Ca^{2+} ions, presence of free calcium carbonate, and limited water-holding capacity, was more prone to volatilisation.

Weather conditions at the time of and following urea application affect volatilisation:

- Higher wind speeds and light rainfall on the day of urea application at Minnipa in 2024 exacerbated losses by leaving urea near the soil surface and allowing rapid volatilisation. In 2025, greater rainfall on the day of application, coupled with lower winds, maintained surface soil moisture and reduced NH_3 losses. At Horsham, even a substantial rainfall event later in the sampling period (26 mm on day 10, 2025) did not affect total NH_3 emissions compared with 2024, as most volatilisation had already taken place before the rainfall.

Most NH_3 losses happen quickly:

- Ammonia losses largely occurred within the first two weeks after urea application, highlighting the critical period for volatilisation.

Implications for N management:

- The findings reinforce that both soil type and seasonal weather conditions should be considered when planning operation for broadcasting urea. On sandy, low-clay Calcarosols under dry and windy conditions, strategies to reduce volatilisation-such as split applications or using urease inhibitors could be beneficial.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC project UOQ2204-010RTX, the author would like to thank them for their continued support. The authors also thank Agriculture Victoria and the South Australian Research and Development Institute (SARDI) for co-funding, as well as the Agriculture Victoria Horsham soil science technical team and SARDI MAC staff for their support throughout the project, which contributed to its successful completion.

References

Adhikari KP, Saggar S, Hanly JA, Guinto DF (2019) Comparing the effectiveness and longevity of the urease inhibitor N-(2-nitrophenyl) phosphoric triamide (2-NPT) with N-(n-butyl) thiophosphoric triamide (nBTPT) in reducing ammonia emissions from cattle urine applied to dairy-grazed pasture soils. Soil Research, 57(7), 719-728.

Fenn LB, Kissel DE (1975) Ammonia volatilization from surface applications of ammonium compounds on calcareous soils: IV. Effect of calcium carbonate content. Soil Science Society of America Journal, 39(4), 631-633.

Incitec Pivot Fertilisers (2024) Reducing nitrogen loss: Results from volatilisation trials across southern Australia. Green Urea NV® Trial Report 2024.

Tang YS, Cape JN, Sutton MA (2001) Development and types of passive samplers for monitoring atmospheric NO_2 and NH_3 concentrations. The Scientific World Journal.

Turner DA, Edis RB, Chen D, Freney JR, Denmead OT, Christie R (2010) Determination and mitigation of ammonia loss from urea applied to winter wheat with N-(n-butyl) thiophosphorictriamide. Agriculture, Ecosystems & Environment, 137(3-4), 261-266.

Wallace AJ, Armstrong RD, Grace PR, Scheer C (2022) Nitrogen use efficiency and N_2O emissions vary according to seasonal water supply across different cereal production systems of southeastern Australia. Geoderma Regional, 29, e00498.

Maximising barley biomass production in mixed farming systems through crop phenology and plant architecture

Brendan Kupke[1,2,3], Catherine Paterson[1], Kym Zeppel[1], Rhiannon K Schilling[2]

[1]SARDI; [2]Flinders University; [3]Adelaide University

Location
Minnipa
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2025 Total: 281 mm
2025 GSR: 228 mm
Paddock history
2024: Wheat
2023: Pasture
Soil type
Calcareous red sandy loam
Plot size
5 m x 1.6 m x 4 reps
Trial design
Split-split plot design with 2 times of sowing x 4 grazing treatments x 8 varieties blocked by replicate

Key messages

- **In the early time of sowing (TOS 1), Beast, Maximus CL, Newton and Titan AX were able to maintain the same grain yield in both grazing treatments (Z30 and Up to Z30) compared to the ungrazed control.**
- **Early sowing resulted in higher grain yields than later sowing, with Neo CL (TOS 1) and Beast (TOS 2) the best yielding barley varieties in un-grazed treatments.**
- **The winter phenology types of Newton and AGTB1010 produced the highest amount of Z30 dry matter (DM), with AGTB1010 producing significantly higher grain yields than Newton and is potentially better suited to the Eyre Peninsula LRZ.**
- **Erect plant architecture types are showing less early vigour and biomass, with semi prostrate and tall types providing increased dry matter.**
- **Beast with a simulated graze at Z30 in TOS 1 achieved a grain yield of 4.27 t/ha and had 0.9 t/ha of dry matter removed in a decile 1 autumn.**

Why do the trial?

Barley is a versatile species for mixed farming systems because it offers opportunities for fast biomass production for livestock feed, as well as reliable grain production in the low rainfall zone (LRZ). Previous work has demonstrated the benefits of wheat and to a lesser extent barley, in providing dual purpose (graze and grain) crops that maximise gross margins in the medium-high rainfall zones. Other recent work with wheat in the LRZ has shown the value of early sowing of slower developing winter wheats as grain crops. The release of new winter barley phenologies, as well as different canopy architecture types, may provide more opportunities to maximise barley biomass for forage, grain, or opportunistic grain and graze scenarios in the LRZ. The aim of this SA Discovery Farms and SAGIT funded project is to identify opportunities to exploit new barley phenologies and architecture types to further improve mixed farming production across variable growing seasons and environments. Replicated field trials are located at Minnipa, Loxton, Tarlee and Struan, with 2025 being the second season of experiments.

How was it done?

A field trial was established on Minnipa Ag Centre with two times of sowing in 2025. The first TOS was irrigated to ensure early germination and establishment due to the extended dry start to the growing season. The equivalent of 20 mm rainfall was applied through pressurised dripper lines in each furrow. TOS 1 was sown on the 28 April and irrigated on 1 May and TOS 2 was dry sown on 22 May with germination occurring with season breaking rains on 12 June (10 mm).

Eight barley varieties were selected that varied in both phenology and plant architecture, with a summary of each in Table 1. Sowing rates were targeted at 150 plants/m^2. Starting soil mineral nitrogen (approx. 120 kg N/ha) plus 80 kg/ha of DAP applied at sowing was sufficient to maintain optimal nutrition. Four different grazing treatments represented different uses for barley in mixed farming systems. A summary of each treatment is presented in Table 2, where a mower was used to simulate grazing for each grazing treatment.

Table 1. Barley varieties at Minnipa in 2025 with relative plant type, maturity and release year.

Variety	Plant Type	Maturity Group	Release year
Beast	Tall	Quick Spring	2020
Neo CL	Semi-prostrate	Mid Spring	2023
Kraken	Semi-prostrate	Mid Spring	2021
Maximus CL	Erect	Quick-Mid Spring	2020
Newton	Prostrate	Slow Winter	2023
Titan AX	Tall	Mid-Slow Spring	2022
AGTB1010	Semi-prostrate	Winter	Breeding line
Cyclops	Erect	Quick-Mid Spring	2022

Table 2. Four grazing treatments used at Minnipa with the farming system scenario, activities performed and projected outcomes of each. Z30 = start of stem elongation.

Grazing Treatment	Scenario	Grazing Activity	Outcome
Untreated control (UTC)	Grain	None, managed as grain crop	Grain yield
Up to Z30	Rotational Grazing to Z30 and Grain	Multiple grazes before Z30 (3-4 leaf stage, tillering and start stem elongation), before being left for grain	Value of longer phenological vegetative phase of winter types and final grain yield
Z30	Graze and Grain	Single graze at Z30, before being left for grain	Total vegetative biomass production value and final grain yield
Forage	Continuous Grazing	Repeated grazing at regular time intervals during the growing season	Total seasonal biomass/forage production value for each variety (re-growth potential)

The main measurements taken and discussed within this report are flowering time, Z30 growth staging, dry matter (DM) removed from each grazing, feed quality and grain yield. Quadrat cuts were conducted on plots immediately before being mowed, representing the amount of biomass removed per m^2. The trial was a split-split plot design with TOS being the main plot, grazing treatment the sub plot and variety being the sub-sub plot with four replicates. Data was analysed spatially using a linear mixed model (REML) through statistical package GenStat 23rd Edition at the 5% significance level and by multiple comparisons through a Bonferroni test.

What happened?

Variety influences grain yield recovery following grazing.

Final grain yields were considerably higher in 2025 (2.43 t/ha site mean) compared to 2024 (0.91 t/ha site mean) with early sowing yielding higher than later sown. In TOS 1, Beast, Maximus CL, Newton, Kraken and Titan AX had similar grain yields in both grazing treatments (Z30 and Up to Z30) to ungrazed. This was consistent with trial results from 2024 (EPFS Summary 2024 p. 75). Neo CL was the highest yielding variety across all grazing treatments in TOS 1, but it had reduced grain yield for the Up to Z30 treatment compared to the UTC. Beast and Titan AX are both 'Tall' plant types that have high growth rates (see below) that may be aiding their recovery post grazing.

However, in 2024 the semi prostate types of Neo CL and RGT Planet were the standouts for graze and grain indicating a potential growing season influence.

In TOS 2, in contrast to 2024, there was a general reduction in grain yield following grazing compared to the UTC. The reduction in TOS 2 was due to the simulated grazing occurring later than Z30 for the spring types. This resulted in the developing head on primary tillers being grazed off. In addition, the drier spring conditions (decile 3 spring rainfall) with warmer temperatures hindered re-growth across both times of sowing. However, there were some varieties that maintained similar grain yields following grazing (Table 3), including Kraken and Newton.

Table 3. Grain yield of 8 barley varieties for two TOS and two grain and graze treatments at Minnipa in 2025. UTC representing un-grazed plots, Z30 a single simulated graze at the start of stem elongation then left for grain, and Up to Z30 representing multiple grazes from the 3-4 leaf stage until the start of stem elongation before being left for grain. Different letters represent statistically significant differences between treatments.

Grain Yield (t/ha)	TOS 1			TOS 2		
Variety	**UTC**	**Z30**	**Up to Z30**	**UTC**	**Z30**	**Up to Z30**
AGTB1010	4.12 $^{q-u}$	3.33 ^{mnop}	3.63 $^{o-s}$	2.58 ^{jkl}	1.26 $^{d-h}$	1.73 ^{ghi}
Beast	4.47 ^{tu}	4.27 ^{stu}	3.88 $^{p-t}$	3.39 $^{n-q}$	0.93 $^{a-e}$	1.32 $^{d-h}$
Cyclops	4.45 ^{tu}	3.78 $^{p-t}$	3.52 $^{n-r}$	2.83 $^{k-n}$	0.90 $^{a-e}$	1.31 $^{d-h}$
Kraken	1.95 ^{hij}	2.14 ^{ijk}	2.08 ^{ij}	1.06 $^{b-g}$	0.63 $^{a-d}$	0.96 $^{b-e}$
Maximus CL	4.30 ^{stu}	4.05 $^{q-u}$	3.58 $^{o-s}$	2.94 $^{l-o}$	0.82 $^{a-e}$	1.20 $^{c-g}$
Neo CL	4.72 ^{u}	4.31 ^{stu}	3.93 $^{p-t}$	2.65 $^{j-m}$	1.01 $^{b-g}$	1.43 $^{e-i}$
Newton	0.52 ^{abc}	0.97 $^{b-f}$	0.80 $^{a-e}$	0.17 ^{a}	0.52 ^{abc}	0.40 ^{ab}
Titan AX	4.16 $^{r-u}$	4.08 $^{q-u}$	3.84 $^{p-t}$	2.92 $^{l-o}$	1.13 $^{b-g}$	1.68 $^{f-i}$
P-value (TOS x grazing x variety)	*<0.001*					

The slow winter type, Newton, struggled again under both TOS, being significantly lower yielding across all treatments than every other variety, including the forage variety Kraken. The second winter type, breeding line (AGTB1010), had a competitive grain yield in TOS 1 UTC treatment compared to the spring lines (Table 3). This breeding line flowered much earlier than Newton (approximately one month earlier) with early sowing. Even in TOS 2, AGTB1010 produced reasonable grain yields, despite later emergence compared to the spring types, which are normally better suited, whilst Newton struggled to fill any grain at all due to the late finish. However, AGTB1010 did not maintain grain yield in the Z30 grazing treatment compared to the UTC, with less time to recover before warmer and drier spring conditions on the upper EP. This sharper growing season shut off compared to other medium to high rainfall environments is likely to be the main factor preventing the slow winter Newton from achieving higher grain yields. Further investigation of earlier sowing into early April would be beneficial in determining if earlier establishments could help lower the risk of heat and moisture stress late in the season.

Winter barley has a prolonged vegetative phase and increased vegetative DM

The variation in relative development between the springs and winters was evident from the timing of Z30. AGTB1010 and Newton reached Z30 two and four weeks later respectively than the spring types due to their vernalisation requirement delaying the transition to reproductive development. This phenology influence created some significant differences in vegetative DM as shown in Table 4, especially for Newton, which was significantly higher than many spring types at 1.05 t/ha DM. However, the slower development of Newton meant that it only reached awn peep on 1 Oct, significantly later than all other varieties and coinciding with increased spring temperatures and drier conditions. This likely caused the lower grain yields mentioned previously (Table 3). AGTB1010 produced competitive grain yields to spring types unlike Newton, a trend seen at other field trials in the project. The other advantage with winters in grazing systems, is the relatively later increase in neutral detergent fibre and acid detergent fibre, as well as later decrease in crude protein in the DM, that reduces livestock feed quality. These parameters normally increase during stem elongation, marking a decline in feed quality as observed at sites in 2024. With winters reaching Z30 later, it is likely the quality of the feed on offer would have remained high for longer compared to the springs that progressed through from tillering to stem elongation quickly.

The earliest simulated grazing was performed at the 3-4 leaf stage (plant anchoring) and late tillering/start of stem elongation to identify varieties with high early growth rates which could help fill the autumn feed gap. With the very dry conditions until mid June, there was little DM removed, and a high level of variability (Table 5). Similar to the 2024 trial, Beast and Titan AX were stronger performers, although the slow winter Newton produced the most DM at the first time point of 0.12 t/ha DM. There was strong regrowth following the first simulated graze, aided by season breaking rains.

Table 4. Total vegetative dry matter (DM) removed in a single simulated graze at Z30 in TOS 1 for each variety at Minnipa in 2025. Statistically significant differences between varieties are represented by different letters. The dates for the start of stem elongation (Z30) and awn peep (Z49) for TOS 1 are included.

Variety	Vegetative dry matter removal (t/ha)	Z30	Z49
AGTB1010	0.90 ab	16 Jul	2 Sep
Beast	0.87 ab	30 Jun	18 Aug
Cyclops	0.82 ab	30 Jun	21 Aug
Kraken	0.61 a	6 Jul	28 Aug
Maximus CL	0.71 a	1 Jul	20 Aug
Neo CL	0.61a	3 Jul	24 Aug
Newton	1.05 b	1 Aug	1 Oct
Titan AX	0.60 a	4 Jul	25 Aug
P-value (variety)	*0.05*		

Table 5. Dry matter removed for TOS 1 for the first (3-4 leaf stage) and second (late tillering-start stem elongation) simulated grazing events. Different letters represent significant differences in DM removal between varieties.

Dry Matter (t/ha)	TOS 1	
Variety	**1st Graze (1 June)**	**2nd Graze (3 July)**
AGTB1010	0.062 ab	0.91 a
Beast	0.080 ab	0.81 a
Cyclops	0.049 ab	0.69 a
Kraken	0.047 a	0.74 a
Maximus CL	0.041 a	0.81 a
Neo CL	0.026 a	0.96 a
Newton	0.118 b	0.41 a
Titan AX	0.073 ab	0.96 a
Means	**0.062**	**0.86**
P-value (variety)	*<0.001*	*0.041*

The amount of re-growth grazed off at the second time point in early July was up to 1 t/ha of DM (Table 4). There was considerable variation across replicates that resulted in no differences between varieties for the second cut. However, Titan AX and Neo CL had the highest DM and Newton the lowest, falling behind following the first graze under cooler temperatures in June. The only pure forage bred variety in the trial, Kraken, had consistently lower DM across both timings, which was also observed in the 2024 trial.

The total seasonal grazing value represented by the forage grazing treatment varied less across varieties than it did in 2024. The range in total seasonal DM production was 0.7 t/ha (Figure 1). This demonstrates that all barley varieties provided useable feed for livestock grazing. There was some consistency from the 2024 season, where the erect plant types of Cyclops and Maximus CL performed similarly and were at the lower end of the seasonal DM totals. In addition, Kraken struggled with the lower rainfall totals, and likely warmer temperatures during winter unlike the higher rainfall zones where it is more suited. Neo CL and Titan AX were the best performers and both previously ranked in the top 3 varieties for DM production in 2024. AGTB1010 had good re-growth throughout the season and seems to be bridging the gap between Newton and the rest of the vigorous spring types (prostrate and tall varieties). Beast ranked best in 2024 and had good early vigour, however it did seem to have a drop off in re-growth following the second to last cut, as evident in Figure 1. This reduced growth in Beast late in the season has also been observed at other higher rainfall sites with longer growing seasons, such as Tarlee and Struan, in this project. Being the quickest developing variety in the trial, it would be the first variety to suffer from repeated grazing and removal of the developing apex. Additionally, it would also be the first variety to run out of soil moisture due its rapid early growth.

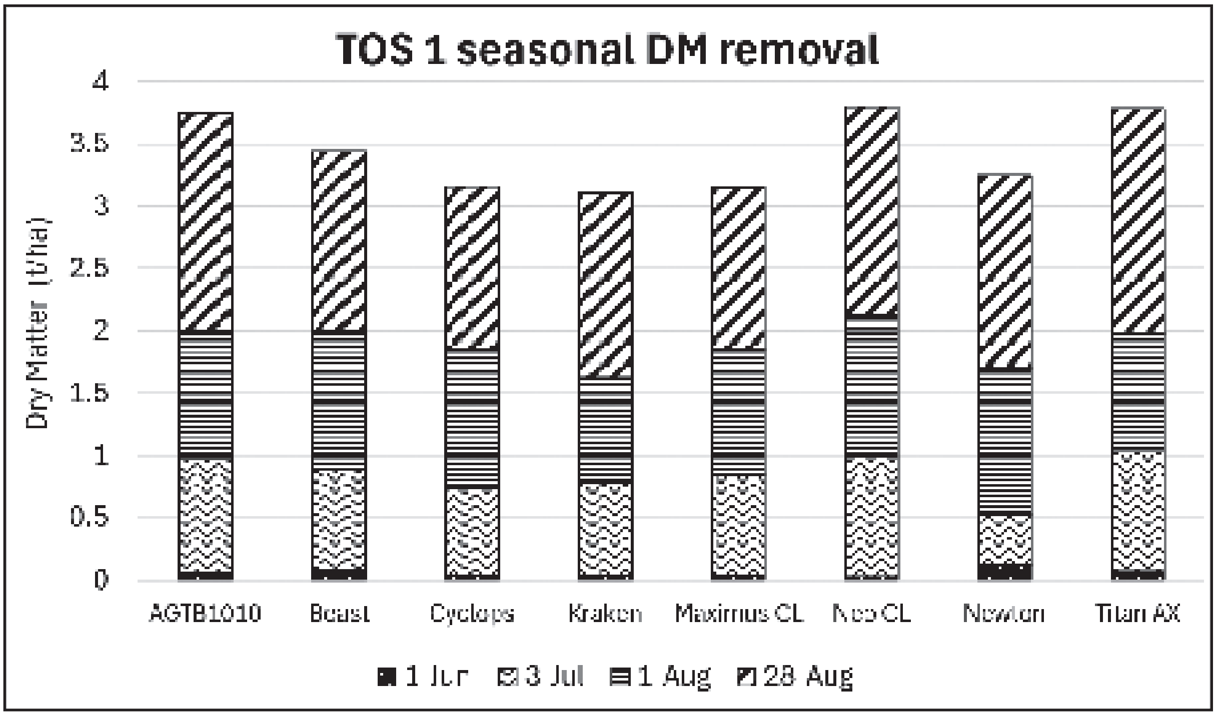


Figure 1. Total seasonal DM removed from the forage treatment in TOS 1 at Minnipa in 2025. Plots were grazed four times during the season (1 Jun, 3 Jul, 1 Aug, 28 Aug).

What does this mean?

The 2025 growing season had a dry start and finish, but a wet winter, resulting in higher growing season rainfall than 2024. This helped high yield potential varieties such as Neo CL, which was the highest yielding variety from TOS 1. However, its grain yield suffered following grazing in TOS 2, likely from the drier spring conditions hampering final biomass recovery and grain fill in the later sown varieties. In TOS 1, 50% of varieties handled the grazing pressure better and were able to maintain grain yield, namely Beast, Maximus CL, Newton and Titan AX; they also maintained grain yield in 2024. This demonstrates that there is an opportunity to provide early season feed for livestock on the upper Eyre Peninsula by grazing barley and removing them at the correct time to maintain grain yield. However, it was evident in TOS 2 that when grazing occurs past the latest optimal grazing growth stage of Z30, there will be significant grain yield reductions. This occurred across all elite spring varieties which had the developing apex removed. This highlights the importance of monitoring crop growth stages when grazing to remove livestock at the correct time. Additionally, it demonstrates the flexibility of a winter type in the graze and grain system, where it takes longer for these phenology types to reach Z30. This allows for both more grazing time and less chance of missing the critical growth stage for livestock removal.

The slow winter Newton performed only slightly better than in 2024 in terms of grain yield and still appears to be too slow in development to provide a profitable farming system option for the Upper EP. However, the addition of the quicker winter type AGTB1010 showed some promise in its first season of this project's trials. The UTC treatment of AGTB1010 was more than competitive in grain yield with elite spring grain types, although it did see a reduction in grain yield following grazing. Both varieties (Newton and AGTB1010) had the most vegetative DM, but not significantly more than other spring varieties. 2024 and 2025 growing seasons had a decile 1 autumn that would not be advantageous for winter types, which perform best on good early season rainfall and early germinations into April. Further understanding of an earlier April germination and good autumn rainfall would be beneficial in demonstrating the potential of winters on the EP, and whether there is a benefit compared to spring types. This would also test out how strong the vernalisation requirement is for AGTB1010 to determine how early it can be sown without bolting. This would also potentially spread the busy sowing window, by allowing early sowing/germinations with no increased frost risk due to the vernalisation requirement delaying reproductive development and flowering.

A decile 1 autumn for the second year in a row puts pressure on trying to fill the feed gap often experienced at this time of year. Beast was again a good performer in terms of early vigour and DM production early in the season, with its tall plant type potentially aiding in this as also seen with Titan AX. This was consistent with 2024 and what has been observed at other trial locations. Grain varieties performed as well as forage (Kraken) and dual-purpose varieties (Newton) in terms of early vigour, and total biomass production for grazing. However, the relatively short growing season from a late break and dry spring in the low rainfall zone, was not conducive for growth for either Kraken or Newton.

Acknowledgements

This project is supported by the SA Discovery Farms, through funding from the Australian Government's Future Drought Fund (Project ID: LTT 24 09) and South Australian Grain Industry Trust (SAGIT code: SAR5124). The authors would also like to thank AGT, Intergrain, Secobra/Seednet and S&W Seeds for grain provision as well as Balco for feed quality analysis. Thank you to the Minnipa Ag Centre staff including Katrina Brands, Tammie Mullen, Julian Post, Dr Buddhi Chaudhary, Marina Mudge, Cayley Gray and Brianna Guidera for their help with the field work, as well as Sharon Nielsen for designing the trial and assisting with statistical analysis.

De-risking the seeding program - early sowing and the performance of pre-seeding herbicides in wheat

Zhaohan (Elijah) Luo[1,2] and Amanda Cook[1,2,3]

[1]SARDI; [2]Adelaide University; [3]Flinders University

Location
Poochera (Karcultaby closest BOM site)

Rainfall
Av. Annual: 308 mm
Av. GSR: 210 mm
2025 Total: 265 mm
2025 GSR: 210 mm

Paddock History
2024: Calibre wheat
2023: Medic Pasture

Soil type
Calcareous sandy loam

Trial design
Split plot design x 3 reps x 2 blocks (TOS)

Plot size
12 m x 2 m

Key messages

- **TOS1 occurred on 24 April before a predicted rainfall event and TOS2 on 16 June after rainfall, with crop establishment being lower in TOS1 (8 weeks from seeding) compared to TOS2 by 29 plants/m^2.**
- **In 2025, crop establishment did not occur earlier with early and dry sowing so the advantage was only operational timeliness.**
- **There was no effect of herbicide treatments on plant establishment at either seeding times. Ideally weed seed banks would be low for dry sowing paddocks.**
- **All herbicides achieved some level of weed control in a high weed burden paddock compared to the Untreated control and the early post emergent (EPE) herbicide treatment.**
- **Mateno Complete 1 L/ha IBS, and Trifluralin 1.8 L/ha + Avadex (a.i.500 g) 1.6 L/ha + Sakura 118 g/ha IBS had the lowest weed numbers with early and dry sowing eleven weeks after sowing, however these are also the more expensive herbicide packages tested.**
- **There was a grain yield decrease of 0.18 t/ha with TOS1 but when ensuring timeliness of large seeding programs this maybe acceptable.**

Why do this trial?

Dry seeding is now an option which many farmers in the western and southern regions of Australia consider due to increased farm size, more variable breaks to the season and to make better use of all available water. In the 2025 season, most farming regions in southern Australia recorded well below average summer and autumn rainfall. Many farmers seeded a large portion of their program before the season break that occurred in mid-June. However, early and dry sown crops can be more vulnerable to water and nutrient deficiencies, higher soil temperature and pre-emergent herbicide toxicity, which may lead to patchy crop establishment.

The research reported here is to further fill knowledge gaps with dry sowing by investigating the effects of sowing time and early grass-control herbicides on crop establishment and yield of Calibre wheat on upper Eyre Peninsula (EP).

How was it done?

In 2025, a demonstration site with a split-plot design was conducted at Poochera in a calcareous sandy loam with a high burden of annual ryegrass with some brome grass and barley grass also present. The soil profile was dry prior to the first time of seeding (8-11% gravimetric water content in the top 80 cm on 11 June). Sowing with Primary Sales split system and press wheels took place on 24 April (TOS1) and 16 June (TOS2), with 75 kg/ha of Calibre wheat and 75 kg/ha of MAP banded below the seed. Herbicide treatments for early grass weed control were applied immediately prior to sowing at both times of sowing and were incorporated by seeding (IBS) (Table 1), except for Mateno Complete 1 L/ha EPE that was applied when plants reached 3 leaf stage (Z13).

Crop establishment, grass weed density and NDVI assessments were made on 24 June, 1 July, 10 July or 17 July. 50 kg/ha of urea was spread on all plots on 14 July. Treatment 6, Mateno Complete 1 L/ha EPE was applied on 11 July (Z13). Early biomass (Z30) cuts were taken on 18 August. Late biomass (Z70) was measured on 8 October. Harvest was undertaken on 10 December. Grain quality was assessed in January.

Table 1. Early season herbicide treatments at Poochera in 2025 on Calibre wheat.

Herbicide Treatments		Chemical Cost ($/ha)
1	Untreated	0
2	Sakura 118 g/ha IBS	$30
3	Overwatch 1.25 L/ha IBS	$43
4	Prosulfocarb 3 L/ha IBS	$24
5	Mateno Complete 1 L/ha IBS	$53
6	Mateno Complete 1 L/ha EPE (GS13)	$53
7	Trifluralin 1.8 L/ha + Metribuzin 100 g/ha IBS	$19
8	Trifluralin 1.8 L/ha + Avadex (a.i.500 g) 1.6 L/ha + Sakura 118 g/ha IBS	$61

What happened?

There was very little moisture available in the soil profile on the 11 June. In 2025 the first significant rainfall event was on 20 March with 19 mm, but only small events occurred in April (3.6 mm) and May (3.4 mm) that was not enough moisture for wheat to emerge. The first significant rainfall event to enable germination and seedling emergence was not until 12 June with 12 mm received. The late seasonal break resulted in most crops being dry sown followed by good winter rainfall (Karcultaby had 46 mm in June, 102 mm in July and 19 mm in August). October rainfall was 30 mm with cooler conditions which resulted in good grain fill and higher than expected yields in the area.

The season break in 2025 occurred on 12 June with 12 mm of rain and the growing season was a decile 4. The first time of sowing (TOS1) was undertaken on 24 April before a predicted rainfall event which ended up being only 1.5 mm, and TOS2 on 16 June after 12 mm of rainfall.

Wheat from TOS1 did not emerge until 24 June (8 weeks after sowing) with an average of 36 plants/m^2, but wheat in TOS2 had still to emerge. However, by 1 July crop establishment was the same for both times of sowing (Table 2). Herbicide treatments had impacted on crop establishment by 1 July with untreated and Prosulfocarb 3 L/ha IBS having the best crop establishment. Plant numbers were lowest with Overwatch 1.25 L/ha IBS and Trifluralin 1.8 L/ha + Metribuzin 100 g/ha IBS.

By 17 July, there was no effect of herbicide treatments on wheat plant density. On 17 July, wheat density in TOS1 was lower by 29 plants/m^2 than in TOS2 (Table 2).

Grass weed pressure was high at Poochera site with an average of 195 grass weeds/m^2 on 17 July. TOS1 had higher grass weed numbers compared to TOS2 at all samplings, indicating that herbicide activity from the later application timing was greater when rainfall finally fell. Untreated and Mateno Complete 1 L/ha EPE had higher grass weed numbers than most other herbicide treatments (Table 3 and Figure 2). By 17 July most herbicide treatments had reduced grass weed numbers compared to untreated and Mateno Complete 1 L/ha EPE.

At Z30, biomass from TOS1 was 0.2 t/ha more than TOS2. Trifluralin 1.8 L/ha + Metribuzin 100 g/ha IBS had lower biomass at both growth stages compared to untreated and Prosulfocarb 3 L/ha IBS.

Grain yield with TOS1 averaged 0.9 t/ha and 1.1 t/ha with TOS2. The Trifluralin 1.8 L/ha + Metribuzin 100 g/ha IBS and untreated treatment had similar and low yields (Table 5). Grain proteins were high in untreated and low with Overwatch 1.25 L/ha IBS, and Trifluralin 1.8 L/ha + Metribuzin 100 g/ha IBS treatments.

Table 2. Wheat density (plants/m²) in herbicide treatments at two times of sowing at 4 sampling times at Poochera in 2025. First time of sowing (TOS1) was 24 April and the second timing was 16 June. Treatments followed by the same letter are not statistically different.

Treatment	24 June		1 July		10 July			17 July	
	TOS1	TOS2	TOS1	TOS2	TOS1	TOS2	Average	TOS1	TOS2
1. Untreated	52	0	122	83	122	125	123 a	108	108
2. Sakura IBS	44	0	101	70	88	110	98 bc	82	100
3. Overwatch IBS	29	0	77	71	59	90	75 d	53	104
4. Prosulfocarb IBS	52	0	120	76	103	112	107 ab	91	107
5. Mateno Complete IBS	27	0	68	61	61	122	91 bcd	67	111
6. Mateno Complete EPE (GS13)	35	0	93	82	91	113	102 bc	83	102
7. Trifluralin + Metribuzin IBS	23	0	66	77	59	106	82 cd	72	100
8. Trifluralin + Avadex + Sakura IBS	25	0	68	67	65	136	100 bc	63	112
Average TOS	36 a	0 b	89	73	81 b	114 a		77 b	106 a
*LSD TOS*Herbicide (P = 0.05)*	*ns*		*ns*		*ns*			*ns*	
LSD TOS (P = 0.05)	*28*		*ns*		*28*			*28*	
LSD Herbicide (P = 0.05)	*ns*		*21*		*23*		*23*	*ns*	

Table 3. Grass weed density at 4 sampling times (plants/m²) in herbicide treatments at two times of sowing at Poochera, in 2025. First time of sowing (TOS1) was 24 April and the second timing was 16 June. *Treatment 6 applied on 11 July. Treatments followed by the same letter are not statistically different

Treatment	24 June		1 July		10 July		17 July	
	TOS1	TOS2	TOS1	TOS2	TOS1	TOS2	TOS1	TOS2
1. Untreated	276 a	42 e	340 a	72 cde	605 a	292 c	525 a	288 bc
2. Sakura IBS	101 d	37 e	152 b	50 de	253 c	93 efg	221cde	128 efgh
3. Overwatch IBS	158 bc	20 e	106 bc	43 de	145 def	160 de	152 efg	90 fgh
4. Prosulfocarb IBS	110 cd	16 e	150 b	27 e	324 c	56 fgh	360 b	69 gh
5. Mateno Complete IBS	32 e	40 e	48 de	49 de	100 def	69 fg	80 fgh	94 fgh
6. Mateno Complete EPE (GS13)*	200* b	40* e	334* a	58* cde	504* b	280* c	492 a	257 cd
7. Trifluralin + Metribuzin IBS	65 de	30 e	85 cd	21 e	175 d	41h	173 def	81 fgh
8. Trifluralin + Avadex + Sakura IBS	34 e	24 e	53 de	28 e	79 fg	32 h	69 gh	49 h
Average TOS	122	31	159	44	273	128	259	132
*LSD TOS*Herbicide (P = 0.05)*	*53*		*53*		*78*		*100*	
LSD TOS (P = 0.05)	*45*		*55*		*40*		*48*	
LSD Herbicide (P = 0.05)	*32*		*39*		*59*		*70*	

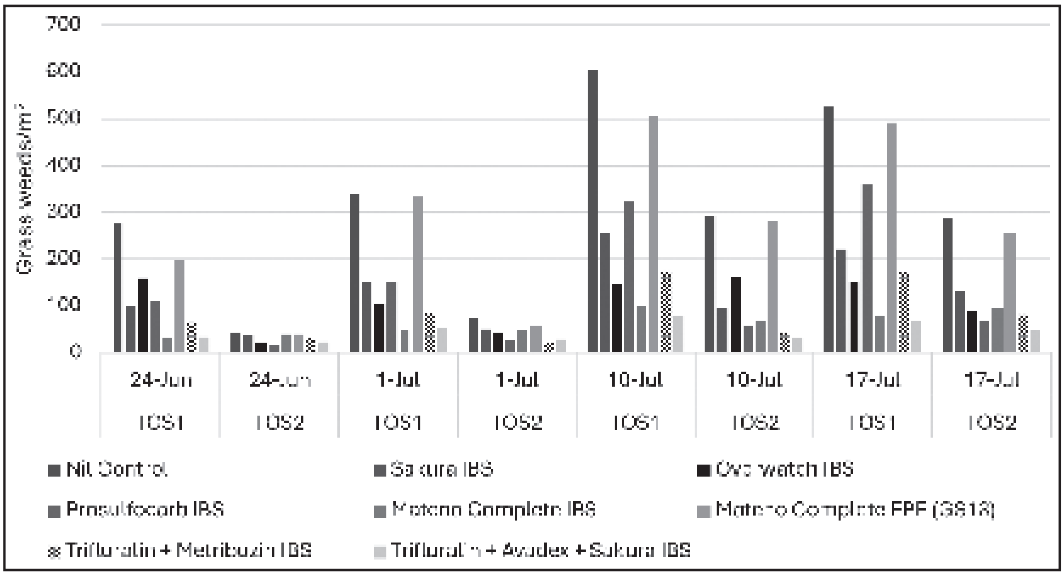


Figure 1. Grass weeds early in the season (plants/m²) in herbicide treatments at two times of sowing at Poochera in 2025. Treatment 6 Mateno Complete EPE applied on 11 July 2025 (GS13). See Table 3 for statistical analysis and more detail of treatments.

Table 4. Early (Zadoks growth stage 30, stem elongation) and late (Zadoks growth stage 70, early grain fill) biomass (t/ha) of wheat in herbicide treatments from two times of sowing at Poochera in 2025. First time of sowing (TOS1) was 24 April and the second timing was 16 June. Treatment 6 was applied on 11 July. Treatments followed by the same letter are not statistically different

Treatment	Z30 Biomass (t/ha)			Z70 Biomass (t/ha)	
	TOS 1	TOS 2	Average	TOS 1	TOS 2
1. Untreated	0.36	0.29	0.32 a	1.41 a	2.03 a
2. Sakura IBS	0.26	0.28	0.27 ab	1.81 a	2.30 a
3. Overwatch IBS	0.23	0.25	0.24 bc	1.91 a	2.24 a
4. Prosulfocarb IBS	0.40	0.34	0.37 a	1.82 a	2.38 a
5. Mateno Complete IBS	0.22	0.56	0.24 bc	2.06 a	2.66 a
6. Mateno Complete EPE (GS13)	0.22	0.22	0.22 bc	2.08 a	2.61 a
7. Trifluralin + Metribuzin IBS	0.27	0.08	0.17 c	1.91a	1.22 b
8. Trifluralin + Avadex + Sakura IBS	0.24	0.29	0.27 ab	1.96 a	2.76 a
Average TOS	0.27	0.25		1.87	2.29
*LSD TOS*Herbicide (P = 0.05)*	*ns*			*0.55*	
LSD TOS (P = 0.05)	*0.02*			*0.28*	
LSD Herbicide (P = 0.05)	*0.08*		*0.08*	*0.41*	

Table 5. Combined grain yield and protein of wheat in herbicide treatments from two different times of sowing at Poochera in 2025. Treatments followed by the same letter are not statistically different.

Treatment	Yield (t/ha)	Protein (%)
1. Untreated	0.81 bc	10.8 a
2. Sakura IBS	0.99 ab	10.6 ab
3. Overwatch IBS	1.28 a	10.2 b
4. Prosulfocarb IBS	1.05 ab	10.4 ab
5. Mateno Complete IBS	1.16 a	10.3 ab
6. Mateno Complete EPE (GS13)	1.10 a	10.3 ab
7. Trifluralin + Metribuzin IBS	0.69 c	10.2 b
8. Trifluralin + Avadex + Sakura IBS	0.93 ab	10.4 ab
LSD (P = 0.05)	*0.40*	*0.3*

What does this mean?

The 2025 season had a late and dry start to the season that resulted in seed and herbicides with early and dry seeding being in the soil for eight weeks before reasonable rains allowed emergence and herbicides to become active. The large gap between sowing and germination resulted in slower crop establishment and increasing seeding rates may be a tool to increase early plant numbers when sowing dry and early.

Neither times of sowing had a knock down herbicide applied, that is most often the situation when dry sowing, which places more pressure on the pre-emergent herbicides. The performance of pre-emergent herbicides is dependent on soil moisture, the persistence of the herbicide and the mobility of the herbicide in the soil that will depend on soil type. The low moisture conditions at TOS1 and the eight-week period before rainfall resulted in some herbicides that rely on soil moisture to be activated not performing as well in TOS1 as TOS2. However, all herbicides achieved some level of weed control in a high weed burden paddock compared to untreated and the early post emergent herbicide application.

There are large differences in the cost of herbicides and herbicide mixes (Table 1) so choosing herbicides depending on the timing of seeding, paddock weed burdens and potential to cause crop damage are important considerations. Mateno Complete 1 L/ha IBS, and Trifluralin 1.8 L/ha + Avadex (a.i.500 g) 1.6 L/ha + Sakura 118 g/ha IBS had the lowest weed numbers with early and dry sowing eleven weeks after sowing, however these are also the more expensive herbicides tested. Ensuring weed seed set and the seed bank are minimised every season is an important weed management tool.

Grain yields with early and drier seeding were 0.2 t/ha below seeding after the break but ensuring timeliness of large seeding programs in current farming systems is important to maximise plant growth and yield potential over the whole farm. In 2025 the exceptional winter rains and cooler than normal grain fill conditions may have resulted in better yields from the later seeding than might result in other seasons with poorer finishes.

Acknowledgement

This project 'Derisking the sowing program on EP in 2025' (DN1 25 02) addresses the South Australian Drought Hub priority themes of Farm planning and decision making to manage climate and operational risk and Soil and land management strategies, technologies, and innovations. This project is supported by the South Australian Drought Resilience Adoption and Innovation Hub, through funding from the Australian Government's Future Drought Fund, delivered by Agricultural Innovation & Research Eyre Peninsula (AIR EP) and SARDI.

Previous SA Drought Hub and Future Drought Fund projects were 'De-risking the seeding program - Adoption of key management practices for the success of dry early sown crops' (4-IMX2CLR) 2024 and 'Best practice for early sowing opportunities' with demonstration sites located at Cowell and Penong in 2022 and 2023 (DN1 23 03 and DN1 22 02).

Thank you to the grower for hosting the demonstration site, and to Kym Zeppel, Marina Mudge, Katrina Brands, Rebbecca Tomney and Cayley Gray for their assistance in completing field work.

Section 3

Crops

Section Editor:
Amy Keeley
SARDI, Port Lincoln

Table 1. Upper Eyre Peninsula 2025 NVT early break wheat trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**		
Nearest town	**Minnipa**		
Site Mean	**0.45**		
Variety	**t/ha**	**%**	**Test Weight kg/hectolitre**
AGT-Colt	2.65	101	81.53
AGT-Hamelin	2.97	113	83.53
AGT-Rio	2.58	98	82.02
Brighton	2.99	114	82.26
Brumby	2.59	98	82.25
Catapult	2.61	99	83.00
Denison	2.87	109	82.94
DS Bennett	2.39	91	83.05
DS Pascal	1.97	75	80.79
EG Titanium	2.04	78	79.52
EGA Wedgetail	2.48	94	80.00
Genie	2.82	107	82.63
Illabo	2.73	104	81.03
Longsword	2.98	113	83.61
LRPB Bale	2.35	89	84.99
LRPB Dual	2.57	98	82.93
LRPB Major	2.57	98	80.15
Mowhawk	2.98	113	82.87
PACKER	2.88	109	83.73
RockStar	2.57	98	81.59
Scepter	2.46	94	82.46
Sheriff CL Plus	2.40	91	82.51
Stockade	2.24	85	81.96
Tomahawk CL Plus	2.93	111	81.90
Valiant CL Plus	2.40	91	82.65
Wallaroo	2.62	100	83.12
Yitpi	2.37	90	83.15
CV (%)	5.16		
Probability	-		
LSD (t/ha)	0.23		
Sowing Date (*Dry Sown)	15/04/2025*		
Germination Rain Date[1]	17-Apr-25		

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Table 2. Eyre Peninsula 2025 NVT barley trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year. Continued over page

Region	Upper EP			Upper EP			Upper EP			Upper EP			Lower EP			Lower EP			Lower EP		
Nearest town	Darke Peak			Elliston			Minnipa			Piednippie			Cummins			Wanilla			Wharminda		
Site mean (t/ha)	2.35			4.66			2.33			2.23			5.73			5.87			3.20		
Variety	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL
AGT-Bunyip IA	2.28	97	71.25	4.81	103	72.04	2.35	101	71.68	2.02	91	69.34	5.89	103	70.84	6.35	108	73.80	3.46	108	70.27
Alestar	2.34	99	72.50	4.12	88	73.47	1.68	72	71.85	2.09	94	69.75	5.05	88	69.12	5.42	92	71.15	2.81	88	71.34
Beast	2.75	117	70.35	4.58	98	72.26	2.98	128	70.66	2.45	110	68.83	5.74	100	70.46	5.97	102	71.26	3.37	105	69.07
Bigfoot CL	2.34	100	71.04	4.54	97	72.37	2.46	105	72.86	2.14	96	69.68	6.18	108	70.23	6.08	104	71.68	3.43	107	69.50
Bottler	-	-	-	-	-	-	-	-	-	-	-	-	5.00	87	69.83	5.32	91	69.99	2.76	86	71.10
Buff	2.04	87	68.74	4.50	97	71.82	2.15	92	70.66	2.23	100	69.01	5.13	89	67.04	5.51	94	71.05	2.97	93	68.93
Combat	2.69	115	69.96	5.04	108	72.27	2.52	108	69.63	2.40	108	71.69	5.26	92	66.69	6.06	103	69.86	3.36	105	68.76
Commodus CL	2.33	99	70.68	4.50	97	71.36	2.59	111	71.47	2.31	104	67.63	5.64	98	68.99	5.32	91	70.81	3.29	103	69.27
Compass	2.65	113	73.05	4.34	93	70.69	2.74	117	71.45	2.41	108	68.52	5.96	104	68.38	5.27	90	70.28	3.24	101	69.14
Cyclops	2.36	101	72.19	4.44	95	70.92	2.43	104	71.82	2.48	111	71.29	6.09	106	70.32	6.22	106	71.19	3.40	106	70.63
Fathom	2.32	99	70.81	4.01	86	69.26	2.69	115	69.70	2.12	95	67.71	5.10	89	67.69	5.39	92	69.91	3.25	101	68.50
Granite CL	2.34	99	71.04	4.67	100	71.72	2.31	99	69.85	2.21	99	70.15	6.12	107	69.98	6.21	106	72.34	3.41	106	69.60
Laperouse	2.15	91	70.50	4.04	87	71.71	2.21	95	71.90	2.10	94	69.26	6.28	110	70.74	5.47	93	72.28	3.27	102	70.33
Leabrook	2.52	107	70.60	4.45	95	69.57	2.60	112	71.64	2.32	104	67.35	5.90	103	68.11	5.73	98	71.53	3.42	107	69.98
Maximus CL	2.35	100	71.10	4.93	106	74.09	2.50	107	71.44	2.16	97	70.18	6.01	105	71.62	6.22	106	73.16	3.46	108	70.73
Minotaur	2.41	103	70.26	4.66	100	72.51	2.12	91	71.56	2.26	101	68.16	6.21	108	70.92	6.34	108	72.51	3.21	100	71.30
Neo CL	2.33	99	71.31	5.46	117	70.11	1.98	85	72.39	2.12	95	67.85	6.33	110	66.06	6.43	110	67.37	3.23	101	68.01
PegasusAX	2.02	86	71.83	4.60	99	72.26	2.17	93	72.51	2.18	98	69.57	5.43	95	69.33	6.23	106	71.91	3.24	101	69.88

Table 2. continued. Eyre Peninsula 2025 NVT barley trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**			**Upper EP**			**Upper EP**			**Upper EP**			**Lower EP**			**Lower EP**			**Lower EP**		
Nearest town	**Darke Peak**			**Elliston**			**Minnipa**			**Piednippie**			**Cummins**			**Wanilla**			**Wharminda**		
Site mean (t/ha)	**2.35**			**4.66**			**2.33**			**2.23**			**5.73**			**5.87**			**3.20**		
Variety	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**
RGT Asteroid	-	-	-	-	-	-	-	-	-	-	-	-	5.17	90	69.35	5.57	95	70.31	2.65	83	70.95
RGT Atlantis	-	-	-	-	-	-	-	-	-	-	-	-	5.45	95	68.47	5.49	94	70.48	2.52	79	69.50
RGT Planet	2.08	89	71.01	4.69	100	70.22	1.52	65	71.08	2.03	91	68.69	5.23	91	67.34	5.69	97	68.99	2.78	87	69.62
Rocket CL	2.52	107	69.94	4.78	102	71.13	2.74	118	69.64	2.05	92	68.35	6.34	111	71.04	5.95	101	72.61	3.60	112	68.61
Rosalind	2.38	101	72.07	4.86	104	71.71	2.45	105	71.13	2.29	103	69.51	5.56	97	68.99	6.11	104	72.18	3.53	110	69.90
Scope CL	2.00	85	71.20	4.21	90	72.82	1.83	79	70.85	2.05	92	69.28	-	-	-	-	-	-	-	-	-
Spartacus CL	2.14	91	71.57	4.28	92	72.53	2.23	95	72.15	2.06	92	71.41	5.57	97	72.13	5.67	97	73.70	3.29	103	69.77
Spinnaker	2.41	103	71.47	4.94	106	70.16	2.15	92	70.87	2.16	97	68.16	5.83	102	67.21	5.76	98	67.07	3.29	103	67.83
Titan AX	2.31	98	70.21	4.44	95	72.84	2.32	99	70.73	2.29	103	65.97	5.29	92	66.83	5.74	98	69.07	3.24	101	69.22
Zena CL	2.14	91	69.84	5.35	115	69.24	1.70	73	69.59	2.09	94	68.08	5.45	95	65.50	5.79	99	68.45	3.02	94	69.27
CV (%)	3.65			4.05			4.19			6.53			5.15			3.82			4.17		
Probability	-			-			-			-			-			-			-		
LSD (t/ha)	*0.15*			*0.32*			*0.17*			*0.24*			*0.48*			*0.38*			*0.23*		
Sowing Date (*Dry Sown)	11-Jun-2025*			13-June-2025			21-May-2025*			13-Jun-2025			29-May-2025			30-May-2025			10-Jun-2025		
Germination Rain Date[1]	24-Jun-2025			-			12-Jun-2025			-			-			-			-		

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Table 3. Upper Eyre Peninsula 2025 NVT wheat trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year. *Continued next page*

Region	Upper EP			Upper EP			Upper EP			Upper EP			Upper EP			Upper EP			Upper EP		
Nearest town	Kimba			Minnipa			Mitchellville			Nunjikompita			Penong			Piednippie			Warramboo		
Site mean (t/ha)	3.39			2.07			3.21			0.68			1.50			2.10			2.46		
Variety	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL
AGT-Colt	3.39	100	84.14	1.90	92	84.61	3.05	95	84.32	0.55	81	83.24	1.35	90	83.98	2.13	101	85.61	2.15	87	81.94
Ballista	3.33	98	82.49	2.24	108	82.23	3.46	108	85.31	0.77	114	79.98	1.71	114	83.99	2.20	105	84.31	2.56	104	79.24
Boree	3.43	101	82.97	2.05	99	83.46	3.17	99	85.23	0.68	101	81.94	1.55	104	83.41	2.23	106	85.35	2.50	102	80.43
Brumby	3.46	102	81.75	2.05	99	83.72	3.35	104	84.73	0.73	108	81.38	1.60	107	83.35	2.27	108	83.82	2.37	96	79.74
Calibre	3.71	109	82.17	2.34	113	82.28	3.63	113	85.00	0.73	108	80.26	1.74	116	82.08	2.21	105	82.68	2.66	108	79.81
Catapult	3.50	103	83.69	2.02	97	84.43	3.17	99	86.08	0.62	92	82.92	1.44	96	84.82	2.04	97	85.46	2.56	104	81.79
Chief CL Plus	3.36	99	82.80	1.73	83	82.29	2.89	90	84.70	0.59	87	79.42	1.22	81	82.73	2.05	98	84.15	2.20	89	80.80
Dale	3.66	108	83.84	2.06	99	84.64	3.43	107	86.35	0.63	93	81.55	1.57	104	83.91	2.07	99	85.30	2.63	107	81.76
Dozer CL Plus	3.31	98	82.08	2.00	97	82.04	3.27	102	84.30	0.60	88	80.02	1.47	98	82.76	2.11	100	83.17	2.36	96	80.14
EG Titanium	3.08	91	82.55	1.90	92	81.58	2.81	87	83.22	0.62	92	81.28	1.25	83	81.77	2.04	97	83.06	1.89	77	80.89
Genie	3.09	91	83.45	1.88	91	81.93	2.94	92	86.06	0.67	99	81.89	1.34	89	83.46	2.06	98	85.70	2.21	90	79.64
Hammer CL Plus	3.33	98	83.60	1.96	95	83.04	3.11	97	86.40	0.76	112	80.88	1.43	95	82.85	2.15	103	84.49	2.32	95	80.62
Kestrel	3.29	97	84.57	2.26	109	83.33	3.05	95	85.08	0.71	105	81.45	1.58	105	84.23	1.98	94	84.84	2.40	98	80.01
LRPB Anvil CL Plus	3.38	100	85.05	2.08	100	84.79	2.72	85	85.25	0.71	104	82.86	1.55	104	86.02	2.04	97	85.73	2.66	108	82.29
LRPB Dual	2.98	88	84.34	1.98	95	83.24	3.02	94	85.26	0.64	95	81.42	1.34	89	83.91	1.86	89	85.43	2.01	82	80.77
LRPB Major	3.43	101	85.27	1.99	96	84.30	2.98	93	85.39	0.70	104	80.98	1.45	96	83.73	2.02	96	85.95	2.52	103	82.54
LRPB Matador	3.45	102	82.22	2.25	108	83.66	3.47	108	86.25	0.70	104	81.68	1.57	104	83.97	2.13	101	83.88	2.71	110	82.78
Mace	3.49	103	83.81	2.12	102	83.50	2.88	90	84.60	0.71	104	82.09	1.64	109	84.65	2.09	100	84.78	2.45	100	82.06
Murray	3.58	105	83.14	2.17	104	82.68	3.54	110	85.84	0.64	94	81.22	1.58	105	83.53	2.17	103	83.13	2.59	105	80.87
Razor CL Plus	3.33	98	84.86	2.20	106	84.59	2.95	92	84.73	0.75	110	82.72	1.59	106	85.05	2.13	101	84.69	2.63	107	81.31

Table 3. continued. Upper Eyre Peninsula 2025 NVT wheat trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**			**Upper EP**			**Upper EP**			**Upper EP**			**Lower EP**			**Lower EP**			**Lower EP**		
Nearest town	**Darke Peak**			**Elliston**			**Minnipa**			**Piednippie**			**Cummins**			**Wanilla**			**Wharminda**		
Site mean (t/ha)	**2.35**			**4.66**			**2.33**			**2.23**			**5.73**			**5.87**			**3.20**		
Variety	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**
Reilly	3.09	91	84.04	2.06	99	84.44	2.76	86	86.10	0.73	107	82.89	1.44	96	84.60	1.94	92	86.02	2.13	86	81.02
RGT Marsh	3.60	106	83.97	2.18	105	83.87	3.21	100	85.08	0.72	106	80.70	1.61	107	83.10	2.21	105	84.81	2.67	109	81.24
RockStar	3.44	101	83.06	1.94	94	83.99	3.07	95	83.45	0.70	104	80.97	1.47	98	83.21	2.18	104	85.04	2.36	96	81.19
Scepter	3.56	105	84.28	2.17	105	85.45	3.47	108	85.69	0.72	107	81.84	1.66	111	84.32	2.26	108	85.43	2.85	116	82.65
Sheriff CL Plus	3.09	91	82.43	1.73	83	83.04	2.90	90	83.97	0.63	92	80.54	1.27	84	83.29	1.97	94	84.98	2.21	90	80.68
Shotgun	3.63	107	82.54	2.26	109	84.64	3.61	112	85.11	0.75	110	81.85	1.59	106	83.55	2.35	112	84.89	2.62	107	81.10
Soaker	3.44	101	84.92	1.96	95	85.14	3.40	106	86.47	0.63	92	80.80	1.56	104	84.40	2.00	95	85.74	2.60	106	83.26
Sunblade CL Plus	3.33	98	84.35	2.00	96	83.77	3.04	95	85.18	0.76	111	82.46	1.43	95	81.98	2.06	98	84.92	2.47	100	82.09
Sunmaster	3.29	97	85.95	2.00	97	84.03	3.13	97	85.18	0.70	104	81.88	1.24	82	82.65	1.97	94	85.59	2.30	93	82.89
Tomahawk CL Plus	3.75	110	83.42	2.38	115	84.66	3.59	112	85.39	0.74	110	81.33	1.83	122	83.17	2.29	109	84.50	2.82	115	81.98
Vixen	3.40	100	81.59	2.16	104	82.03	3.30	103	83.68	0.68	100	80.35	1.62	108	82.50	2.07	99	83.41	2.65	108	80.01
Yitpi	3.20	94	85.07	1.80	87	84.38	2.87	89	84.66	0.51	76	82.72	1.23	82	84.10	1.95	93	85.75	2.04	83	81.90
CV (%)	2.63			2.92			2.48			4.53			5.28			3.66			7.15		
Probability	-			-			-			-			-			-			-		
LSD (t/ha)	*0.15*			*0.11*			*0.14*			*0.05*			*0.14*			*0.13*			*0.30*		
Sowing Date (*Dry Sown)	27-May-2025*			21-May-2025*			19-May-2025			03-Jun-2025*			30-May-2025*			13-Jun-2025			04-Jun-2025*		
Germination Rain Date[1]	06-Jun-2025			12-June-2025						12-Jun-2025			12-Jun-2025						14-Jun-2025		

[1]*Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.*

Table 4. Lower Eyre Peninsula 2025 NVT wheat trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	Lower EP			Lower EP			Lower EP			Lower EP		
Nearest town	Cummins			Rudall			Wanilla			Wharminda		
Site mean (t/ha)	5.75			3.11			4.50			2.98		
Variety	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL	t/ha	%	Test Weight kg/hL
AGT-Colt	5.69	99	84.51	3.06	99	85.74	4.71	105	84.16	3.05	102	81.57
Ascot	5.40	94	84.46	2.64	85	82.93	3.90	87	84.17	2.67	90	79.81
Ballista	5.73	100	81.50	3.29	106	83.38	4.29	95	82.68	3.01	101	77.52
Boa	5.89	102	81.35	3.01	97	83.55	4.35	97	82.74	2.97	99	78.23
Boree	5.84	102	81.64	3.08	99	83.89	4.28	95	83.21	3.02	101	79.79
Brumby	6.10	106	81.85	3.23	104	83.88	4.96	110	84.61	3.17	106	79.75
Calibre	5.84	102	81.50	3.51	113	83.50	4.85	108	82.96	2.95	99	76.02
Catapult	5.72	99	82.15	3.22	104	85.01	4.74	105	84.47	3.06	103	81.84
Chief CL Plus	5.70	99	82.70	2.66	86	82.75	4.32	96	83.32	2.96	99	79.80
Dale	6.18	107	83.00	3.50	113	85.36	5.38	119	85.24	3.38	113	80.88
Denison	6.15	107	83.77	3.05	98	84.71	4.69	104	84.92	2.91	97	82.12
Dozer CL Plus	5.45	95	81.23	2.99	96	82.73	4.19	93	83.08	2.89	97	77.97
EG Titanium	5.39	94	81.95	2.88	93	82.90	4.11	91	83.60	2.78	93	80.03
Genie	5.93	103	84.19	2.88	93	82.95	4.03	89	85.58	2.77	93	80.04
Hammer CL Plus	5.23	91	82.01	2.87	92	84.00	4.15	92	84.66	3.01	101	79.85
Ironbark	5.50	96	83.28	3.01	97	83.51	4.51	100	84.43	2.81	94	78.40
Kingston	5.70	99	84.03	2.88	93	84.86	4.75	105	86.44	2.92	98	80.44
LRPB Anvil CL Plus	5.50	96	84.43	2.95	95	84.76	4.46	99	85.52	2.83	95	80.86
LRPB Major	5.39	94	84.54	3.04	98	85.34	4.61	102	85.04	2.97	100	81.98
LRPB Matador	6.00	104	81.98	3.38	109	84.13	4.62	103	83.50	2.86	96	77.96
LRPB Trojan	5.89	103	85.81	2.78	89	85.61	4.19	93	85.55	2.75	92	82.91
Mace	5.38	94	83.09	2.99	96	83.58	4.31	96	83.81	3.06	103	79.65
Mowhawk	5.81	101	84.08	3.14	101	85.34	4.15	92	84.79	2.97	100	84.12
Murray	5.74	100	81.08	3.28	106	83.67	4.68	104	83.33	3.11	104	77.64
Razor CL Plus	5.36	93	83.56	3.01	97	84.50	4.13	92	84.71	2.91	97	81.13
Reilly	4.96	86	83.72	2.62	84	85.66	3.60	80	85.67	2.63	88	80.65
RGT Marsh	5.93	103	83.24	3.30	106	84.38	4.80	107	84.94	3.16	106	80.62
RGT Ponsford	5.94	103	82.73	3.16	102	83.17	4.93	109	83.04	2.95	99	78.75
RockStar	5.93	103	82.09	3.13	101	83.34	4.84	107	83.92	3.20	107	79.22
Scepter	5.88	102	83.42	3.38	109	85.10	4.29	95	85.20	3.16	106	80.41

Table 4. continued. Lower Eyre Peninsula 2025 NVT wheat trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Lower EP**			**Lower EP**			**Lower EP**			**Lower EP**		
Nearest town	**Cummins**			**Rudall**			**Wanilla**			**Wharminda**		
Site mean (t/ha)	**5.75**			**3.11**			**4.50**			**2.98**		
Variety	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**	**t/ha**	**%**	**Test Weight kg/hL**
Sheriff CL Plus	5.49	95	83.60	2.73	88	83.18	4.08	91	85.35	2.84	95	79.30
Shotgun	6.10	106	81.39	3.39	109	85.15	5.15	114	84.22	3.28	110	79.86
Soaker	5.91	103	82.80	3.39	109	85.27	4.32	96	85.64	3.06	103	81.41
Sunblade CL Plus	5.77	100	84.13	3.04	98	84.34	4.37	97	85.06	2.94	99	79.62
Sunmaster	6.22	108	85.30	2.94	95	85.31	4.25	94	85.61	2.94	99	81.68
Tomahawk CL Plus	6.21	108	82.33	3.46	111	85.24	4.85	108	84.41	3.35	112	79.19
Valiant CL Plus	5.61	98	85.72	2.86	92	85.54	4.57	101	86.28	2.79	93	82.88
Vixen	5.81	101	81.96	3.06	98	81.96	4.47	99	82.56	2.93	98	78.18
Yitpi	5.36	93	84.55	2.73	88	85.09	3.90	87	85.40	2.82	95	82.78
CV (%)	1.81			3.17			6.12			3.46		
Probability	-			-			-			-		
LSD (t/ha)	0.18			0.17			0.47			0.18		
Sowing Date (*Dry Sown)	29-May-25			5-Jun-25*			30-May-25			10-Jun-25		
Germination Rain Date[1]				18-Jun-25								

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Table 5. Eyre Peninsula 2025 NVT oat trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**		
Nearest town	**Nunjikompita**		
Site mean (t/ha)	**0.51**		
Variety	**t/ha**	**%**	**Test Weight kg/hL**
Archer	0.28	54	52.89
Bannister	0.59	116	54.35
Bilby	0.65	127	53.23
Durack	0.62	121	52.11
Goldie	0.61	118	54.05
Koala	0.50	98	54.82
Kowari	0.54	105	52.85
Kultarr	0.46	90	50.41
Minnie	0.50	98	54.86
Mitika	0.56	109	52.44
Williams	0.36	69	53.28
Yallara	0.57	112	54.58
CV (%)	10.20		
Probability	-		
LSD (t/ha)	*0.08*		
Sowing Date (*Dry Sown)	03-Jun-2025*		
Germination Rain Date[1]	12-Jun-2025		

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Crops

Table 6. Eyre Peninsula 2025 NVT field pea trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**			**Lower EP**		
Nearest town	**Minnipa**			**Murdinga**		
Site mean (t/ha)	**1.33**			**2.38**		
Variety	**t/ha**	**%**	**Seed Weight (g)**	**t/ha**	**%**	**Seed Weight (g)**
APB Bondi	1.46	110	20.70	2.83	118	19.01
GIA Kastar	1.07	80	20.12	1.98	83	20.53
Kaspa	1.39	104	19.77	2.52	106	19.37
PBA Butler	1.25	94	18.65	2.52	105	18.83
PBA Gunyah	1.38	103	19.95	2.26	95	19.68
PBA Noosa	1.25	93	20.57	2.30	97	20.34
PBA Oura	1.34	100	21.80	2.20	92	22.08
PBA Pearl	1.35	101	17.65	2.42	101	19.44
PBA Taylor	1.53	115	20.80	2.67	112	19.35
PBA Wharton	1.33	99	21.57	2.45	103	19.32
CV (%)	7.04			2.86		
Probability	-			-		
LSD (t/ha)	*0.16*			*0.12*		
Sowing Date	11-Jun-2025			03-Jun-2025		

Table 7. Eyre Peninsula 2025 NVT faba bean trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Lower EP**		
Nearest town	**Yeelanna**		
Site mean (t/ha)	**3.93**		
Variety	**t/ha**	**%**	**100 Seed Weight (g)**
Farah	3.72	95	70.76
Nura	3.83	98	67.36
PBA Amberley	3.67	93	66.30
PBA Bendoc	4.02	102	62.48
PBA Marne	3.75	95	69.33
PBA Samira	4.03	103	69.91
PBA Zahra	3.73	95	75.95
CV (%)	2.56		
Probability	-		
LSD (t/ha)	*0.16*		
Sowing Date	28-May-2025		

Table 8. Eyre Peninsula 2025 NVT lentil trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**			**Upper EP**			**Lower EP**			**Lower EP**		
Nearest town	**Kimba**			**Mt Damper**			**Murdinga**			**Yeelanna**		
Site mean (t/ha)	**1.23**			**1.47**			**1.71**			**2.89**		
Variety	**t/ha**	**%**	**100 Seed Weight (g)**	**t/ha**	**%**	**100 Seed Weight (g)**	**t/ha**	**%**	**100 Seed Weight (g)**	**t/ha**	**%**	**100 Seed Weight (g)**
ALB Dane	1.02	83	3.65	1.41	96	4.27	1.81	106	3.76	2.83	98	4.99
ALB Terrier	1.20	98	3.47	1.43	98	3.89	1.67	97	3.64	2.83	98	4.03
GIA Colombo	1.26	102	4.19	1.45	99	4.69	1.77	103	4.41	3.14	109	4.88
GIA Leader	1.10	90	4.18	1.35	92	4.69	1.36	80	4.09	2.79	97	4.57
GIA Lightning	1.24	101	2.93	1.45	98	3.45	1.90	111	3.19	3.19	110	3.67
GIA Thunder	1.16	94	3.27	1.50	102	3.65	1.76	103	3.43	3.00	104	3.78
PBA HighlandXT	1.48	121	3.80	1.66	113	3.94	1.91	111	3.72	2.77	96	3.77
PBA Hurricane XT	1.11	90	3.01	1.37	93	3.58	1.56	91	3.23	2.58	89	3.39
PBA Kelpie XT	1.12	92	4.39	1.39	95	5.06	1.57	91	4.33	2.83	98	4.44
CV (%)	10.89			4.94			9.52			3.76		
Probability	0.00			0.00			0.01			-		
LSD (t/ha)	0.22			0.12			0.26			0.18		
Sowing Date (*Dry Sown)	27-May-2025*			23-May-2025*			03-Jun-2025			28-May-2025		
Germination Rain Date[1]	06-Jun-2025			06-Jun-2025			-			-		
Trial Comments							This trial was sprayed with diflufenican at label rates during the season. Some lentil varieties may be more sensitive than others to diflufenican.					

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Crops

Table 9. Eyre Peninsula 2025 NVT lupin trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Lower EP**		
Nearest town	**Ungarra**		
Site mean (t/ha)	**2.18**		
Variety	**t/ha**	**%**	**100 Seed Weight (g)**
Coyote	2.21	101	19.02
Lawler	2.17	100	18.89
Mandelup	2.34	107	19.34
PBA Barlock	2.12	97	19.13
PBA Bateman	2.27	104	19.41
PBA Gunyidi	2.15	99	19.33
PBA Jurien	2.36	108	20.37
Rosemont	2.31	106	17.70
Wonga	2.32	106	18.85
CV (%)	5.66		
Probability	0.00		
LSD (t/ha)	*0.21*		
Sowing Date	25-Jun-2025		

Table 10. Eyre Peninsula 2025 NVT canola trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year. Cont. next page

Region	**Upper EP**			**Upper EP**		
Nearest town	**Lock**			**Minnipa**		
Site mean (t/ha)	**2.55**			**1.21**		
Resistance	**IMIDAZOLINONE**					
Variety	**t/ha**	**%**	**Oil (6% moisture)**	**t/ha**	**%**	**Oil (6% moisture)**
Hyola Solstice CL	2.50	98	44.21	1.15	95	47.30
Nuseed Ceres IMI	2.64	103	44.26	1.29	107	47.10
Pioneer 43Y92 (CL)	2.37	93	43.61	1.13	93	45.63
Pioneer 44Y94 CL	2.98	117	44.15	1.33	110	45.67
Pioneer PY327C	2.66	104	44.00	1.25	103	45.98
Pioneer PY421C	2.95	116	44.44	1.32	109	46.03
Vesta IMI	2.56	100	46.06	1.10	90	47.51
CV (%)	4.32			4.44		
Probability	-			-		
LSD (t/ha)	*0.18*			*0.09*		
Sowing Date (*Dry Sown)	23-May-2025*			20-May-2025*		
Germination Rain Date[1]	10-Jun-2025			08-Jun-2025		
Resistance				**TRIAZINE**		
Site mean (t/ha)				**1.07**		
Variety Name				**t/ha**	**%**	**Oil (6% moisture)**
AGT-Insurgent TT				1.16	108	44.71
Bandit TT				0.90	84	41.22
Hyola Blazer TT				1.10	103	46.39
Hyola Defender CT				1.13	106	45.62
HyTTec Trident				1.08	100	44.85
HyTTec Trophy				1.03	96	41.62
HyTTec Velocity				1.19	111	44.51
InVigor LT 4030P				1.10	103	42.81
InVigor LT 4530P				1.09	102	42.92
InVigor T 4511				1.08	101	46.79
Nuseed Griffon TTI				1.08	101	43.72
Renegade TT				0.97	91	44.80
RGT Capacity TT				1.04	97	43.66
CV (%)	4.32			4.44		
Probability	-			-		
LSD (t/ha)	0.18			0.09		
Sowing Date (*Dry Sown)	23-May-2025*			20-May-2025*		
Germination Rain Date[1]	10-Jun-2025			08-Jun-2025		

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Table 10. continued. Eyre Peninsula 2025 NVT canola trial yields expressed in both t/ha and as a percentage of the site mean. Data presented are Single Site Trial Results, as such they have lower reliability than Long Term MET results. These results are derived from three variety replicates, tested in one environment, in one year.

Region	**Upper EP**		
Nearest town	**Minnipa**		
Site mean (t/ha)	**1.21**		
Resistance	**GLYPHOSATE**		
Site mean (t/ha)	**1.09**		
Variety Name	**t/ha**	**%**	**Oil (6% moisture)**
Chronos TFI	1.10	101	47.35
Hyola Regiment XC	1.16	107	48.55
InVigor LR 3540P	1.13	104	49.56
InVigor LR 4540P	1.13	104	49.65
InVigor R 4520P	1.12	103	46.45
Nuseed Emu TF	1.11	102	49.76
Nuseed Hunter TF	1.18	108	49.51
Nuseed Raptor TF	0.94	86	45.44
Pioneer 44Y27 (RR)	1.19	109	48.00
Pioneer PY323G	1.03	95	49.81
Pioneer PY424GC	1.01	93	48.51
CV (%)	4.93		
Probability	-		
LSD (t/ha)	0.11		
Sowing Date (*Dry Sown)	20-May-2025*		
Germination Rain Date[1]	08-Jun-2025		

[1]Germination Rain Date only applicable when trial has been dry sown. Date recorded is the date of first subsequent rainfall post dry sowing that triggers germination.

Is nutrition holding back lentil on sandy alkaline soils

Amy Keeley and Emma Turner
SARDI

Location
Murdinga
Farmer: CJ Kay & Sons
Rainfall
Av. Annual: 386 mm
Av. GSR: 291 mm
2025 Total: 347 mm
2025 GSR: 302 mm
Paddock history
2025: Lentil
2024: Wheat
2023: Canola
Soil test
(0-10cm)
pH ($CaCl_2$): 7.4
Ammonium N: 1 mg/kg
Nitrate N: 18 mg/kg
Phosphorus: 21 mg/kg
Potassium: 267 mg/kg
Sulphur: 7 mg/kg
Organic Carbon: 0.70%
PBI: 44.0
(10-60cm)
pH ($CaCl_2$): 7.9
Ammonium N: <1 mg/kg
Nitrate N: 13 mg/kg
Sulphur: 25 mg/kg
Plot size
10 m x 1.5 m x 4 reps
Trial design
Randomised complete block design

Key messages

- **A range of nutrition treatments did not improve grain yield of lentil compared to grower practice at Murdinga on Eyre Peninsula in 2025.**
- **Grower practice of 80 kg/ha MAP applied at sowing was sufficient for maximum yield where Colwell Phosphorus was marginal.**
- **Further research into P management for lentil is required on sandy alkaline soils**

Why do the trial?

According to the 2025/26 state crop and pasture report, lentil production increased by 13% compared to 2024/25. A large part of this increase has occurred on Eyre Peninsula (EP). Second only to wheat, lentil area is now the largest on the Upper EP. However, growing lentil has not come without its problems, including the inability to successfully grow lentil on calcareous sandy soils, which are common on Upper EP.

In 2025, a trial was established at Murdinga on EP to assess the effects of various nutrition treatments on grain yield of lentil grown on a sandy alkaline rise. This work is a continuation of the lentil nutrition trials performed in 2024 (EPFS Summary 2024, p. 89) where low and high phosphorus (P), and new nutrition treatments, were investigated.

How was it done?

After consultation with local agronomists who service the Murdinga area, eight nutrition treatments were selected (Table 1) and a site adjacent to the NVT trial was chosen. P reserves at this site were marginal (Colwell P of 21 mg/kg and PBI of 44, in the top 10 cm). GIA Thunder CL Lentil was sown into moisture at Murdinga on 3 June 2025. Treatments were allocated to a randomised complete block design with four replicates. Machinery restrictions meant that treatments (other than grower practice) had to be broadcast by hand prior to seeding. The trial experienced a dry start with below average rainfall from January-May, followed by above average winter rainfall, a dry September and average October - November. The trial was managed throughout the season as per best grower practice and label rates were adhered to when applying chemicals for the control of weeds, pests and diseases. The trial was harvested on 12 November 2025. Data was statistically analysed using standard analysis of variance (ANOVA) and Fisher's least significant difference (LSD) test was used to compare the treatment means in base R.

What happened?

There were no significant differences in August NDVI, however, visual assessments in early spring indicated a slight increase in growth with gypsum (0.5 t/ha) or sulphate of ammonia (SOA; 40 kg/ha) (Table 2). The visual observations of gypsum (0.5 t/ha) were reflected in early spring NDVI (3 Sept in table 2) where gypsum @ 0.5 t/ha and the high P rate recorded the highest readings. All except MOP @ 50 kg/ha recorded higher NDVI than low P.

The nutrition treatments did not significantly change grain yield of lentil compared to grower practice. Grain yield averaged 2.1 t/ha for the trial. Lack of responses to SOA and MOP are consistent with the soil having reasonable reserves of both sulphur and potassium (see trial information at the end of this article).

Table 1. Nutrition treatments applied to lentil at Murdinga, 2025.

Treatment		Product	Timing of Application	Rate
1	Grower practice	Mono-ammonium Phosphate (10-22-0-1.5)	Applied in-furrow at seeding	80 kg/ha
2	Low P		Spread immediately prior to sowing	40 kg/ha
3	High P			200 kg/ha
4	Gypsum Low	Gypsum Clay Breaker (0-0-0-18)		0.5 t/ha
5	Gypsum High			2.5 t/ha
6	SOA Low	Sulphate of Ammonia (21-0-0-24)		40 kg/ha
7	SOA High			80 kg/ha
8	MOP Low	Muriate of Potash (0-0-50-0)		30 kg/ha
9	MOP High			50 kg/ha

Table 2. Nutrition treatment effects on NDVI and Grain Yield of GIA Thunder CL lentil at Murdinga, 2025. Data labelled with the same letters within a column are not significantly different (P<0.05).

Treatment	NDVI 7 Aug 2025	NDVI 21 Aug 2025	NDVI 3 Sep 2025	Grain Yield (t/ha)
Control	0.263	0.312	0.588 ab	1.96
Low P	0.217	0.273	0.467 c	2.14
High P	0.252	0.343	0.600 a	2.16
Gypsum Low	0.253	0.340	0.610 a	2.26
Gypsum High	0.235	0.325	0.555 ab	1.97
SOA Low	0.258	0.323	0.578 ab	2.13
SOA High	0.255	0.335	0.588 ab	1.92
K Low	0.233	0.318	0.522 bc	1.98
K High	0.228	0.328	0.540 abc	2.06
Average	0.244	0.322	0.561	2.06
P-Value	0.771	0.319	0.021	0.392
LSD	*ns*	*ns*	*0.08*	*ns*

What does this mean?

The application of 9 fertiliser options prior to sowing did not increase grain yield of lentil at Murdinga in 2025 compared to the grower practice of 80 kg/ha MAP at seeding. Little response was seen in the high gypsum application, which is consistent with no sodicity being detected at the site. The late rain break resulted in slow early crop vigour and the lentil may not have reaped the full benefits of additional fertiliser in such cold conditions in June. Inconclusive nutrition trials over the past couple of seasons on the EP demonstrate the need to further investigate different nutrient applications and their impact on lentil yields. In 2026, we aim to look more specifically at P across a larger range of rates in sandy, calcareous soils, and that have higher PBI levels than that investigated at Murdinga in 2025, to understand the impact of P on grain yield of lentil on lower fertility soils.

Acknowledgements

The authors wish to acknowledge CJ Kay & Sons and local agronomists, George Pedler and Josh Hollitt for their cooperation and support. The research undertaken is made possible largely due to the support of the GRDC (UOA2105-013RTX– SA Grain Legume Production) and we thank them for their continued contributions. The continued efforts of the SARDI Agronomy team at Pt Lincoln is always gratefully appreciated.

Correcting iron deficiency in faba bean and lentil

Nigel Wilhelm[1,2], Luke Simpson[1], Sam Trengove[3], Stuart Sherriff[3] and Amanda Pearce[1,2]

[1]SARDI; [2]Adelaide University, [3]Trengove Consulting Pty Ltd.

Location
Conmurra, south east of SA
Farmer: Glenlea Partners
Rainfall
Av. Annual: 595 mm
Av. GSR: 462 mm
2025 Total: 502 mm
2025 GSR: 405 mm
Paddock history
2024: Wheat
Soil type
Calcareous grey clay
Plot Size
1.5 m x 12 m

Location
Marion Bay, Southern Yorke Peninsula
Rainfall
Av. Annual: 443 mm
Av. GSR: 259 mm
2025 Total: 438 mm
2025 GSR: 383 mm
Paddock history
2024: Cereal
Soil type
Calcareous grey sandy loam
Plot Size
1.5 m x 12 m

Key messages

- **The cause of bright yellowing in faba beans growing on highly calcareous clays of the south-east and in lentil growing on very highly calcareous sands of southern Yorke Peninsula is due to Fe deficiency. Similar symptoms occur in pulses growing on highly calcareous sands of the Eyre Peninsula.**
- **Fe-EDDHA is a chelated form of iron which, if applied at high rates, can prevent or correct yellowing, and improve crop performance.**
- **Field trials in 2025 are indicating that there is scope for reducing the rates and number of applications of Fe-EDDHA.**
- **The cheapest source of Fe (sulphate) has not proven effective.**
- **Tissue testing is not proving reliable as a diagnostic tool for Fe deficiency.**

Why do this trial?

Bright yellowing in pulses growing on highly calcareous soils on Eyre Peninsula has been noted for decades. Manganese (Mn), or iron (Fe) sprays have sometimes been used to treat the problem but with limited success. In spring, these areas tend to recover and their impact on grain yield is often uncertain.

In the south-east of SA, faba bean are the preferred pulse for many growers due to their tolerance to waterlogging and higher market value. Despite their adaptation to these environments, severe yellowing of faba bean occurs, and remains widespread when they are grown on highly calcareous soils. Current strategies are to use foliar sprays of Mn and/or Fe but they are very poorly effective. This issue was addressed in a recently completed project jointly funded by the High Performance Soils CRC and GRDC (CRC code 4.2.003). In a 2022 field trial, untreated Aquadulce broad bean yielded 2.3 t/ha, but yields increased to 7.5 t/ha with large and multiple applications of Fe-EDDHA, which is a chelate rarely used in broad-acre cropping. The cost of this treatment is very prohibitive for south-east growers and unlikely to be profitable for other situations.

At the same time that this work with faba beans in the south-east was concluding, the popularity of lentil continued to grow in southern Australia, exposing them to more diverse environments and soil types. Their cultivation on Yorke and Eyre Peninsulas has expanded, now including highly calcareous sandy soils known for Mn deficiency in cereals. On these soils, lentils are going yellow and lack vigour, although the cause appears to be Fe deficiency rather than Mn deficiency. An experiment conducted by Trengove Consulting in 2024 on southern Yorke Peninsula recorded a 30% yield increase in lentils with a single foliar spray of Fe-EDDHA. Trengove Consulting are also working with a client in the Far West to better manage yellowing in their lentils and they are finding that a Fe-EDDHA application will reduce yellowing during the season.

GRDC has now funded more work to build on these initial studies which identified Fe-EDDHA as an effective Fe source to prevent yellowing and stunting of broad beans on highly calcareous clay soils and lentil on highly calcareous sandy soils. The project will investigate cost-effective and practical fertiliser strategies using Fe-EDDHA and other Fe sources. The current project will also explore the potential tolerance of different genotypes to Fe deficiency based on recent observations of variability in lentil lines.

Table 1. Yellowness scores (1: bright yellow – 3: dark green) on 28 August 2025 and grain yield (t/ha) in PBA Kareema broad bean in the south-east. Note that only the early Fe applications had been applied at the time of scoring, mid and late timings were applied at a later date and are identified by italics in the body of the table.

Fe Source and timing, rate (kg Fe/ha)	Score	Grain yield
Nil	1.0	3.80
EDDHA prior to seeding, 0.4	1.7	4.91
EDDHA early, 0.2	2.0	4.65
EDDHA early, 0.4	3.0	5.34
EDDHA early, 0.8	3.0	5.80
EDDHA *mid*, 0.4	*1.2*	5.46
EDDHA *late*, 0.4	*1.0*	4.77
EDDHA early & *late*, 0.2+0.2	*2.3*	5.19
EDTA early, 0.2	1.3	3.73
EDTA early, 0.4	1.3	4.29
FeSO4 early, *mid* & *late*, 0.4+0.4+0.4	*1.2*	4.31
EDDHA banded at seeding, 1.0 plus early & *late*, 0.4+0.4	*3.0*	5.71
EDDHA banded at seeding, 2.0 plus early & *late*, 0.4+0.4	*3.0*	6.05
LSD (P=0.05)	*0.6*	*0.59*

How was it done?

Two field trials were conducted in 2025. At Conmurra in the south-east of SA, a range of Fe strategies and sources were implemented on broad beans (cv PBA Kareema) on a highly calcareous grey clay in a paddock where severe yellowing in beans regularly occurred. The other trial was conducted near Marion Bay on southern Yorke Peninsula (YP) on a very highly calcareous sandy soil with lentil (cv GIA Thunder). Lentil are a recent crop for this soil type on southern YP. In both trials, the pulse was managed with strategies typical of the district (without any Fe applications) and a range of Fe sources, timings and rates were applied from pre-seeding through to flowering. Crop vigour and colour were monitored through the season and grain yield measured.

What happened?

The results below are an initial assessment of treatment performance in the two trials undertaken in 2025 but findings are provisional only. A thorough review of the data has yet to be finalised.

Beans in the south-east

The trial was seeded in late June, well after the farmer had sown the paddock (to faba bean). The faba bean in the paddock developed severe yellowing during winter while the broad beans in the trial developed slowly and the untreated plots were only pale green at the same time. However, a score of yellowness in late August showed that several strategies involving Fe-EDDHA were reducing yellowness (Table 1).

A package of a high rate of Fe-EDDHA banded at seeding plus two foliar sprays increased grain yields by 60% or more than 2 t/ha (Table 1). This same package, but at half rates, still produced nearly 2 t/ha of more grain than the nil. Early sprays of Fe-EDDHA increased grain yields by 1-2 t/ha from the nil, depending on timing and rate. Using sulphates or EDTA as sources of Fe was poorly effective at increasing grain yields.

Lentils on southern Yorke Peninsula

Lentil grew very slowly through the winter of 2025. Untreated lentils became very yellow very early in the season, although the severity of the yellowing varied across the trial and perhaps not as severely as in the previous year. A visual score of yellowness in the canopy was taken nearly 3 months post-seeding and before late foliar applications had been made (Table 2). In general, treatments which had received no Fe by the time of scoring were the most yellow while low rates of Fe-EDDHA or alternative sources such as EDTA or sulphate were poorly effective at reducing yellowing. Banding a high rate of Fe-EDDHA at seeding followed by a foliar spray resulted in lentil which were the darkest green. Treatment 3 is interesting because it partially reduced yellowing lentils but also was a low rate of Fe-EDDHA. There was little impact of treatments on biomass at the time of scoring.

Winter and early spring were well below average rainfall and mild for the southern YP in 2025, but yield potentials improved with better rainfalls in late spring. Multiple applications of high rates of Fe-EDDHA (the package which performed best in the 2022 trial) increased grain yields from 1.7 t/ha (untreated) to 2.0 t/ha (Table 3).

This package had Fe applied at seeding as bands under the crop rows (@ 2 kg Fe/ha) plus two foliar sprays during the season (each @ 0.4 kg Fe/ha). Halving Fe rates in the package of multiple rates of Fe-EDDHA resulted in a similar yield to the full rate package.

Single or two foliar applications of Fe-EDDHA did not reliably increase yields compared to the untreated.

Table 2. Yellowness scores taken eleven weeks after seeding in GIA Thunder lentil on the southern YP in 2025 (1: bright yellow – 5: dark green). Note that late Fe applications had not been applied at the time of scoring and are in italics in the body of the table.

Fe Source and timing, rate (kg Fe/ha)	Score
Nil	2.4
EDDHA banded at seeding, 1.0	3.0
EDDHA prior to seeding, 0.4	3.1
EDDHA early, 0.1	2.3
EDDHA early, 0.2	2.4
EDDHA early, 0.4	3.3
EDDHA early, 0.8	2.9
EDDHA mid, 0.4	3.3
EDDHA *late*, 0.4	*2.3*
EDDHA early & *late*, 0.2+0.2	*2.1*
EDDHA early & *late*, 0.4+0.4	*2.6*
EDDHA 2 banded at seeding, 1.0	3.0
EDDHA 2 early, 0.4	3.0
EDTA early, 0.4	2.4
EDTA early & *late*, 0.2+0.2	*2.5*
EDTA early, 0.8	2.6
EDTA early & *late*, 0.4+0.4	*3.0*
FeSO4 early & *late*, 0.4+0.4	*3.1*
FeSO4 early, mid & *late*, 0.4+0.4+0.4	*2.3*
EDDHA banded at seeding, 1.0 plus early & *late*, 0.2+0.2	*2.6*
EDDHA banded at seeding, 2.0 plus early & *late*, 0.4+0.4	*4.1*
EDDHA banded at seeding, 0.2 with phos acid	2.9
EDDHA banded at seeding, 0.2	2.3
LSD (P=0.1)	*0.9*

There were a large range of treatments with yields between those of the untreated control and the most effective package, and more research is required to assess if these other treatments have merit as moderately effective strategies.

Although Fe-sulphate is the cheapest source of Fe for broad-acre applications, it was not effective at reducing yellowing or in improving crop performance. Fe-EDTA, a chelate that is stable under acidic conditions, was variably effective. Fe-EDDHA is a chelate stable under alkaline conditions and more reliably corrected yellowing and increased grain yield.

Trengove Consulting have also been investigating nutrition management of lentil in the Far West over the last couple of seasons in addition to the trials reported here from southern YP. They are finding that a foliar spray of Fe-EDDHA is relieving yellowness in lentils but have yet to rigorously assess the impact of Fe strategies on grain yield.

What does it mean?

The two trials from 2025 were further confirmation that the bright yellowing occurring in faba/broad bean growing on highly calcareous clays of the south-east and in lentil growing on very highly calcareous sands of southern Yorke Peninsula is due to Fe deficiency. They also confirmed that this yellowing can be eliminated by multiple applications of high rates of Fe-EDDHA. Cheaper sources of Fe (EDTA and sulphate) were poorly effective at alleviating Fe deficiency.

The trials are indicating that there is scope for adjusting this package of multiple applications of high rates of Fe-EDDHA to make it cheaper but still correct Fe deficiency in faba/broad bean or lentil. The full package currently being evaluated in the trials is made up of a total of 2.8 kg Fe/ha, at an approximate cost of nearly $400/ha for the product.

At this stage, the discrimination between alternative strategies is not sufficiently clear to offer precise recommendations, especially for lower rainfall environments and lower value pulses. However, a single early foliar spray of Fe-EDDHA shows strong promise as a strategy for alleviating Fe deficiency in broad beans; for example, a grain yield increase of 1.5 t/ha was recorded for a strategy which cost approximately $55/ha for the product.

Table 3. Grain yield of GIA Thunder lentil on the southern YP, in 2025.

Fe Source and timing, rate (kg Fe/ha)	Grain yield (t/ha)
Nil	1.73
EDDHA banded at seeding, 1.0	1.73
EDDHA prior to seeding, 0.4	1.89
EDDHA early, 0.1	1.85
EDDHA early, 0.2	1.70
EDDHA early, 0.4	1.72
EDDHA early, 0.8	1.95
EDDHA mid, 0.4	1.77
EDDHA late, 0.4	1.91
EDDHA early & late, 0.2+0.2	1.75
EDDHA early & late, 0.4+0.4	1.87
EDDHA 2 banded at seeding, 1.0	1.81
EDDHA 2 early, 0.4	1.80
EDTA early, 0.4	1.70
EDTA early & late, 0.2+0.2	1.77
EDTA early, 0.8	1.87
EDTA early & late, 0.4+0.4	1.81
FeSO4 early & late, 0.4+0.4	1.74
FeSO4 early, mid & late, 0.4+0.4+0.4	1.67
EDDHA banded at seeding, 1.0 plus early & late, 0.2+0.2	1.98
EDDHA banded at seeding, 2.0 plus early & late, 0.4+0.4	2.03
EDDHA banded at seeding, 0.2 with phos acid	1.87
EDDHA banded at seeding, 0.2	1.77
LSD (P=0.05)	*0.3*

We have been monitoring crop performance in the trials with biomass production at flowering, grain yield, progressive visual scores and NDVI readings during the season, in conjunction with Fe concentrations in young leaves/growing tips. Fe concentrations in young shoot material is not yet proving useful as a diagnostic tool for Fe deficiency or for assessing the effectiveness of strategies.

Plans for 2026

Field experiments

Two field experiments will be conducted in 2026, each one with the same crop and in the same environment as in 2025. They will be used to further refine the scope to reduce Fe rates and timings, whilst eliminating Fe deficiency as a constraint to faba bean and lentil production on highly calcareous soils.

Pot studies

Pot experiments will commence in 2026 to investigate other strategies for correcting Fe deficiency in broad acre crops. These strategies will include different sources of Fe and also the value of seed coating or priming with Fe to alleviate Fe deficiency. Potential tolerance to Fe deficiency will also be evaluated using elite lines from the Adelaide University faba bean breeding program and Grains Innovation Australia's lentil breeding program. Other crops such as wheat, field pea, and canola will also be assessed for their sensitivity to Fe deficiency.

Acknowledgement

The authors would like to acknowledge the significant contributions of growers through both trial cooperation and the support of the GRDC in the current project (DAS2506-005RTX) and to both GRDC and the High Performance Soils CRC for the previous project (CRC code 4.2.003). Grains Innovation Australia have also been very supportive of this research including generous provision of lentil breeding lines. McKillop Farm Management Group are an important partner in the research in the south-east.

Trengove Consulting

Adelaide University

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Government of South Australia Department of Primary Industries and Regions

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Performance of lentil vs faba bean at Ungarra on lower Eyre Peninsula

Josh Telfer
SARDI

Location
Ungarra
Rainfall
Av. Annual: 375 mm
2025 Total: 343 mm
2025 GSR: 331 mm
Paddock history
2024: Wheat
2023: Canola
2022: Faba bean
Soil type
Ironstone and siliceous acidic sand over clays; siliceous sand over alkaline clay

Key points

- **The relative performance of lentil and faba bean depends on soil type.**
- **Large changes in paired comparison between lentil and faba bean.**
- **Weed competition and N fixation are also important considerations for break crop selection.**
- **Faba bean seem to be more tolerant of subsurface acidity than lentil.**

Why do this trial?

On the Lower Eyre Peninsula, as elsewhere on Eyre Peninsula (EP), there has been a significant increase in pulse production-particularly lentil-driven by strong prices and improved agronomic options, especially for weed and disease control. However, lentil are not the only profitable pulse crop option. The area sown to faba bean has also been growing steadily though not quite as high profile as lentil. Although faba bean generally have lower value than lentil, their weed control options have improved substantially with the introduction of imidazolinone (IMI)-tolerant varieties such as PBA Bendoc, combined with the use of the herbicide Overwatch®. Furthermore, faba bean typically produce higher biomass and offer better tolerance to waterlogging compared to lentil, which are notorious for their sensitivity to waterlogging. Faba bean also provide superior weed competition, particularly against annual ryegrass. As part of the SA Drought Hub Pulse Break Crop project, a side-by-side agronomic comparison of these two crops was conducted at Ungarra in 2025. This trial methodology involved transects of paired swaths of lentil and faba bean spanning multiple soil types, looking at agronomic and economic comparisons.

How was it done?

In a grower's 300 hectare paddock at Ungarra sown with faba bean in 2025 after a wheat crop in 2024, a 1.7 km transect was chosen based on a pH map (using the VERIS method) and previous faba bean yield maps to represent 3 different production zones. The monitoring areas were 3 swath widths of 12 m (36 m in total) to align with the controlled traffic line of the seeder, sprayer, and harvester. Soil samples were taken from all 3 zones.

Sampling regions were:

1. Glen West - acidic sandy soil, moderate yield potential
2. Glen Central - acidic sand, low yield potential
3. Glen East - calcareous loam, high yield potential

Initial soil sampling was undertaken prior to seeding to 10 cm, and soil pH was additionally taken in 5 cm sampling increments. Deep soil nitrogen (N) was also sampled.

Bendoc faba bean were sown dry at 100 kg/ha with 75 kg/ha of MAP in anticipation of rain on 28 April with Thunder lentil sown later at 55 kg/ha also with 75 kg MAP/ha on 31 May. Both crops were farmer sown with a JD 1895 single disc.

Both crops received pre-emergence herbicides. Faba bean received 2.5 L/ha of Overwatch plus 400 g/ha of diuron, and the lentil had 750 g/ha Ultra and 400 g/ha of diuron. Both crops received 1 L/ha of 360 g/ha Clethodim and 180 g/ha Factor, as well as best practice insecticide, fungicide and micronutrition management during the growing season. The predominant weed was annual ryegrass, with some capeweed.

Crop growth was measured on 10 July and 20 August with Canopeo® green cover (Table 2) and plant biomass was measured (17 September) with cuts taken just prior to majority of pod fill (Table 3). Grain yield was taken from the grower harvester yields. Yield comparisons were undertaken at the three different monitoring sites across 1.7 km transect and compared with mean yield for total transects using data collected extracted from the grower yield monitor dataset and is shown in Table 4.

Table 1. Soil test results at the three paddock locations at Ungarra in 2025.

Parameter	Unit	Glen West	Glen Central	Glen East
0-5 cm pH	pH $CaCl_2$	6.5	6.4	6.5
5-10 cm pH	pH $CaCl_2$	5.1	4.5	5.1
10-20 cm pH	pH $CaCl_2$	6.4	4.4	nr
Organic Carbon (W&B)	% (40°C)	1.45	1.17	1.21
MIR – Aus Soil Texture	–	Loamy sand	Loamy sand	Sandy loam
MIR – Clay	% w/w	8.9	6.7	13.2
MIR – Sand (+20 µm)	% w/w	79.6	83.9	74
MIR – Silt (2–20 µm)	% w/w	11.4	9.4	12.8
pH $CaCl_2$		5.48	5.41	7.59
Nitrate–N (2M KCl)	mg/kg	28	20	25
Ammonium–N (2M KCl)	mg/kg	2.7	2.1	1.3
Colwell Phosphorus (P)	mg/kg	34	35	26
PBI + Col P	–	39	39	57
DGT–P	µg/L	53	61	31
KCl Sulfur (S)	mg/kg	6.3	7.7	5.4
Exchangeable Calcium (Ca) – AmmAc	mg/kg	1070	800	57
Exchangeable Magnesium (Mg) – AmmAc	mg/kg	91	50	31
Exchangeable Potassium (K) – AmmAc	mg/kg	170	76	394
Exchangeable Sodium (Na) – AmmAc	mg/kg	32.9	14.5	40.6
Ca:Mg Ratio	–	7.1	9.7	9.2
K:Mg Ratio	–	0.58	0.47	0.43
ECR	%	8.7	5.5	4.8
ECEC	cmol/kg	6.64	4.66	24.9

Table 2 . Canopeo (% green area) over time at the three paddock locations at Ungarra in 2025. (https://canopeoapp.com/)

Date 2025	Location	Crop	Mean	SE	Change in 41 days	Daily Rate of Change
10 July	Glen Central	Bean	17	0		
20 August	Glen Central	Bean	84	4	66.3	1.62
10 July	Glen East	Bean	13	1		
20 August	Glen East	Bean	84	2	70.3	1.71
10 July	Glen West	Bean	17	1		
20 August	Glen West	Bean	64	4	46.55	1.14
10 July	Glen Central	Lentil	5	1		
20 August	Glen Central	Lentil	21	2	15.69	0.38
10 July	Glen East	Lentil	4	0		
20 August	Glen East	Lentil	43	4	38.35	0.94
10 July	Glen West	Lentil	7	1		
20 August	Glen West	Lentil	29	3	21.9	0.53

What happened?

Table 1 shows soil results from the 0-10 cm sampling from the locations, and also pH in 5 cm sampling increments as soil acidity can be a big production factor when growing lentil and faba bean. While the sites have good surface pH, particularly Glen East, pH was at toxic levels for species like faba bean and lentil below 5 cm, which wasn't apparent in the 0-10 cm testing (Table 1). There are also some key differences in the texture in Glen East, though the total clay differences weren't large. There were differences in soil cation exchange capacity (ECEC) again in the Glen East zone.

The faba bean sown early and dry on 28 April were just emerging when the lentil were being sown on 31 May, with very little rainfall in the previous month. There was little difference in emergence of beans across the 3 zones, (20, 20 & 25 plant/m^2 West to East) and there was only a slight reduction in emergence in lentil (133,109 & 139 plants/m^2 West, Central, East), but plant numbers were still acceptable.

The trend in crop performance for both crops across the three zones were similar with Glen East having the highest spring biomass and highest grain yield in both lentil and faba bean. Growth was lowest in Glen West. This was the same as previous yield trends in faba bean for the site from discussions with the farmer and also suggested from soil data particularly the CEC, clay contents, and soil pH.

The comparison in Table 4 shows that determining which break crop (lentil or faba bean) can be challenging with significant in-paddock variation in yield and therefore economic return.

Glen East, while having a high yield potential of 3.93 t/ha on a calcareous sandy loam, saw lentil yield 85% of the yield of faba bean, even when the faba beans had a month longer growing season. However, Glen Central, even though biomass and Canopeo measurements were similar (Tables 2 and 3) to Glen West, these two pulses really struggled to yield (Table 4). This would have been in part due to the acidity both restricting root growth which is needed to finish grain, as well as nutrient imbalance, and the higher amount of gravel in this soil compared to Glen West. During root inspections in July, all crops were well nodulated, but in October, crops in the Glen Central site seemed already stressed, and stunted, while not being particularly water logged.

Table 3. Plant biomass (kg/ha) for lentil and faba bean in Glen paddock at Ungarra on 17 September 2025.

Location	Lentil (kg/ha)	Faba bean (kg/ha)
Glen West	747	1857
Glen Central	720	1731
Glen East	1163	2553

Table 4. Grain yield (t/ha) comparisons at the three different monitoring sites across 1.7 km transect compared with mean yield for total transects Standard Error shown.

	Lentil yield (t/ha)	% of Glen East	Number of yield monitor points	SE	Faba bean yield (t/ha)	% of Glen East	Number of yield monitor points	SE
Glen East	3.35	100	103	0.630	3.93	100	73	0.036
Glen Central	0.86	26	34	0.017	2.48	63	43	0.044
Glen West	1.82	54	81	0.066	3.70	94	43	0.064
Total Transect	1.3				2.87			

What does this mean?

This paddock-scale paired comparison highlights the distinct niches occupied by each crop type across the transect. Consistent with the experiences of many farmers on Lower Eyre Peninsula (EP), faba bean generally outperform lentil on more challenging soil types, particularly acidic sands even after a robust multi-year liming program.

However, lentil demonstrated strong resilience in a short season like 2025, achieving competitive yields even under limited growing conditions. The yield differences on the Glen East soil type between faba bean and lentil was minimal, suggesting lentils may be the preferable option for this soil type due to their comparable performance combined with typically lower input risks or better market consistency in some seasons. Across the rest of the transect, however, the results favour faba bean as the superior choice. Faba bean delivered higher yields, stronger crop competition (e.g. better weed suppression), and likely greater nitrogen fixation all driven by substantially higher biomass production. Glen West, while still having some acidity, was not as acidic at depth as Glen Central, and the lentil yields here reflect this. At 1.8 t/ha the yield was still economic. However, the soil type wasn't as conducive to lentil production, whereas faba bean yield here was almost as high as the Glen East zone. This is in spite of the fact that the soil in Glen East could be seen as more fertile, maybe there was more moisture in the Glen West zone being lower down in the catchment which may have been a benefit in a dry spring.

Economic comparisons between the two crops fluctuate significantly from season to season. Lentil prices have varied by around 50% since the previous season, while faba bean prices have shown much larger swings (250–300%). These price volatilities can dramatically shift the relative profitability of each crop. A more detailed economic analysis of these trial results is planned as part of the ongoing project.

Acknowledgements

Thanks to Isaac and Luke Telfer for hosting the demonstration site. The project 'Building resilience - Break Crop Suitability Across Landscapes (Stage 2)' DN3 25 10 is led by Upper North Farming Systems in conjunction with AIR EP and supported by the South Australian Drought Resilience Adoption and Innovation Hub, through funding from the Australian Government's Future Drought Fund.

Section Editor:
Cathy Paterson
SARDI, MAC

Section
4

Weeds

Geospatial analytics to predict the impact of residual herbicides on establishment and yield

Michael Rose[1], Buddhi Chaudhary[2], Nicolas Dimopoulos[1], Brad Keen[3], Mark Congreve[4], Amanda Cook[2,5,6] and Lukas Van Zwieten[3]

[1]Southern Cross University, Lismore NSW; [2]SARDI; [3]NSW Department of Primary Industries and Regional Development, Wollongbar NSW; [4]ICAN; [5]Adelaide University; [6]Flinders University

Location
Minnipa Agricultural Centre
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2024 Total: 191 mm
2024 GSR: 132 mm
2025 Total: 281 mm
2025 GSR: 228 mm
Trial design
2024 - Randomised complete block design
2025 - Split plot over 2024 experimental design

Key messages

- **Field experiments have been established in Minnipa, SA; Geraldton, WA; Toowoomba, Qld and near Griffith, NSW, to improve modelling and soil residue analysis approaches for quantifying crop toxicity risk posed by herbicide carryover in soil.**
- **Dissipation curves for seven different herbicide products in two soil types have been established for the 2024 season.**
- **Three different rotation crops planted at Minnipa into the residues of last season's herbicide showed carryover damage (NDVI) of high label rate applications of Sentry® to canola in both soil types and wheat in the heavier soil type; Reflex® damage to lentil in both soil types and canola and wheat in the lighter soil type; and Lontrel Advanced® damage to lentil in the heavier soil type**
- **Ongoing analysis will measure effects on yield and determine whether glasshouse dose-response toxicity thresholds accurately reflect in-field toxicity.**

Why do the trial?

The aim of these trials were to relate herbicide persistence to carryover toxicity, using soil herbicide analysis to benchmark toxicity and provide data for modelling. Herbicides are an important weed management strategy in Australian farming systems. It is estimated that between 20-30% of paddocks across Australia contain soilborne herbicide residues that constrain crop selection, while around 10% of paddocks have herbicide residues that could result in crop damage and economic losses to growers (Rose et al., 2022). Based on the value of Australian grain crop production of ~$40B in 2021, a conservative 10% yield reduction in 10% of paddocks equates to a $400M loss (Rose and Van Zwieten, 2024). The primary drivers of herbicide breakdown are qualitatively well known; however, simple decision support tools to predict the level of herbicide remaining in soil over time, and the risk to rotation crops, are not currently available.

Table 1. Details of herbicides and the concentration of their application, applied on two different soil types at MAC in 2024.

Wheat - Tomahawk CL				Field Pea - Butler			
ID	**Herbicide**	**Rate (g or mL/ha)**	**MOA Group**	**ID**	**Herbicide**	**Rate (g or mL/ha)**	**MOA Group**
1	Sentry (525 g imazapic 175g imazapyr/kg)	50	2	1	Terbyne Extreme (875 g/kg terbuthylazine)	1200	5
2	Terrain (500 g/kg flumioxazin)	120	14	2	Reflex (240 g/L fomesafen)	1500	14
3	Metsulfuron (600 g/kg metsulfuron-methyl)	7	2	3	Overwatch (400 g/L bixlozone)	1250	13
4	Lontrel Advanced (600 g clopyralid/L)	75	4	4	Untreated		
5	Untreated			5	Terbyne Extreme (875 g/kg terbuthylazine)	2400	3
6	Sentry (525 g imazapic 175 g imazapyr/kg)	100	2	6	Reflex (240 g/L fomesafen)	3000	14
7	Terrain (500 g/kg flumioxazin)	240	14	7	Overwatch (400 g/L bixlozone)	2500	13
8	Metsulfuron (600 g/kg metsulfuron-methyl)	14	2				
9	Lontrel Advanced (600 g clopyralid /L)	150	4				

How was it done?

The research trials are being carried out in multiple sites of Queensland, New South Wales, Western Australia and South Australia to represent different soil types and climatic conditions. Two research trials were set up at Minnipa Agricultural Centre (MAC), South Australia (SA) - one on a sandy loam and one on a red loam - in 2024. Two crops, Tomahawk CL wheat and Butler field pea, were sown in randomised complete block design (RCBD) with three replications, under different residual herbicide applications (Table 1).

An individual plot size was 20 m long and 4 m width. As the key aim is to measure herbicide persistence for the development of climate-driven models, and subsequent risk to rotation crops in 2025 across multiple environments, some herbicide treatments and application rates are atypical and do not represent local practice. Double rate applications of herbicides were off-label but used to ensure sufficient carryover and damage if seasonal conditions were conducive to full dissipation of the label rate.

In 2024, pre-emergent knock down herbicides were applied to all plots the day before the application of residual pre-emergent herbicides. Spray cards were used to ensure uniform spray application of herbicides in each plot. Wheat was sown on 12 June 2024 and inoculated field pea was sown on 19 June 2024 after background medic had germinated.

Soil samples were collected four times in 2024 at different growth stages of crops with the first after the first substantial rainfall event (above 10 mm) in June. Soil was sampled from two depths, 0-10 and 10-30 cm. Each sample was a composite of six sub-samples collected from three on-row and three off-row. Soil samples were stored in the freezer before herbicide residue analysis.

Soil samples were collected from the plots on 9 April, 2025 to provide pre-sowing (residual) herbicide concentrations prior to sowing rotational crops into the plots. The herbicide plots were then divided into three and cross-sown with three rotation crops: wheat (cv. Calibre), canola (cv. Diamond) and 2 lentils (cv. Jumbo2 and Thunder XT) on 16 May, 2025. These rotation subplots were 4 m long and 1.7 m width. Plant counts and biomass cuts were taken from 4 x 0.5 m row length per plot for wheat and canola; and 8 x 0.5 m row length per plot for lentil on 24 July, 2025. Fresh biomass was recorded and then dried at 60°C for 48 h for dry weight. These plant tissue samples have been prepared for herbicide analysis, to enable a correlation between pre-soil herbicide residue levels, crop uptake and crop damage to be performed. NDVI measures for each plot were also taken on 13 August, 2025. Harvest occurred in mid-November for canola/lentil and early December for wheat.

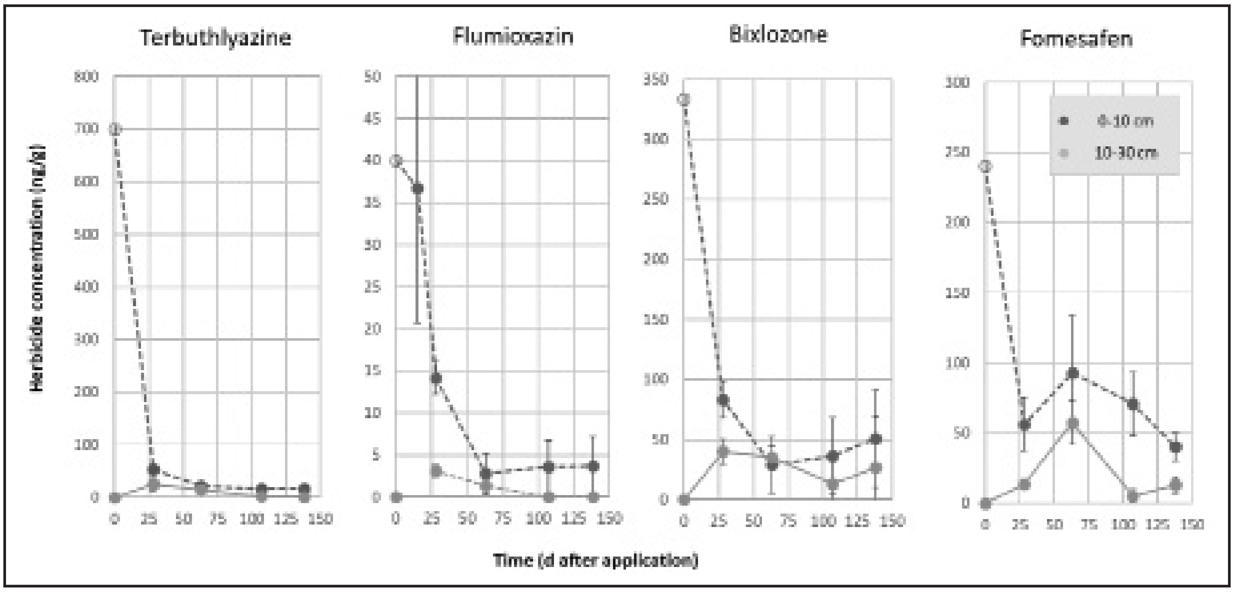


Figure 1. Dissipation of herbicides (ng/g dry soil) in the red loam at Minnipa

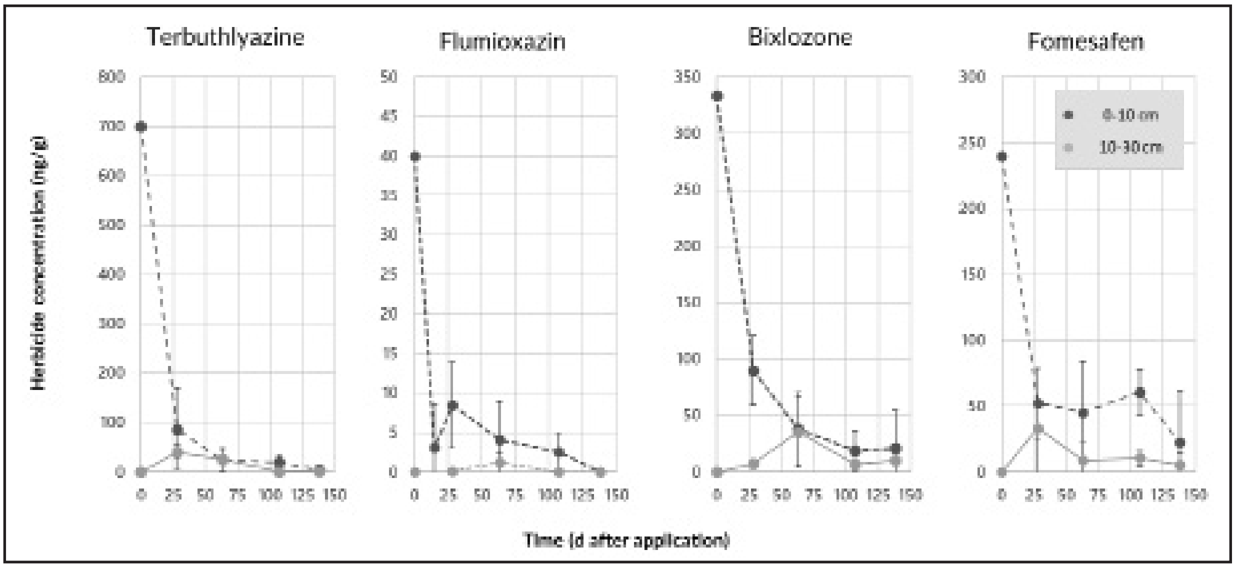


Figure 2. Dissipation of herbicides (ng/g dry soil) in the sandy loam at Minnipa

Weeds

What happened?

Herbicide dissipation in 2024

Analysis of herbicide residues in soil throughout 2024 showed that the order of dissipation was terbuthylazine > flumioxazin > bixolozone > fomesafen in both the heavier soil (Figure 1) and lighter soil (Figure 2). This agrees generally with the literature half-life (DT50) values of each active, ranging from terbuthylazine (average DT50 of 22 days) and flumioxazin (average DT50 of 18 d) to bixlozone (average DT50 of 99 d) and fomesafen (average DT50 of 86 d). Generally, dissipation of each active was greater in the sandy loam rather than the loam, although these differences weren't statistically significant (P>0.05).

Herbicide dissipation curves for the acid herbicides clopyralid, metsulfuron-methyl and imazapic/imazapyr are still being finalised, but persistence appears to be greater in the red loam.

Effect of residues on rotation crops in 2025

Carryover from several herbicides following their application in 2024 affected the biomass of rotation crops in 2025 (Figure 3). Reflex at both rates reduced wheat growth in both soil types, and canola growth in the lighter soil. Double-rate Reflex reduced canola growth in the heavier soil. Sentry reduced canola growth at both rates in both soil types, and wheat growth in the heavier soil type. Double-rate Overwatch dramatically reduced canola biomass in the heavier soil. Although there appeared to be an effect of Lontrel and Metsulfuron on wheat biomass in the heavier soil, this was not supported by NDVI readings (Figure 4).

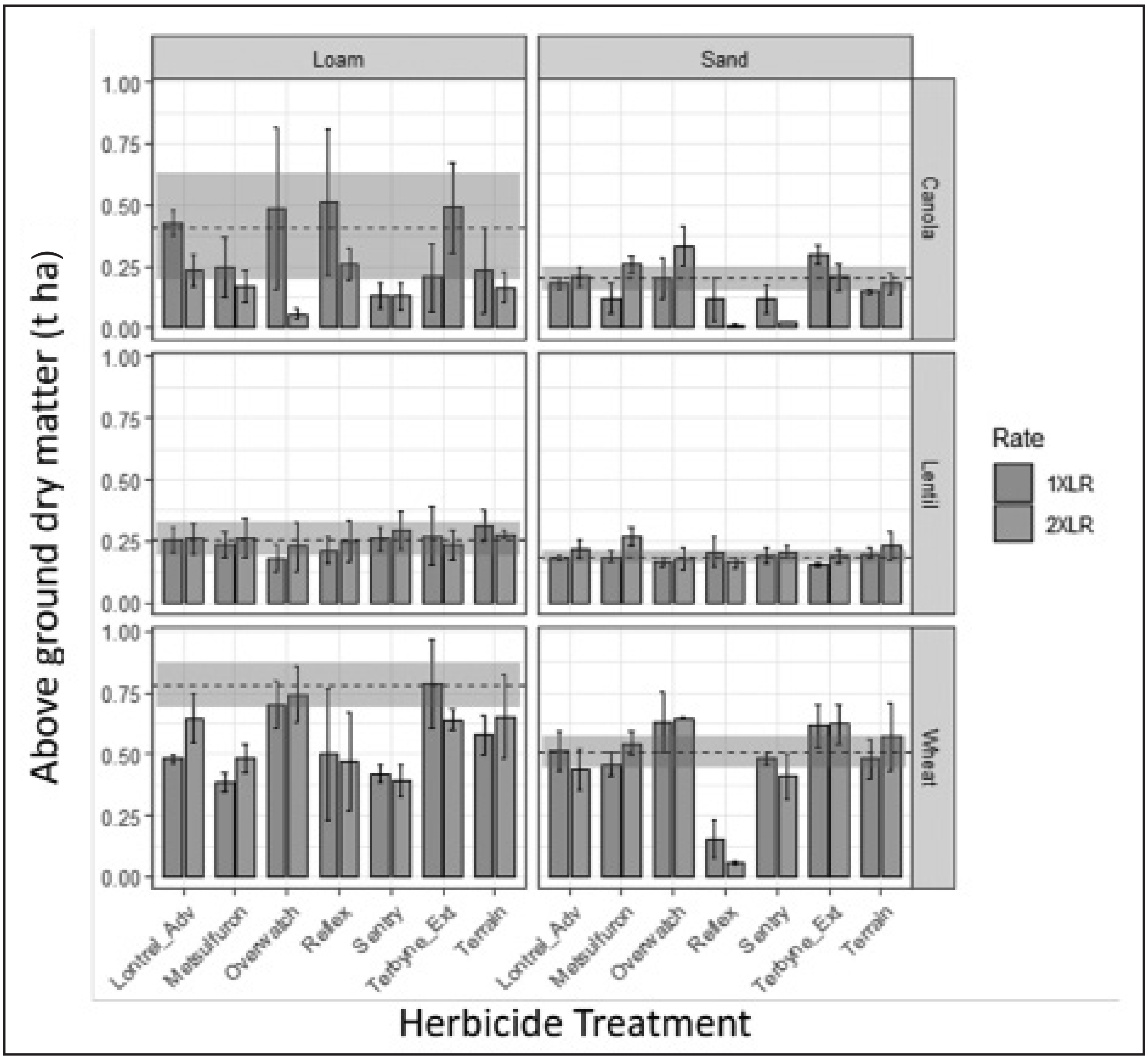


Figure 3. Effect of herbicide carryover from 2024 application on biomass (t/ha) of rotation crops wheat, lentil and canola on a loam and sandy loam at Minnipa, 2025. Error bars represent standard error (n=3). The black dashed line is the mean biomass of the untreated control and the grey shaded area is the standard error of the untreated (n=3). 1XLR indicates label rate application, 2XLR is double the standard application rate.

NDVI readings supported the finding of a negative effect of Reflex on wheat and canola at both rates in the lighter soil, and also a negative effect of Sentry at both rates on wheat in the heavier soil and canola in both soil types (Figure 4). NDVI measures also supported the negative effect of Overwatch on canola in the heavier soil type. Note that there were broadleaf weeds present in some treatments, particularly in Terbyne, Extreme and untreated (nil herbicide) plots, so these results should be interpreted in light of this.

At harvest, average yields for untreated were 1.20 (canola), 0.63 (lentil) and 3.04 (wheat) t/ha on the light soil type and 1.58 (canola), 0.81 (lentil) and 2.53 (wheat) t/ha on the heavier soil type. As with the NSW site, many of the plots where early season biomass reductions were observed, recovered to yield statistically similar grain weights to untreated plots (Table 5). The exceptions were for single and double application rates of fomesafen on the light soil type, which reduced canola yields by 61% and 92%, respectively, and reduced wheat yields by 26% at the double rate on the light soil type. Double application rates of imazapic + imazapyr also reduced canola yields on the light soil type (by 43%); lentil yields on the heavier soil type (by 43%) and wheat yields on both soil types (by 43% on heavy soil type and 15% on light soil type). Label rate application of imazapic + imazapyr also reduced wheat yields by 20% on the heavier soil type. Flumioxazin at label rate also reduced wheat yields by 17% on the heavier soil type.

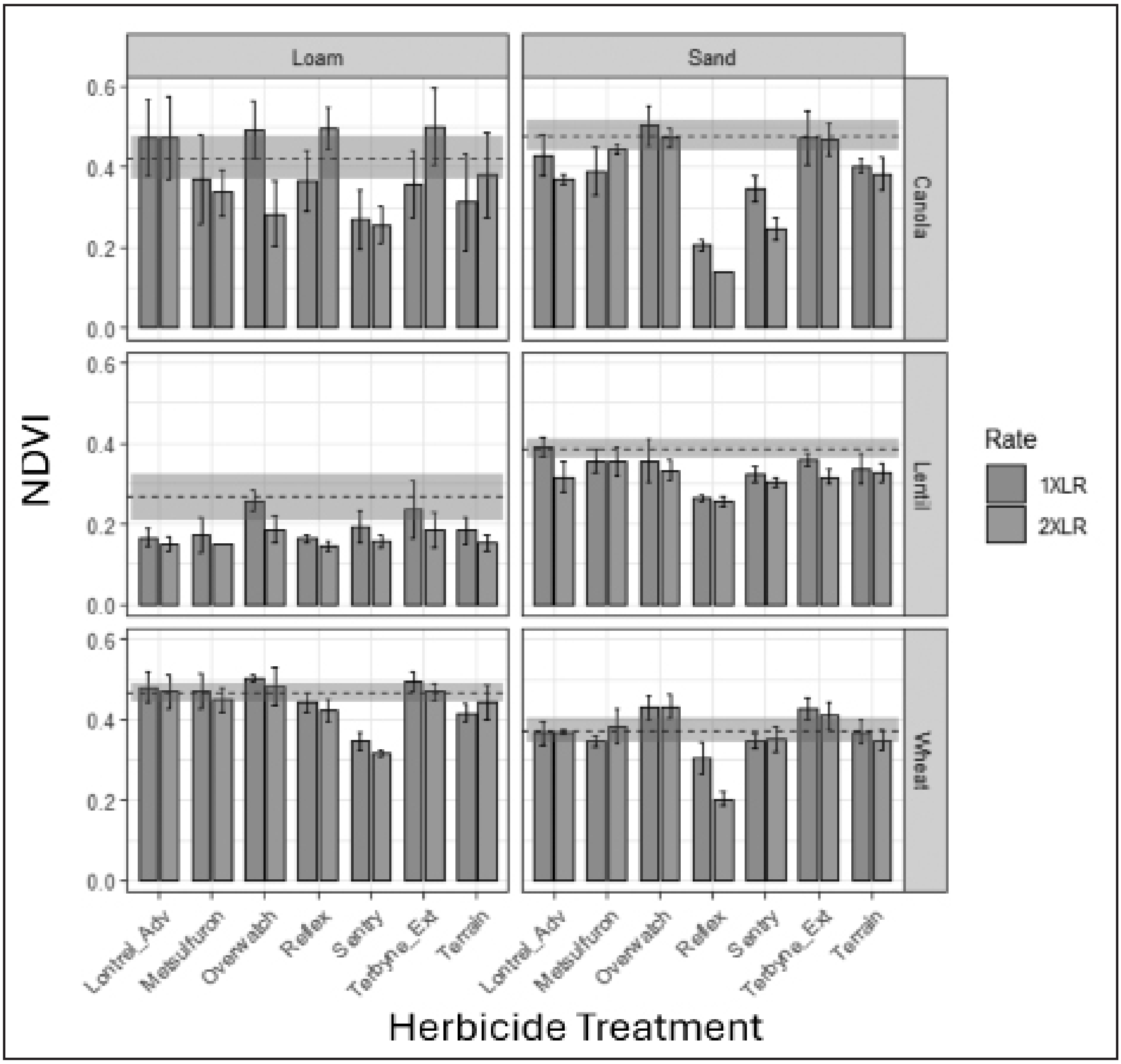


Figure 4. Effect of herbicide carryover from 2024 on NDVI of rotation crops wheat, lentil and canola on a loam and loamy sand at Minnipa, 2025. Error bars represent standard error (n=3). The black dashed line is the mean biomass of the untreated control plots and the grey shaded area is the standard error of the untreated (n=3). 1XLR indicates label rate application, 2XLR is double the standard application rate.

What does this mean?

The primary drivers of herbicide breakdown are well known, with factors such as rainfall, soil texture, organic matter, pH and microbial activity, being key. However, simple decision support tools to predict the level of herbicide remaining in soil over time, and the risk to rotation crops, are not currently available. This research aims to validate herbicide breakdown in different soil types and link this to carryover damage for different crop types and in different climates and regions of southern Australia. Of particular interest is the spatial variation of herbicide persistence in different soil types and our ability to accurately predict this persistence under different soil by environment by crop combinations.

Our results confirm that there is significant spatial variability in herbicide residue concentration in soil, even within a controlled field experiment (shown by the large error bars in Figures 1 and 2). After the dry 2024 season, more than 10% of the initial applied dose of bixlozone and fomesafen remained in the soil after harvest of the 2024 crop. This resulted in early season damage for canola and wheat planted into fomesafen residues from a 1.5 L/ha application rate of Reflex®, but wheat recovered on both soil types to yield statistically-similar to untreated. Canola, on the other hand, did not recover on the sandy soil type, and suffered ~60% yield loss compared to untreated. Recovery from early-season herbicide damage is a well-known phenomenon for many herbicides - but in certain circumstances where early season damage is severe, such as that for canola planted into fomesafen residues on the light soil type, recovery is not always guaranteed and yields can be impacted.

Weeds

Table 5. Grain yields relative to respective untreated plots (%). LR = label rate according to table 1; 2XLR = 2 times the label rate. Light grey shading indicates biomass reductions of 10-25%; dark grey shading indicates biomass reductions of >25%. Figures in bold indicate statistically significant reductions (P<0.05) compared to control plots.

Herbicide	Rate	Canola		Lentil		Wheat	
		Loam	Sandy loam	Loam	Sandy loam	Loam	Sandy loam
bixlozone	LR	**87**	101	82	76	96	112
	2XLR	**77**	116	97	115	115	113
clopyralid	LR	96	105	118	165	91	104
	2XLR	104	112	135	204	95	104
flumioxazin	LR	**89**	105	127	109	**83**	98
	2XLR	**83**	110	151	152	**89**	104
fomesafen	LR	98	**39**	125	122	108	91
	2XLR	97	**8**	114	113	92	**74**
imazapic + imazapyr	LR	**78**	100	91	120	**80**	101
	2XLR	**74**	57	57	118	**57**	**85**
metsulfuron-methyl	LR	**80**	97	121	115	92	98
	2XLR	95	117	95	204	93	103
terbuthylazine	LR	116	141	121	**82**	114	112
	2XLR	120	135	106	128	109	108

Additional work within this project will better define crop toxicity thresholds for different soil-herbicide combinations, to enable better interpretation of herbicide residue analysis in soil samples. A combined understanding of spatial variation of herbicide residue concentrations and crop toxicity thresholds will allow for improved understanding and ability to manage herbicide carryover risk. It should be noted that in all cases label recommendations must be followed, but it is clear that even when these have been adhered to, examples of crop damage still occur.

References

Rose, M.T., Zhang, P., Rose, T.J., Scanlan, C.A., McGrath, G. and Van Zwieten, L., 2022. Herbicide residues in Australian grain cropping soils at sowing and their relevance to crop growth. Science of The Total Environment, 833, p.155105.

Rose, M.T., Van Zwieten, L., 2024. Annual Results Repot 2023-2024. Geospatial analytics to predict the impact of residual herbicides on establishment and yield. NSW DPI, Unpublished.

Acknowledgements

GRDC for funding this research through project DPI2306-013RTX. The authors thank Olena Kravchuk, Adelaide University and AAGI, for critical input in experimental design. We also acknowledge the Minnipa Agricultural Centre Agronomy team for assistance the trial, and Wollongbar NSW DPIRD technical staff for assistance with herbicide analysis.

Impact of soil herbicide residues on crop performance in challenging soil types

Andong Shi[1,2,3], Brian Dzoma[2] and Nigel Wilhelm[1,2]
[1]SARDI; [2]Adelaide University; [3]Flinders University

Location
Wirrulla, Coulta, Bowhill & Warooka
Rainfall
Wirrulla
Av. Total: 306 mm
Av. GSR: 223 mm
2025 Total: 248 mm
2025 GSR: 210 mm
Coulta
Av. Total: 520 mm
Av. GSR: 436 mm
2025 Total: 511 mm
2025 GSR: 467 mm
Bowill
Av. Total: 303 mm
Av. GSR: 202 mm
2025 Total: 191 mm
2025 GSR: 131 mm
Warooka
Av. Total: 445 mm
Av. GSR: 351 mm
2025 Total: 438 mm
2025 GSR: 383 mm
Soil type
Red calcareous sandy loam at Wirrulla
Rocky sandy loam at Coulta
Sandy and sandy loam at Bowhill
Calcareous loam at Warooka
Soil test
Soil testing in underway, and data will be available soon
Plot Size
50 m x 12 m x 2 reps for Wirrulla and Coulta, 50 m x 1.5 m x 2 reps for Bowhill and Warooka. Randomised complete block design.

Key messages

- **Impact of IMI herbicide residues on canola was stronger than other crop types.**
- **At Warooka, Roundup Ready canola (LR 4540P) suffered yield penalty when exposed to Imazamox and Imazapyr compared to IMI-tolerant canola variety (PY421C). No yield loss was found in conventional wheat variety (Calibre), relative to IMI variety (Anvil CL) at the same site.**
- **At Bowhill, Roundup Ready canola had lower yield compared to IMI-tolerant canola variety, likely caused by residues (diflufenican and propyzamide) rather than IMIs.**
- **Biomass and yield of barley (Commodus CL) were not affected by herbicide residue of Sakura up to 64% (118 g/ha) at Wirrulla, and canola biomass (PY421C) was not affected by Reflex residue up to 78% of label rates (1000 ml/ha) at Coulta.**

Why do the trial?

It has been estimated that between 20-30% of paddocks across Australia contain soil-borne herbicide residues that constrain crop selection, and 10% of paddocks have residues that could result in crop damage and economic losses to growers (Hollaway et al. 2006; Rose et al. 2016, Rose et al. 2022). Several National Grower Network forums in South Australia have identified herbicide residues as a concern for growers, especially in low rainfall regions. Due to the complexity of the interaction between herbicide types, soil, crop types and environment, many growers lack confidence in the relevance of crop type selection and plant back periods. Therefore, more research in various regions targeting herbicide residues of concern is required to better understand if sensitive crops are being damaged by the presence of residues. This work will guide growers in making better-informed decisions with regards to in-crop and pre-emergent chemistry applications, thereby reducing plant-back issues and improving crop growth and yield.

In this project, consultation with local growers and agronomists was initially conducted in multiple soil types of concern covering different growing regions in SA to develop an overview of the nature and scope of herbicide residues issues. It was identified that herbicide residues of Intervix, Sakura, Reflex and Propyzamide are major concerns, particularly in the regions of Murray Mallee, lower YP, upper Eyre Peninsula and lower EP. Four trials were established in 2025 to test the impact of these herbicide residues on crop establishment, growth and yield.

How was it done?

After collecting and screening soil samples for a wide range of herbicide residues from 18 paddocks across major cropping regions in SA, four trials were established in 2025. These included two trials on Eyre Peninsula (Wirrulla on upper EP and Coulta on lower EP), one in Murray Mallee (Bowhill) and the fourth on lower YP (Warooka), targeting the influence of different herbicide residues on the growth and yield of various crop types. Soil screening for herbicide residues was conducted by ACS Laboratories.

The Wirrulla trial was set up as the grower had concerns that there might be Sakura residues (Pyroxasulfone) following a summer of below-average rainfall. There were three treatments: untreated (background residues only, medium (25% of recommended field application rate (RFR) on top of background residues, applied as 25 g ai/ha) and high (50% RFR, applied as 50 g ai/ha). Each treatment was duplicated in the paddock. Applications of herbicide were done using a boom spray on 30 April 2025, followed by sowing of barley (variety: Commodus CL) in May by the grower. Each strip was 12 m wide x 50 m long. Plant establishment was assessed on 9 July, and shoot dry matter was measured on 2 September. Harvest cuts were taken on 12 November 2025.

The Coulta trial was set up as the grower had concerns that Reflex residues (fomesafen) had persisted in the soil. It also had six strips (12 m wide x 50 m long), duplicates of three herbicide treatments, which were untreated (only background residues), medium (25% RFR, applied as 45 g ai/ha) and high (50% RFR, applied as 90 g ai/ha). The application of herbicide was by boom spray on 1 May 2025. Paddock was sown to canola (variety: PY421C) in June by the grower. Plant establishment was assessed on 9 July and shoot dry matter on 2 September. Harvest was performed directly by grower's header, and we are currently coordinating with the grower to obtain the yield data.

The growers at both Bowhill and Warooka had concerns about Intervix residues in their paddock. Both trials examined the impact of Intervix residues on crop establishment and growth using different crop types and varieties. At Bowhill, the trial included IMI-tolerant and conventional canola (PY421C and LR4540P), sown at the rate of 5 kg/ha using a plot seeder, and two lentils (IMI tolerant GIA Thunder and PBA Jumbo) at 70 kg/ha, as well as conventional field peas (Butler) at 100 kg/ha and lupins (Mandelup) at 105 kg/ha. The trial was sown on 19 June 2025, and all crops were sown in double-pass plots (each plot 1.5 m wide x 50 m long), except the lentil variety of Jumbo, where single-pass plots were used. All crop types and varieties were duplicated in the paddock and randomized. Plant establishment counts were done on 19 September 2025, and all plots were harvested on 10 December 2025. Plots extended from a flat area of sandy loam with limestone rocks onto the rise of a low sand hill. Due to differences in crop performance on either end of the trial, all plots were harvested as two separate sub-plots and recorded as northern and southern yield.

The Warooka trial was sown on 28 May 2025 to Calibre and Anvil CL wheat at the rate of 60 kg/ha and Roundup Ready (variety: LR4540P) and CL canola (PY421C) at 5 kg/ha rate using a plot seeder. Plot size was 1.5 m wide and 50 m long. Similar to the trial at Bowhill, all crops were sown as double-pass plots and duplicated. Plant establishment counts were done on 11 July 2025 and shoot dry matter cuts on 20 August 2025. Grain yield was assessed on 11 December 2025.

What happened?

Simulated herbicide residues

Wirrulla

Prior to seeding, Pyroxasulfone was detected in the 0-10 cm layer of the soil at 0.01 mg/kg, but none was detected in the 10-30 cm layer. The residues in the 0-10 cm layers are equivalent to 14% of the label rate of Sakura. As a result, the treatments of medium and high rate were actually 39% and 64% of label rate, respectively. Despite the high residue levels in the soil, the applied Sakura treatments did not change the establishment of barley. In the high treatment, shoot dry matter weight and grain yield appeared to become higher, compared to the other two treatments (Table 1). Barley is not registered for Sakura and is recommended to be sown after an interval of at least 9 months and with minimum interim rainfall of 250 mm. Our result at Wirrulla trial suggested that the growth and yield of barley variety Commodus CL was not affected by Sakura residues up to 64% of label rate.

Table 1. Effect of soil and simulated residues of Sakura at three levels: Low, medium (25% of label rate) and high (50% of label rate) on establishment, shoot dry matter and grain yield of barley at Wirrulla, in 2025.

Herbicide residue treatments	Plant establishment (plant/m^2)	Shoot dry matter (t/ha)	Grain yield (t/ha)
Low (background residue level)	156	1.6	0.86
Medium (25% of label rate added)	148	1.6	0.81
High (50% of label rate added)	150	1.9	0.96

Coulta

As expected by the grower, Reflex residues were detected in soil, both at 0-10 cm (0.05 mg/kg) and 10-30 cm (0.01 mg/kg). The concentration of active ingredient was equivalent to approximately 70 g/ha of product at 0-10 cm and 28 g/ha at 10-30 cm, reaching 98 g/ha as the soil background residues. As a result, the imposed medium and high residue treatments increased the effective rate to 143 g/ha (60% of label rate when applied at 1000 ml/ha) and 188 g/ha (78% of label rate). In this article, we are only presenting establishment and biomass at anthesis, as the extraction and analysis of the yield data is still ongoing with the grower (Table 2). Reflex treatments at medium and higher rates tended to reduce plant numbers, but high rate had the highest shoot dry matter when compared to other treatments. Canola is not a crop registered for Reflex and for re-cropping the recommendation is to sow after 9 months with rainfall of at least 250 mm). Our preliminary result at Coulta trial suggested that growth of IMI-tolerant canola (PY421C) was not influenced by Reflex residues up to 78% of label rate.

Trials with only background herbicide residues

Bowhill and Murray Mallee

Two trials were established solely based on the grower's concerns about possible residues of Intervix. At Bowhill, soil testing prior to seeding showed no Intervix residues of either imazamox or imazapyr at both 0-10 and 10-30 cm soil depth (results not received until after trial seeded). Instead, it found residues of diflufenican (0.02 and 0.01 mg/kg at 0-10 and 10-30 soil depth, respectively) and propyzamide (0.01 mg/kg at 10-30 cm depth). The rate of diflufenican was approximately 50% of label rate and the rate of propyzamide was around 5% of label rate for products containing 500 g/kg of propyzamide.

At this site, germination and establishment of crop were late due to a very dry start to the season. The dry season and a thick stand of medic on the loamy flat reduced crop growth and yield substantially. The conventional variety of both canola and lentil had reduced plant numbers compared to the IMI-tolerant varieties. The IMI-tolerant canola had 21 plants/m^2 while Roundup Ready canola had only 11 plants/m^2 (Table 3). Similarly, Thunder lentils had 81 plants/m^2, compared to 59 plants/m^2 for Jumbo lentil. Overall, the yield for all crop types was low at the site.

The lentil yield between the two varieties was too low to compare. We assessed one NVT trial on Murray Mallee to compare the varietal difference between Thunder and Jumbo, and found the yield of Thunder was, on average, 9 to 48% higher than Jumbo.

For canola, yield at both northern and southern ends was higher for IMI-tolerant canola variety than Roundup Ready variety. For varietal difference in canola, we only found one NVT site at Murray Mallee in 2025 which reported the yield of both IMI-tolerant and Roundup Ready varieties, which reported similar yield, being 1.28 and 1.27 t/ha. Thus, our finding of higher yield in IMI canola is likely attributed to other factors, rather than the IMI tolerance, because no Intervix residues were present. One possible reason could be the high residue of diflufenican, as it is registered for field peas, lentils and lupins, but not canola. However, it could equally cause damage to Roundup Ready canola variety, yet no symptoms typical of diflufenican damage were noted during the season. The higher yield in IMI canola at Bowhill site requires further examination.

Table 2. Effect of soil and simulated residues of Reflex at three levels: Low, medium (25% of label rate) and high (50% of label rate) on the establishment and shoot dry matter of canola at Coulta, in 2025.

Herbicide residue treatments	Plant establishment (plant/m^2)	Shoot dry matter (t/ha)
Low (background residue level)	47	4.6
Medium (25% of label rate added)	41	4.8
High (50% of label rate added)	40	5.6

Table 3. Establishment and grain yield of IMI-tolerant and conventional varieties of canola and lentil, as well as field peas and lupins at Bowhill, in 2025.

Crop Type	Varieties	Plant establishment (plant/m^2)	Grain yield - North (t/ha)	Grian yield - South (t/ha)
Canola	PY421C	21	0.33	0.48
Canola	LR4540P	11	0.19	0.24
Lentil	GIA Thunder	81	0.04	0.01
Lentil	Jumbo	59	0.08	0.02
Field peas	PBA Butler	32	0.52	0.25
Lupins	Mandelup	21	0	0.60

Table 4. Effect of soil background Intervix residues on establishment, shoot dry matter and grain yield of both IMI-tolerant and conventional varieties of wheat and canola at Warooka, in 2025.

Crops	Varieties	Plant establishment (plant/m^2)	Shoot dry matter (t/ha)	Grain yield (t/ha)
Wheat	Anvil CL	125	1.6	4.6
Wheat	Calibre	162	1.5	5.7
Canola	PY421C	48	3.2	4.9
Canola	LR4540P	44	1.7	3.4

Warooka

Residues of imazamox and imazapyr were detected at the Warooka site, with 0.003 and 0.004 mg/kg, respectively in the 0-10 cm layer. Assuming an application rate of 500 ml/ha, the residues represented 25% and 75% label rate of imazamox and imazapyr, respectively. In this trial, the IMI-tolerant canola had higher plant population than the Roundup Ready variety of canola (Table 4), with the shoot dry matter and yield being 88% and 44% higher in the IMI variety. The IMI-tolerant variety of wheat had the opposite pattern, with higher plant establishment and yield (24% higher) in conventional than IMI-tolerant variety. The varietal difference in wheat yield between Anvil CL and Calibre when assessed at three NVT trials on YP, was, on average, 18 to 19% higher for Calibre than Anvil CL, which is very similar to our findings. For varietal difference in canola, it was challenging to find the data of both IMI-tolerant and Roundup Ready varieties at same location and in the same growing season. But we suspect that the 44% higher yield in IMI-tolerant canola would be too high to be solely attributed to varietal differences, hence, it is likely that IMI herbicide residues (25% and 75% label rate of imazamox and imazapyr) have caused damage to Roundup Ready canola in this trial.

What does this mean?

The dry season in 2024 (18% less GSR at Bowhill, 50% less at Warooka and Coulta, and 75% less at Wirrulla, compared to GSR in 2025) led to residue persistence in soil, which was found at all four trials. Additionally, large regional differences were observed from these trials. At Wirrulla, barley (Commodus CL) growth and yield were not affected by Sakura residue up to 64% of label rates (118 g/ha spray rate). Similarly, canola establishment and shoot dry matter at anthesis did not respond to Reflex residue up to 78% of label rate at 1000 ml/ha at Coulta. Considering the GSR of 210 mm and 467 mm in 2025 at Wirrulla and Coulta, Coulta site offers a relatively safe soil environment in the 2026.

In the two other trials where the impact of soil background herbicide residues on crop growth was investigated, only the Warooka site had responses between IMI-tolerant and conventional varieties to IMI residues. Roundup Ready canola was more susceptible to IMI herbicide residue damages, compared to the IMI-tolerant variety, which had 44% higher yield in the latter. Given the GSR of 383 mm in 2025 (nearest town to Warooka site), the carry over effect of IMI herbicide should be minimum in the coming season. On the contrary, the below-average GSR at Bowhill in 2024 (111 mm) and 2025 (131 mm) would continue to pose challenges for crop growth in the coming season.

Acknowledgements

The trials were undertaken by various research groups or directly by the growers, which all being part of the research project under the support of the GRDC (project code: OA2501-005RTX). The authors would like to acknowledge the continued support and assistance for managing the various demonstration trials from Josh Telfer at Pt Lincoln, Kym Zeppel, Buddhi Chaudhary, Katrina Brands and Amanda Cook at Minnipa Agricultural Centre and Trengove Consulting.

Adelaide University

Flinders University

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Government of South Australia Department of Primary Industries and Regions

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Stopping seed set of barley grass on the upper Eyre Peninsula

Amanda Cook[1,2,3], Dr Gurjeet Gill[2] and Ben Fleet[2]

[1]SARDI; [2]Adelaide University; [3]Flinders University

Location
Minnipa Agriculture Centre - Airport
Rainfall
Av Annual: 324 mm
Av GSR 241 mm
2025 Total: 281 mm
2025 GSR: 228 mm
Paddock history
2025: Lentil (Thunder)
2024: Wheat (Calibre)
2023: Peas
Soil type
Red loamy sand
Plot Size
12 m x 2 m x 3 reps
Trial design
Randomized Complete Block Design (RCBD)

Key messages

- **Infrequent rainfall events, poor early weed germination, early and dry conditions at seeding all resulted in challenging conditions for barley grass weed control in 2024 and 2025.**
- **Clearfield Tomahawk wheat achieved higher yield and good barley grass weed control in both seasons.**
- **Newer herbicides provide opportunities for grass weed management, but overall Sakura is still a good option for barley grass weed control in cereals.**
- **Seed separation from herbicides is important for crop establishment, especially when using Trifluralin or Luximax.**

Why do the trial?

Barley grass (*Hordeum glaucum*) continues to be the major grass weed in cereal cropping on the upper Eyre Peninsula (EP). Barley grass on the upper EP has been documented to have higher seed dormancy levels than elsewhere in the lower rainfall zone (UOA1904-004SAX). Additionally on the upper EP, there are emerging levels of Group 1 resistance in barley grass, thereby reducing in-crop weed control options. The research reported here evaluates a second season of the use of pre-emergent herbicides in managing barley grass in cereals.

How was it done?

One trial was sown at Minnipa Agricultural Centre on 4 June 2025 with Calibre wheat @ 75 kg/ha and MAP @ 75 kg/ha with the seed. A knockdown herbicide of Glyphosate (Weedmaster) @ 2 L/ha was applied presowing. CL Tomahawk wheat was sown with Intercept (0.5 L/ha) applied early post emergent as a treatment. Mateno Complete (1 L/ha) EPE (early post-emergent) treatments were applied on 18 June. The pre-emergent (IBS, incorporated by sowing) and EPE herbicide treatments are listed in Table 1. In 2024 a similar trial was undertaken at Minnipa Agricultural Centre.

Measurements undertaken in 2025 were plant establishment (25 June and 8 July), early grass weeds (8 July), NDVI (8 July), late grass weeds (15 September), barley grass head count and barley grass weed seed set (28 October), grain yield (28 October) and grain quality. Barley grass weed seed set was calculated by dividing the treatment barley grass head count weight per metre square by the average weight of barley grass seeds.

What happened?

Total annual rainfall in 2025 was 312 mm and the growing season rainfall was 252 mm for Minnipa which is a decile 5 year. The first significant rainfall event was on 20 March with 20 mm, but only small events occurred in April (4 mm) and May (8 mm) until 12 June with 14 mm received. The late seasonal break resulted in most crops being dry sown, followed by an above average winter rainfall (June 60 mm, July 99 mm and August 35 mm). October rainfall of 41 mm and cooler conditions resulted in good grain fill and higher than expected yields.

The late season break and drier seeding conditions resulted in very little weed germination or weed control before sowing. There were differences in wheat establishment in early July due to the pre-emergent herbicides (Table 1). Luximax is the most mobile of the herbicides tested and resulted in reduced crop establishment compared to other herbicide treatments. Trifluralin also showed reduced plant establishment compared to untreated possibly due to being too near to the seed (sown too shallow) or not enough soil movement away from the seed. Early barley grass densities were low despite the paddock being known for a high barley grass burden and there were no reductions in early barley grass numbers due to the pre-emergent herbicides. The Minnipa Agricultural Centre is known to be a later germinating barley grass genotype (germinating mid-June). NDVI was greatest in untreated and lower with reduced plant establishment treatments.

Table 1. Pre-emergent (IBS, incorporated by sowing) and early post emergent (EPE) herbicide treatments (per ha) and crop and weed numbers (plants/m²), NDVI and dry matter (t/ha) in the barley grass trial sown at Minnipa Agricultural Centre, in 2025. Treatments followed by the same letter are not statistically different.

Treatment (herbicide per ha)	Herbicide Group	Chemical Cost ($/ha)	Plant Establishment 8 July (plants/ m²)	Barley grass 8 July (plants/m²)	NDVI 8 July
Untreated		0	109 abcd	6	0.55 a
Glyphosate only (2 L)	9	$15	100 bcdef	10	0.52 ab
Sakura (118 g) IBS	15	$30	92 bcdefg	7	0.43 bcde
Sakura (118 g) and Avadex 500 gm/L (1.6 L) IBS	15	$46	93 bcdefg	8	0.39 cdef
Sakura (118 g) and Voraxor (0.2 L) IBS	15, 14	$69	110 abc	15	0.29 f
Prosulfocarb (3 L) IBS	15	$24	96 bcdefg	15	0.34 ef
Mateno Complete (1 L) IBS	32, 12, 15	$53	104 bcde	9	0.42 bcde
Mateno Complete (1 L) EPE	32, 12, 15	$53	106 bcd	1	0.44 abcde
Trifluralin (1.8 L) IBS	3	$15	99 bcdefg	5	0.47 abc
Trifluralin (1.8 L) and Sakura (118 g) IBS	3, 15	$45	72 fgh	6	0.35 def
Trifluralin (1.8 L/ha) and Overwatch (1.25 L) IBS + Mateno Complete (1 L) EPE	3, 13, 32, 12, 15	$111	75 efgh	10	0.46 abcd
Trifluralin (1.8 L) IBS and Mateno Complete (1 L) EPE	3, 32, 12, 15	$68	82 cdefgh	14	0.47 abc
Trifluralin (1.8 L) and Overwatch (1.25 L) IBS	3, 13	$59	79 defgh	1	0.43 bcde
Trifluralin (1.8 L) and Diuron (300 gm) IBS	3, 6	$20	81 cdefgh	7	0.44 abcde
Trifluralin (1.8 L) IBS and Luximax (500 mL) IBS	3, 30	$62	60 h	11	0.40 bcdef
Trifluralin (1.8 L) IBS and Avadex 500 (1.6 L) IBS	3, 15	$31	71 fgh	25	0.45 abcde
Luximax (0.5 L) IBS	30	$45	69 gh	10	0.41 bcde
Overwatch (1.25 L) IBS	13	$43	74 efgh	11	0.50 abc
Diuron (300 g) and Metrabuzin (100 g) IBS	6, 5	$8.50	114 ab	8	0.49 abc
CL wheat Tomahawk with Intercept (0.5 L/ha) EPE	2	$17	138 a	12	0.43 bcde
LSD (Fprob=0.05)			*31*	*ns*	*0.12*

Table 2. Pre-emergent (IBS, incorporated by sowing) and early post emergent (EPE) herbicide treatments (per ha) and late barley grass weed numbers (plants/m²), weed seed set and grain yield in the barley grass trial sown at Minnipa Agricultural Centre, in 2024 and 2025. Treatments followed by the same letter are not statistically different.

Treatment (herbicide per ha)	2025 Barley grass 28 Oct (plants/ m²)	2025 Barley grass seed set 28 Oct (seeds/m²)	2025 Grain Yield (t/ha)	2024 Late Barley grass 15 Sept (plants/m²)	2024 Grain Yield 26 Nov (t/ha)
Untreated	27	1200	1.87 a	24	1.71
Glyphosate only (2 L)	0	0	1.97 a	104	1.44
Sakura (118 g) IBS	0	0	1.59 cde	1.5	1.74
Sakura (118 g) and Avadex 500 gm/L (1.6 L) IBS	0	0	1.49 e	33	1.65
Sakura (118 g) and Voraxor (0.2 L) IBS	19	1808	1.57 cde	16	1.66
Prosulfocarb (3 L) IBS	11	406	1.86 a	28	1.39
Mateno Complete (1 L) IBS	26	954	1.72 abc	9	1.71
Mateno Complete (1 L) EPE	1	67	2.05 a	16	1.60
Trifluralin (1.8 L) IBS	0	0	1.87 a	65	1.54
Trifluralin (1.8 L) and Sakura (118 g) IBS	0	0	1.45 e	12	1.80
Trifluralin (1.8 L/ha) and Overwatch (1.25 L) IBS + Mateno Complete (1 L) EPE	64	5743	1.54 de	1	1.61
Trifluralin (1.8 L) IBS and Mateno Complete (1 L) EPE	3	240	1.79 ab	23	1.78
Trifluralin (1.8 L) and Overwatch (1.25 L) IBS	3	68	1.79 ab	15	1.71
Trifluralin (1.8 L) and Diuron (300 gm) IBS	9	663	1.82 a	11	1.67
Trifluralin (1.8 L) IBS and Luximax (500 mL) IBS	4	542	1.65 bcd	16	1.68
Trifluralin (1.8 L) IBS and Avadex 500 (1.6 L) IBS	24	1488	1.72 abc	5	1.65
Luximax (0.5 L) IBS	19	2301	1.53 de	35	1.54
Overwatch (1.25 L) IBS	1	56	1.72 abc	15	1.74
Diuron (300 g) and Metrabuzin (100 g) IBS	3	1013	1.91 a	17	1.59
CL wheat Tomahawk with Intercept (0.5 L/ha) EPE	0	0	2.11 a	0	1.72
LSD (Fprob=0.05)	*ns*	*ns*		*ns*	*ns*

**2024 Treatment was Boxer Gold (2.5 L/ha) IBS*

Weeds

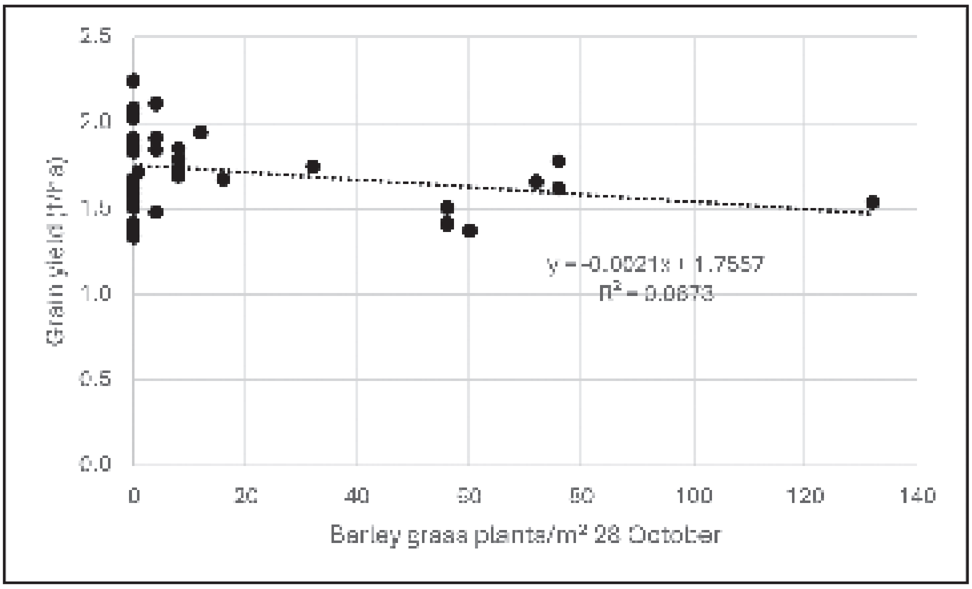


Figure 1. Effect of barley grass on wheat grain yield (t/ha) in the barley grass trial sown at Minnipa Agricultural Centre, in 2025.

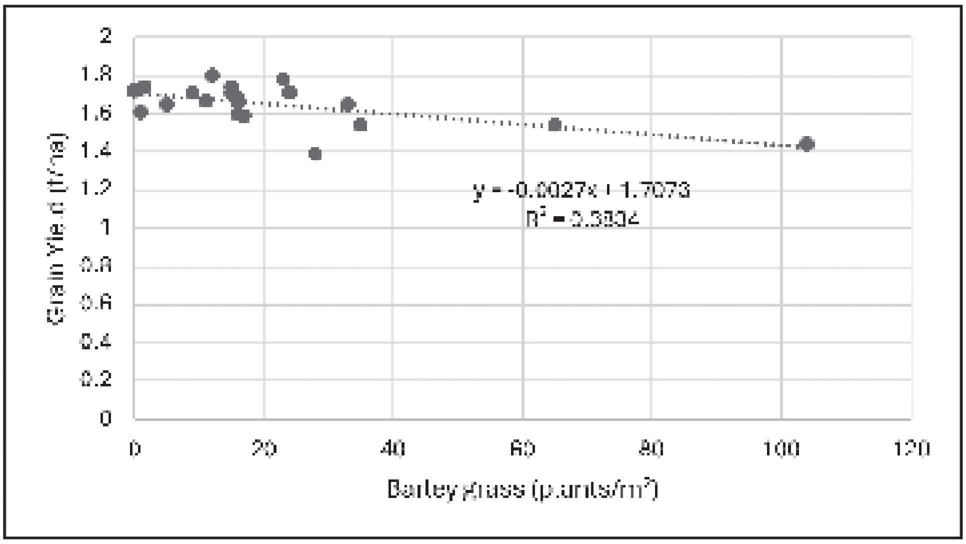


Figure 2. Grain yield (t/ha) and barley grass weed numbers (plants/m²) in the cereal trial sown at Minnipa Agricultural Centre, in 2024.

In 2024, there was a difference in plant establishment with the CL Tomahawk wheat having higher plant numbers at establishment compared to the Calibre wheat, but no differences in establishment due to the pre-emergent herbicides applied in the drier sowing conditions with little soil moisture in June 2024 (data not presented).

Under the dry seasonal conditions of 2024 there were no differences in early or late grass weed control, weed seed set or plant biomass, grain yield or grain quality with the different herbicides used (Table 2). The Trifluralin and Sakura treatments generally performed well for barley grass weed management in 2024. Generally, in the dry seasonal conditions Matento Complete used earlier as IBS performed better than early post emergent (EPE) application. Average grain quality in 2024 was 11.7 % protein and 5.7% screenings.

In 2025 there were no differences in late grass weed control, weed seed set or grain quality (data not presented). Grain yield was highest with the CL wheat system using Tomahawk with Intercept (0.5 L/ha) EPE at 2.11 t/ha. Lower grain yields in 2025 (1.54 to 1.45 t/ha) were with Sakura treatments and Luximax IBS indicating that the more soluble herbicides may have washed into the root zone and caused reductions in crop growth. Average grain quality in 2025 was 11.8 % protein and 8% screenings.

In both 2024 and 2025, with drier conditions at the start of the season, Matento Complete used earlier (IBS) performed better than as an EPE application.

What does this mean?

Overall in this research Clearfield Tomahawk wheat achieved higher yield and good barley grass weed control in both seasons. The newer herbicides provide opportunities for different herbicide groups to be used for grass weed management and Sakura is generally a good option for barley grass weed control in cereals. Seed separation from herbicides is important for crop establishment, especially when using Trifluralin or Luximax, which impacted on grain yield.

The cost of herbicides vary greatly from $8.50/ha to $111/ha (Table 1) and the activity of the herbicide on the targeted grass weed will vary between seasons with rainfall patterns, soil moisture and placement/soil movement at seeding. Selecting the best herbicide and length of herbicide persistence for the predicted paddock weed burden, as well as the cost of the herbicide is important. It may be worth using a more expensive herbicide or a Clearfield system on paddocks with known high grass weed numbers, or alternatively using a breakcrop.

In dry sowing conditions there is no prior or very little weed germination so no knock down herbicides can be used to control part of the weed burden, placing more pressure for weed control on the pre-emergent herbicides The performance of many pre-emergent herbicides is dependent on soil moisture, the persistence of the herbicide and the mobility of the herbicide in the soil water that will depend on soil type. Low moisture conditions at sowing result in some herbicides which rely on soil moisture to be activated not preforming as well as in other seasons.

The herbicides used differ in how they behave in the soil and with soil water to activate grass weed control. Trifluralin is not mobile and is tightly bound so will stay in the topsoil where it is placed and prevent weed germination by forming a gas in the soil environment with moisture, however herbicide and seed separation by moving soil out of the furrow is important. Sakura has low solubility so is likely to require moist conditions for incorporation and weed uptake, and has moderate mobility but low solubility and so has limited movement with soil water.

Avadex has low solubility so requires moist conditions for incorporation and weed uptake, and is slightly mobile but with lower solubility therefore tends to stay in the topsoil. Prosulfocarb is slightly mobile so tends to stay in the topsoil and has low solubility so is likely to require moist conditions for incorporation and uptake.

Aclonifen in Mateno Complete has high solubility and low mobility so will not move through the soil. Bixlozone in Overwatch has low to moderate solubility and moderately mobile so is more likely to move with soil water. Cinmethylin in Luximax has moderate solubility and moderately mobile so is more likely to move with soil water

The new chemistries from different herbicide groups provide opportunities for grass weed management and options when dry sowing. Continued evaluation of these herbicides in lower rainfall regions will determine potential herbicide residue carry over issues in dry seasons, particularly with alkaline soils.

The differences in a herbicide's ability to move through the soil profile with soil water and to bind to organic matter will influence the uptake of the chemical by the target weeds, the crop, and the impact on both. Soil texture and soil chemical properties can affect chemical movement and availability in the soil profile. Some chemicals will have greater activity and mobility and be 'hotter' in lighter sandier soils than the red loamier soils. The dry seeding conditions and with small rainfall events at the start of the 2025 season resulted in lower weed control due to lower soil mobility.

When choosing the most appropriate pre-emergent herbicide for use in dry sowing systems, it is important to consider:

- current position of any soil moisture,
- the mobility of the herbicide in soil water,
- the persistence of the herbicide activity relative to the germination pattern of the target weeds,
- specific tillage/seeding system and level of soil disturbance,
- the likely rainfall pattern and soil moisture conditions post application,
- the susceptibility of the crop to the herbicide,
- the position of the weed and crop seeds in the soil profile.

Herbicide residues may cause issues in low rainfall seasons and low summer moisture seasons as limited soil moisture reduces the activity of microbial populations to breakdown herbicide residues. Check paddock rotations to ensure varieties and crop types are tolerant to any potential herbicide residues. Check the herbicide label for the required rainfall for herbicide breakdown, but in practice, different soil types and environmental conditions will vary the speed of breakdown for any herbicide. A simple bioassay could be conducted where seeds of the desired crop are sown into the paddock a few weeks prior to the desired sowing date and establishment is observed to see the likely level of crop injury. Also note adequate breakdown may have been achieved in the topsoil where there are higher microbial populations and germination may be unaffected, however damage or death could still result when the roots of the new crop extend into the residual herbicide layer further down the profile especially if soils have clay layers in the profile (Congreve and Cameron, 2023).

Reducing the weed seed bank in every season is pivotal to managing grass weeds. If barley grass herbicide resistance is suspected, it is essential is to test the population to know exactly what you are dealing with and then ensure the best application of appropriate herbicides to maximise the efficacy of the operations. As part of this research project a weed survey has been undertaken in 2024 and 2025 of barley grass populations on EP focusing on barley grass in cereal crops grown after pasture and lentils. Twenty barley grass populations per year were collected from paddocks where growers are having difficulty in managing barley grass to be evaluated for herbicide resistance.

For further information on herbicide mode of actions and herbicide residues see 'Soil behaviour of pre-emergent herbicides in Australian farming systems - a national reference manual for agronomic advisers', Mark Congreve (ICAN) and John Cameron (ICAN) Third edition, November 2023.

Acknowledgements

This research was funded by GRDC (UOA2403-011RTX). Thank you to Kym Zeppel, Katrina Brands, Marina Mudge, Tammie Mullen, Julian Post, Rebbecca Tomney and Cayley Gray for their assistance with the field work.

Combinations of crop rotations and herbicides for effective management of brome grass (Poochera, SA)

Ben Fleet[1], Buddhi Chaudhary[1,2,] Amanda Cook[1,2,3] and Gurjeet Gill[1]

[1]Adelaide University; [2]SARDI; [3]Filinders University

Location
Poochera
Rainfall
2025 Total: 265 mm
2025 GSR: 210 mm
2024 Total: 155 mm
2024 GSR: 125 mm
Paddock history
2025: Wheat (Calibre, Tomahawk CL), Barley (Combat) & Lentils (GIA Thunder)
2024: Wheat (Calibre, Tomahawk CL), Barley (Titan AX)
2023: Scepter wheat
Soil type
Calcareous grey sandy loam
Plot Size
15 m x 3 m (two seeder plot) x 4 reps
Trial design
Randomized Complete Block Design (RCBD)

Key messages

- **Sole reliance on pre-emergent herbicides led to a substantial increase in brome grass plant density (60%) and panicle density (33%) in 2025.**
- **One-year break from brome grass seed set was achieved by growing Titan AX barley or Clearfield (CL) wheat in 2024 (System 2 and System 3). Both systems prevented a rebound in brome grass plant and panicle density in wheat treated with Sakura + Avadex Xtra in 2025.**
- **Two-year breaks provided highly effective brome grass control and either eliminated panicle production by brome grass or reduced it to a very low level.**

Why do the research?

Brome grass is currently ranked as the second worst weed in grain crops in Australia, causing annual revenue loss of $42 million (Ouzman et al. 2025). Brome grass tends to be difficult to control with the pre-emergent herbicides currently registered for use in cereal crops. Development of herbicide tolerant cereal varieties has increased options for growers to manage brome grass effectively in the cereal phase of the rotations. Integration of herbicide tolerant cereals with break crops such as pulses and canola offer opportunities to effectively deplete brome grass seedbank and minimise the risk of buildup in its populations. It is important to demonstrate to growers the effectiveness of carefully considered cropping sequences for the management of brome grass in different agroecological environments. To achieve this objective, a 3-year field trial was initiated near Poochera on the upper Eyre Peninsula during the 2024 growing season. The study aims to identify rotations and herbicide programs that effectively suppress brome grass populations and minimise seedbank replenishment while maintaining crop productivity.

How was it done?

A field trial was established in a randomised complete block design on a commercial farm near Poochera on the upper Eyre Peninsula. This farm has calcareous grey sandy loams soil which are favoured by brome grass.

The trial was sown with a no-till cone seeder with 25 cm row spacing and seeding width of 1.5 m (Table 1). There were two seeder runs per plot, and the plots were 15 m long. There was one buffer plot between all experimental plots to minimise the risk of herbicide spray drift and dispersal of weed seeds to neighbouring plots during crop harvest or by wind dispersal. All pre-emergent herbicides were sprayed just prior to crop sowing and incorporated by the no-till seeding tines (IBS). Data was analysed by using GenStat 23rd Edition.

Information on herbicide products, active ingredients and label rates can be found in Table 2.

The summer of 2025 was extremely dry with only 26 mm rainfall from January to May. Crops were sown dry on 2 June, but some rainfall (6 mm) was received on 6 June and then subsequent light rains on 8 and 9 June. Total rainfall in June was slightly higher than the long-term average for this area. The season had a real turnaround in July when 102 mm rainfall was received, which is more than double the long-term average for the site. However, August and September were drier than average, but October was slightly higher than average. Overall rainfall for the year and the growing season was well below the long-term average of 308 mm and 230 mm, respectively.

Table 1. Trial details for 2025.

Project duration	2024–2026 (3-years)
Trial location	Poochera, SA (EP)
Plot size	12 m x 1.5 m (paired)
Replications	3
Soil type	Calcareous sandy loamy
Sowing date	2 June 2025
Target crop density (plants/m^2)	Wheat 180, barley 150 and lentils 120
Fertiliser	75 kg/ha MAP at sowing; barley and wheat also had 50 kg/ha urea at GS14 (9 July)
Herbicides	See Table 2
Crop-topping	glyphosate 2 L/ha DST 470 (system 6) on 27 October
Harvest date	5 December

Table 2. Information about the herbicides used for brome grass control in 2025 at Poochera.

Product name	Active ingredient	Label rate
Sakura	Pyroxasulfone (850 g/kg)	118 g/ha
Treflan	Trifluralin (480 g/L)	1.5-3.0 L/ha when used as incorporated by sowing (IBS) in no-till knifepoint press wheel system (KP PW)
Avadex Xtra	Triallate (500 g/L)	2.6-3.2 L/ha when used IBS with KP PW
Intervix	33 g/L Imazamox and 15 g/L Imazapyr	375-750 mL/ha for brome grass
Targa	Quizalofop 100 g/L	375 mL/ha
Ultro	Carbetamide 900 g/kg	1.1–1.7 kg/ha (IBS)

In this trial report, the term ‘break’ refers to the year where crop × herbicide combinations are expected to effectively prevent brome grass seed production (Table 3).

No-break system (S1): Calibre wheat treated with Sakura + Avadex in 2024 was followed by Combat barley sprayed with pre-emergent herbicide mixture of Treflan + Avadex Xtra in 2025. This system is expected to allow considerable brome grass seed production each year and weed density is likely to remain high.

1-year break systems (S2 and S3): Titan AX barley (S2) or Tomahawk CL Plus (S3) in 2024 were followed by wheat sprayed with pre-emergent herbicides Sakura + Avadex Xtra in 2025. These management systems are expected to lead to a rebound in brome grass populations due to weed establishment from the residual seedbank.

2-year break systems (S4 and S5): Brome grass was controlled in 2024 in Titan AX barley (S4 and S5), which was followed in 2025 either by Thunder lentil sprayed with carbetamide (Ultro PRE) and quizalofop (Targa POST) (S4) or Tomahawk CL Plus wheat sprayed with Intervix (S5). Both systems are expected to provide effective brome grass control in 2024 and 2025.

3-year break system (S6): Titan AX barley in 2024 was followed by Thunder lentil in 2025 (S6) to provide an effective second break from brome grass. Lentil were sprayed with carbetamide (Ultro PRE) followed by quizalofop (Targa POST) for brome grass control. In 2026, CL plus wheat will be grown to achieve 3 consecutive years of effective weed control.

What happened?

Crop establishment

Even though the seedbed was dry at crop sowing, rains received within a few days after sowing allowed excellent establishment of wheat, barley and lentils in various systems (Table 5). Crop density in wheat and barley-based systems in 2025 ranged from 140 to 170 plants/m^2, which was close to the target density of 150 plants/m^2 for barley and 180 plants/m^2 for wheat. Importantly, these plant densities are adequate to produce high grain yields and to provide competition with brome grass that survive herbicide treatments. The local grower group participating in this trial was keen to assess the suitability of lentils in this environment where growing seasons tend to be short. Crop establishment in lentils in system 4 and 6 was also close to the target density of 120 plants/m^2.

Brome grass plant and panicle density

Sole reliance on pre-emergent herbicides in System 1 led to an increase in brome grass plant and panicle density in 2025 as compared to 2024 (Table 4). Presence of high panicle density of brome grass (222 panicles/m^2) in System 1 is likely to have a negative impact on barley grain yield in 2025 and is likely to increase the weed seedbank for 2026.

Table 3. Crops, varieties and herbicide input programs (per ha) in the field trial at Poochera, in 2024 and 2025.

System	2024	2025
S1 (no break)	**Calibre wheat** PRE: Sakura 118 g + Avadex Xtra 2.4 L	**Combat barley** PRE: Treflan 2 L + Avadex Xtra 2 L
S2 (one-year break)	**Titan AX barley** PRE: Treflan 1.2 L POST: Aggressor AX 200 mL	**Calibre wheat** PRE: Sakura 118 g + Avadex Xtra 2 L
S3 (one-year break)	**Tomahawk CL Plus wheat** PRE: Treflan 1.2 L POST: Intervix 600 mL	**Tomahawk CL Plus wheat** PRE: Sakura 118 g + Avadex Xtra 2 L
S4 (two-year break)	**Titan AX barley** PRE: Treflan 1.2 L POST: Aggressor AX 200 mL	**GIA Thunder lentils** PRE: Ultro 1.4 kg POST: Targa 375 mL
S5 (two-year break)	**Titan AX barley** PRE: Treflan 1.2 L POST: Aggressor AX 200 mL	**Wheat Tomahawk CL Plus** PRE: Treflan 2L POST: Intervix 600 mL
S6 (3-year break)	**Titan AX barley** PRE: Treflan 1.2 L POST: Aggressor AX 200 mL	**GIA Thunder lentils** PRE: Ultro 1.4 kg POST: Targa 375 mL

Table 4. Densities of brome grass plants and panicles across crop rotation sequences and herbicide input programs in 2024 and 2025. Crop names in bold indicate the phase, in 2025. Refer to Table 3 for information on herbicide treatments. Means followed by a different letter indicate statistical significance (P=0.05).

System	**Rotation sequence**	**Brome density 2024[1] (plants/m²)**	**Brome density 2025 (plants/m²)**	**Brome panicles 2024[1] (panicles/ m²)**	**Brome panicles 2025 (panicles/ m²)**
S1 (no break)	Wheat - **Barley** - Wheat (PRE herbicides - weak system)	102 bc	166 c	173 c	222 b
S2 (1-year break)	AX barley - **Wheat** - wheat	35. a	5 ab	0 a	0 a
S3 (1-year break)	CL wheat - **Wheat** - wheat	143 c	9 b	18 b	4 a
S4 (2-year break)	AX barley - **Lentil XT** - wheat	27 a	0 a	0 a	0 a
S5 (2-year break)	AX barley - **CL wheat** - wheat	51 ab	5 ab	0 a	7 a
S6 (3-year break)	AX barley - **Lentil XT** - CL Wheat	33 a	1 ab	0 a	0 a
P-value		*<0.001*	*<0.001*	*<0.001*	*<0.001*

[1]Plant and panicle density data were square root transformed before performing ANOVA.

One-year break from brome grass seed set was achieved by growing Titan AX barley or CL wheat in 2024 (S2 and S3). Use of Sakura® + Avadex® Xtra in wheat in 2025 in these systems was able to prevent a rebound in brome grass plant and panicle density (Table 4). Even a single year of effective weed control in 2024 in herbicide tolerant crops followed by moderate control with pre-emergent herbicides in 2025 is likely to maintain future infestation of brome grass at a low level at this site.

In this trial, the two-year break from brome grass seed set was achieved by growing Titan AX barley in 2024 and lentil or CL wheat in 2025. These systems were able to provide highly effective brome grass control and either eliminated panicle production (S4) or reduced it to a very low level (S5 & S6) (Table 4). Any brome grass which establishes in these management systems in 2026 is likely to come from its persistent seedbank.

Overall, there was a clear separation between the management systems in terms of plant and panicle density with System 1 having significantly higher brome grass than all other management systems. However, the impact of 1-, 2-year breaks on brome grass panicle density in 2025 was similar. Use of lentils offered an opportunity to use an effective pre-emergent herbicide (Ultro®/carbetamide) and post-emergent herbicide (Targa®/ quizalofop), which effectively killed all brome grass and prevented panicle production.

Weeds

Table 5. Grain yield of crops in response to brome grass management systems at Poochera in 2025. Crop names in bold indicate the phase, in 2025. Refer to Table 4 for information on herbicide treatments. Means followed by a different letter indicate statistical significance (P=0.05).

Treatment	Rotation sequence	Grain yield (kg/ha)
S1 (no break)	Wheat - **Barley** - Wheat (PRE herbicides - weak system)	2289 d
S2 (1-year break)	AX barley - **Wheat** - Wheat	1817 b
S3 (1-year break)	CL wheat - **Wheat** - Wheat	2061 c
S4 (2-year break)	AX barley - **Lentil XT** - Wheat	16 a
S5 (2-year break)	AX barley - **CL wheat** - Wheat	2185 cd
S6 (3-year break)	AX barley –-**Lentil XT** - CL Wheat	27 a

Crop grain yield

Even though lentil establishment in this trial was excellent and close to the target density, it failed to produce commercially viable grain yield (Table 5). It appears that below average rainfall at the site in August and September imposed severe water stress on the crop during its flowering and podding period. As a result, there was very little pod set and grain yield. It is also possible that lentils are not well adapted to the calcareous sandy soil at the trial site.

Wheat and barley are widely recognized as being more tolerant to dry spring conditions and this was clearly seen in this trial with grain yields over 2000 kg/ha (Table 5). Combat barley in System 1 was the highest yielding treatment, which may be associated with superior weed competitive ability and water use efficiency of barley than wheat. For reasons which are unclear, Tomahawk CL (S3 and 5) produced higher grain yields than Calibre wheat in System 2 (Table 5).

What does this mean?

Even though the seedbed was dry at crop sowing, rains received within a few days after sowing allowed excellent establishment of wheat, barley or lentils in all systems. Sole reliance on pre-emergent herbicides in System 1 led to an increase in brome grass plant and panicle density in 2025 as compared to 2024. Even a one-year break from brome grass seed set, which was achieved by growing Titan AX barley or CL wheat in 2024 (S2 and S3), followed by moderate weed control with Sakura + Avadex Xtra in wheat in 2025 was able to prevent a rebound in brome grass plant and panicle density. This result varies from other trial sites where 1-year break allowed brome grass density to rebound in the next year. As expected, the two-year break from brome grass seed set with Titan AX barley in 2024 and lentil or CL wheat in 2025 either eliminated its panicle production (S4) or reduced it to a very low level (S5,6).

References

Ouzman J, Azeem M, Llewellyn R (2025) Impact of weeds on Australian grain and cotton production. Grains Research and Development Corporation. pp 66. Accessible at: grdc.com.au

Acknowledgements

This research was funded by GRDC through the ‘Effective control of brome grass in the southern and western cropping zones’ (UOA2303-006RTX). We also thank the grower collaborator for hosting this field trial. Thank you to MAC staff, Kym Zeppel, Katrina Brands, Marina Mudge, Tammie Mullen, Julian Post, Rebbecca Tomney and Cayley Gray for their assistance with the field work.

Combinations of crop rotations and herbicides for effective management of brome grass (Cowell, SA)

Ben Fleet[1], Buddhi Chaudhary[1,2], Amanda Cook[1,2,3] and Gurjeet Gill[1]

[1]Adelaide University; [2]SARDI; [2]Flinders University

Location
Cowell
Rainfall
2025 Total: 201 mm
2025 GSR: 166 mm
2024 Total: 108 mm
2024 GSR: 77 mm
Paddock history
2025: Wheat (Calibre, Tomahawk CL) & Lupins (Coyote)
2024: Wheat (Calibre, Tomahawk CL), Barley (Titan AX) & Canola (Battalion)
2023: Scepter wheat
Soil type
Sandy soil
Plot Size
15 m x 3 m (two seeder plot) x 4 reps
Trial design
Randomized Complete Block Design (RCBD)

Key messages

- **Reduced crop establishment on non-wetting sands will allow brome grass that survive herbicide application to be highly competitive with crops and set many seeds for future infestations.**
- **Sole reliance on pre-emergent herbicides for brome grass control increased brome plant density 20-fold and panicle density by 35%. Treatments with a 1-year break initially reduced brome grass in 2024, but then experienced a 10-to-20-fold increase in brome panicle density in 2025. This indicates a rebound in brome grass pressure.**
- **High brome grass plant density wheat grain yield by more than 50%. Superior control of brome grass in systems with effective brome grass control tactics increased wheat yield from 500 to 800 kg/ha.**
- **Systems with 2-year breaks were effective in achieving low in-crop infestation of this weed.**

Why do the research?

Brome grass is currently ranked as the second worst weed in grain crops in Australia, causing annual revenue loss of $42 million (Ouzman et al. 2025). Brome grass is difficult to effectively control with the pre-emergent herbicides that are currently registered for use in cereal crops but development of herbicide tolerant cereal varieties has opened new options for growers to manage brome grass effectively in the cereal phase of the rotations. Integration of herbicide tolerant cereals with break crops such as pulses and canola offers opportunities to effectively deplete brome seedbank and manage its populations. It is important to demonstrate to growers the effectiveness of carefully considered combinations of cropping sequences and herbicide options for the management of brome grass in different agroecological environments. To achieve this objective, a 3-year field trial was initiated near Cowell on the Eyre Peninsula during the 2024 growing season.

This study aims to identify rotations and herbicide programs that effectively suppress brome grass populations and minimise seedbank replenishment while maintaining crop productivity.

How was it done?

A field trial was established in a randomised complete block design on a commercial farm near Cowell on the Eyre Peninsula. This farm has a yellow sandy loam which is favoured by brome grass. According to the grower, the soil in this paddock has some non-wetting, which also favours brome grass and reduces efficacy of pre-emergent herbicides.

The trial was sown with a no-till cone seeder with 25 cm row spacing and seeding width of 1.5 m (Table 1). There were two seeder runs per plot, and the plots were 16 m long. There was one buffer plot between all experimental plots to minimise the risk of herbicide spray drift and dispersal of weed seeds to neighbouring plots during crop harvest or by wind dispersal. All pre-emergent herbicides were sprayed just prior to crop sowing and incorporated by the no-till seeding tines (IBS). Data was analysed by using GenStat 23rd Edition. Information on herbicide products, active ingredients and label rates can be found in Table 2.

After below-average rainfall in 2024, Cowell again experienced below-average rainfall in 2025. Total rainfall from January to April was only 10 mm. After dry conditions continued into May, it was decided to sow the trial dry on 21 May. The trend of below-average conditions continued throughout 2025 except for July and September, which were above the long-term average. Cowell only received 9 mm rain in August, which was well below the average for the month (26 mm). Annual rainfall and growing season rainfall for Cowell in 2025 was 35% and 23% below the long-term average (218 mm and 188 mm), respectively.

In this trial report, the term 'break' refers to a year where crop × herbicide combinations are expected to effectively prevent brome grass seed production. System components for the first two years are summarised in Table 3.

No-break system (S1): pre-emergent herbicide mixture of Arcade® + Treflan in wheat was used in 2025 to provide some control of brome grass. This system is expected to allow considerable brome grass seed production each year and weed density is likely to remain high.

1-year break systems (S2 and S3): Tomahawk CL (S2) or canola (S3) in 2024 were followed by wheat sprayed with pre-emergent herbicides Arcade® + Treflan in 2025. These management systems are expected to lead to a rebound in brome grass populations due to weed establishment from the residual seedbank.

2-year break systems (S4 and S5): brome grass was controlled in 2024 in Titan AX barley (S4), which was followed in 2025 by Tomahawk CL wheat sprayed with Intervix. In S5, Hyola XC canola provided effective brome grass control in 2024, which was followed by Tomahawk CL wheat sprayed with Intervix in 2025.

3-year break system (S6): Titan AX barley in 2024 was followed by lupins in 2025 (S6) to provide an effective second break from brome grass. Lupin were sprayed with herbicides simazine + Treflan pre-sowing and grass control herbicide quizalofop (Targa) for post-emergent weed control (Table 3). Lupin were selected to diversify crop rotations in this trial because it is already grown on this farm (i.e. good local adaptation).

What happened?

Crop plant density

The combination of dry sowing at this site and the non-wetting nature of the topsoil caused a large reduction in crop establishment, especially in lupins. Across the management systems, wheat plant density ranged from 37 to 56 plants/m^2, with an average of 47 plants/m^2. Therefore, established wheat density at the site in 2025 was less than half the target density of 180 plants/m^2. Below par crop establishment was also observed at this site in 2024 when wheat plant density was 63 plants/m^2. Wetting agents to promote wetting of this non-wetting soil would be useful in these situations. Crops with large seeds such as lupins are considered more sensitive to non-wetting soils than cereals. This viewpoint was supported by the results in this trial where lupin plant density was only 6 plants/m^2 as compared to target density of 40 plants/m^2. Such a low crop establishment in lupins will reduce crop vigour, weed competitiveness and grain yield. However, the combination of herbicides used in lupins is still expected to reduce brome grass infestation for the next season.

Table 1. Trial details for 2025.

Project duration	2024–2026 (3-years)
Trial location	Cowell, SA (EP)
Plot size	16 m x 1.5 m (2 seeder passes)
Replications	4
Soil type	Sandy loam
Sowing date	21 May 2025
Target crop density (plants/m^2)	Wheat 180, barley 150 and lupins 40
Fertiliser	75 kg/ha MAP at sowing; barley and wheat also had 60 kg/ha urea (1 July)
Herbicides	See Table 2
Harvest date	8 December

Table 2. Information about herbicides used for brome grass control in the trial at Cowell, in 2025. Herbicide active ingredients and label rates registered in Australia are also presented.

Product name	Active ingredient	Label rate
Arcade	Prosulfocarb (800 g/kg)	3 L/ha
Treflan	Trifluralin (480 g/L)	1.5-3.0 L/ha when used as incorporated by sowing (IBS) in no-till knifepoint press wheel system (KP PW)
Avadex Xtra	Triallate (500 g/L)	2.6-3.2 L/ha when used IBS with KP PW
Intervix	33 g/L Imazamox and 15 g/L Imazapyr	375-750 mL/ha for brome grass
Targa	Quizalofop 100 g/L	375 mL/ha
Simazine 900	Simazine 900 g/kg	600 g/ha

Table 3. Crops, varieties and herbicide input programs (per ha) used at Cowell, in 2024 and 2025.

System	2024	2025
S1 (no break)	**Calibre wheat** PRE: Sakura 118g + Avadex Xtra 2.4 L	**Calibre wheat** PRE: Arcade 3L + Treflan 2L
S2 (one-year break)	**Tomahawk CL Plus wheat** PRE: Treflan 1.2 L POST: Intervix 600 mL	**Tomahawk CL Plus wheat** PRE: Arcade 3L + Treflan 2L
S3 (one-year break)	**Hyola Batallion XC Canola** PRE: Propyzamide 1 L POST: Crucial + Clethodim POST + Crucial POST	**Tomahawk CL wheat** PRE: Arcade 3L + Treflan 2L
S4 (two-year break)	**Titan AX barley** PRE: Treflan 1.2 L POST: Aggressor AX 200 mL	**Tomahawk CL Plus wheat** PRE: Treflan 2 L POST: Intervix 600 mL
S5 (two-year break)	**Hyola Batallion XC Canola** PRE: Propyzamide 1 L POST: Crucial + Clethodim POST Late POST: Crucial	**Tomahawk CL Plus wheat** PRE: Treflan 2L POST: Intervix 600 mL
S6 (3-year break)	**Titan AX barley** PRE: Treflan 1.2 L POST: Aggressor AX 200 mL	**Coyote lupins** PRE: Simazine 900 @ 600 g + Treflan 2 L POST: Targa 100 @ 375 mL

Brome grass plant and panicle density

Sole reliance on pre-emergent herbicides in System 1 caused a 20-fold increase in brome grass plant density from 2024 to 2025 (Table 4). Even though Sakura + Avadex is generally considered the best pre-emergent herbicide option available, it often provides only around 60% weed kill and surviving brome grass plants can set seed. In 2024, brome grass was able to set >11,000 seeds/m^2, which was reflected in high weed density in 2025 (346 plants/m^2). Brome grass produced more than 400 panicles/m^2 in this management system, which is likely to cause high weed infestation in the next crop in 2026. Systems 2 and 3 (single year break) resulted in a 10 to 20-fold increase in brome grass panicle density (Table 4), which should be reflected in higher brome grass infestations next year. In contrast, systems 4 and 5 (2-year break) showed an ongoing decline in brome grass panicle density, which should lead to even lower weed infestations in 2026.

It was interesting to note that brome grass in system 6 (lupin) was able to produce significantly more panicles (9 panicles/m^2) as compared to <2 panicles/m^2 in systems 4 and 5 (Table 4). As mentioned earlier, lupin establishment in the trial was severely reduced by the non-wetting soil and this would have reduced the ability of lupin to compete with brome grass plants that survived the POST herbicide treatment (quizalofop).

Weeds

Crop grain yield

Brome grass is known to be a highly competitive weed with wheat where even 10 plants/m^2 can reduce yield by 5% (Gill and Davidson 2000). Therefore, it was not surprising to see around 50% yield loss in wheat in System 1, which was infested by 300 plants/m^2 of brome grass (Table 5). As 5 out of 6 management systems were in wheat in 2025, it is valid to directly compare grain yields across these systems. Superior control of brome grass in systems with 1-, 2- and 3-year break in brome grass resulted in wheat yield increases ranging from 500 to 800 kg/ha (Table 5). There was a general trend for higher wheat yields in 2-year break systems than in single year break systems.

System 6 (3-year break) was sown to lupins in 2025 and experienced poor crop establishment due to dry soil conditions and a non-wetting soil. Even though lupin plant density in this trial was only 6 plants/m^2, they recovered well during the vegetative phase and managed to produce grain yield of 328 kg/ha. More importantly, this system allowed effective brome grass control with simazine + trifluralin (PRE) and quizalofop (POST) in 2025. Lupin will be followed by CL wheat in 2026, which is expected to eliminate brome grass from this system.

Table 4. Densities of brome grass plants and panicles across crop rotation sequences and herbicide input programs at Cowell in 2024 and 2025. Crop names in bold indicate the phase in 2025. Means followed by a different letter indicate statistical significance (P=0.05).

System	Rotation sequence	Brome density 2024 (plants/m^2)	Brome density 2025 (plants/m^2)	Brome panicles 2024 (panicles/m^2)	Brome panicles 2025 (panicles/m^2)
S1 (no break)	Wheat – **Wheat** – Barley (PRE herbicides – weak system)	15 b	346 c	307 b	472 e
S2 (1-year break)	CL wheat – **Wheat** - Barley	20 bc	33 b	2 a	50 d
S3 (1-year break)	Canola – **Wheat** - Barley	2 a	5 a	2 a	24 c
S4 (2-year break)	AX barley – **CL wheat** - Barley	31 c	3 a	6 a	2 a
S5 (2-year break)	Canola – **CL wheat** - Barley	1 a	0 a	2 a	1 a
S6 (3-year break)	AX barley – **Lupins** – CL Wheat	35 c	2a	6a	9b
Probability (P)		*<0.001*	*<0.001*	*<0.001*	*<0.001*

Table 5. Grain yield of crops in response to brome grass management systems at Cowell. Crop names in bold indicate the phase in 2025. Means followed by a different letter indicate statistical significance (P=0.05).

Treatment	Rotation sequence	Grain yield (kg/ha)
S1 (no break)	Wheat – **Wheat** – Barley (PRE herbicides – weak system)	416 a
S2 (1-year break)	CL wheat – **Wheat** - Barley	1122 bc
S3 (1-year break)	Canola – **Wheat** - Barley	956 b
S4 (2-year break)	AX barley – **CL wheat** - Barley	1249 cd
S5 (2-year break)	Canola – **CL wheat** - Barley	1387 d
S6 (3-year break)	AX barley – **Lupins** – CL Wheat	328 a
Probability (P)		*<0.001*

What does this mean?

The soil type at this site has a significant level of non-wetting, which can reduce crop establishment. This negative effect was evident in 2025, especially in lupins. Reduced crop establishment on such soil types will allow brome grass plants that survive herbicide application to be competitive with crops and set many seeds for future infestations. Growers observing unexpectedly low crop establishment should determine if non-wetting is an issue and use of an in-furrow spray of a wetting agent could be a viable option.

Sole reliance on pre-emergent herbicides for brome grass control in System 1 increased brome plant density 20-fold and panicle density by 35% from 2024 to 2025. Such high brome grass density in this system reduced wheat yield by more than 50% compared to the systems with better brome grass control. The results of this trial clearly show that currently available pre-emergent herbicides are ineffective at managing high brome grass densities. Systems 2 and 3 (1-year break) also resulted in a 10 to 20-fold increase in brome grass panicle density, which should be reflected in higher brome grass infestations next year. In contrast systems with 2-year breaks from brome grass maintained its populations at a low level. The results from this trial clearly show the need for crop rotation x herbicide combinations likely to provide effective brome grass control over 2–3 consecutive years.

References

Gill, G. S. and Davidson, R. (2000). Weed interference. In Australian Weed Management Systems, ed. B. Sindel, pp. 61-80. RG and FG Richardson, Melbourne.

Ouzman J, Azeem M, Llewellyn R (2025) Impact of weeds on Australian grain and cotton production. Grains Research and Development Corporation. p. 66. Accessible at: grdc.com.au

Acknowledgements

This research was funded by GRDC through the 'Effective control of brome grass in the southern and western cropping zones' (UOA2303-006RTX).

We acknowledge AIR EP for their project management and thank the grower collaborator and family for hosting this field trial. Thank you to the SARDI MAC Crop Agronomy team Kym Zeppel, Katrina Brands, Marina Mudge, Tammie Mullen, Julian Post, Rebbecca Tomney and Cayley Gray for the delivery the research and assistance with the field work.

Herbicide resistance status of brome grass populations in the cropping regions of southern and Western Australia

Ben Fleet and Gurjeet Gill
Adelaide University

Key messages

- **During the summer of 2024/25, brome grass populations (n=115) were collected from grain producing farms in WA (n=62), SA (n=40) and Victoria (n=13).**
- **Resistance was only detected to Group 2 herbicides Intercept (imazamox + imazapyr) and Crusader (pyroxsulam). More than two-thirds of the populations showed detectable level of resistance to pyroxsulam, which is most likely related to prior exposure to sulfonylurea herbicides in cropping systems.**
- **Resistance to imidazolinone (IMI) herbicides was identified in 4 brome grass populations; 3 of these were from SA and one from WA. Considering the current popularity pf these herbicides in these regions, this is an important result to raise awareness among the grain producers.**
- **None of the populations were resistant to Group 1 (quizalofop and clethodim) or Group 9 (glyphosate) herbicides tested even though resistance has been detected to these herbicides in previous studies.**

Why do the trial?

Brome grass is a serious weed of many Australian cropping regions and is widespread across the sandy soils of the low-medium rainfall zones of WA, SA, Vic and south-western NSW. Since the previous weed survey by Llewellyn et al. (2016), brome grass has moved up one place from 4th to 3rd most important weed by area infested in grain crops. In the latest weed survey of this series (Ouzman et al. 2025), brome grass has been estimated to infest 4.4 M ha of grain crops in Australia and cause a revenue loss of $42 million per year. Frequency of herbicide resistance in brome grass populations in Australian cropping regions is still low. A previous random survey of brome grass in Australian grain cropping regions from 2013 to 2017, showed detectable resistance to Group 1 herbicides in the Wimmera-Mallee (6%) and to the IMI herbicides in western NSW (7%) and Eyre Peninsula (2%) (Broster et al. 2023). Some brome grass populations in this region have also evolved resistance to glyphosate (Malone et al. 2015). To manage brome grass effectively, it is important for growers to know the resistance status of populations present on their farm. To raise awareness of herbicide resistance in brome grass among grain growers, brome grass populations (n=115) were collected from grain producing farms in WA (n=62), SA (n=40) and VIC (n=13) by several farming systems groups.

How was it done?

Seeds of brome grass populations were allowed to undergo after-ripening at the Roseworthy campus of the Adelaide University over the summer to autumn period. Once seeds had become non-dormant, they were sown into seedling trays filled with a standard potting mix on 18 May 2025. Trays were irrigated as needed to create favourable conditions for seed germination and seedling emergence. Once seedlings had reached 2 leaf stage (Z12), they were carefully uprooted and transplanted into pots filled with the same potting mix (6 plants per pot).

Brome grass seedlings were sprayed with label rates of 5 different herbicides (Table 1) and an untreated control. There were 3 replicates of all herbicide treatments. Adjuvants recommended by the manufacturers were added to the spray solution of all herbicides. Herbicide treatments were applied in a spray chamber, which was calibrated to deliver 100 L/ha through a single TeeJet 8002E flat-fan nozzle at a speed of 3.6 km/h. A herbicide susceptible brome grass population previously collected from Riverton in South Australia was used as the susceptible control. Plants were assessed for survival 4 weeks after the herbicide treatment and individuals with new shoot growth after herbicide treatment were counted as the survivors.

Table 1. Herbicide treatments used to investigate resistance status of brome grass populations.

Treatment	Active ingredient	MOA group	Trade name, manufacturer	Rate	Brome growth stage
1	Untreated control	-	N/A	-	-
2	Quizalofop 200 g/L	1	ELANTRA Xtreme, Sipcam	190 mL/ha	3-4 leaf
3	Clethodim 240 g/L	1	Grasidim, Sipcam	500 mL/ha	3-4 leaf
4	Imazamox 33 g/L + imazapyr 15 g/L	2	Intercept, Nufarm	600 mL/ha	3-4 leaf
5	Pyroxsulam 215 g/kg	2	Crusader GoDRI, Corteva	70 g/ha	2-3 leaf
6	Glyphosate 600 g/L	9	Crucial, Nufarm	750 mL/ha	3-4 leaf

Table 2. Resistance status of brome grass populations in 2024 sample collection.

Detail	Pyroxsulam	Imazamox + Imazapyr	Glyphosate	Clethodim	Quizalofop
Samples tested	112	115	115	115	115
Developing resistance %	22	0	0	0	0
Resistant %	46	4	0	0	0
Susceptible %	31	97	100	100	100

Resistant = 20% or greater survival; Developing resistance = 1-19% survival

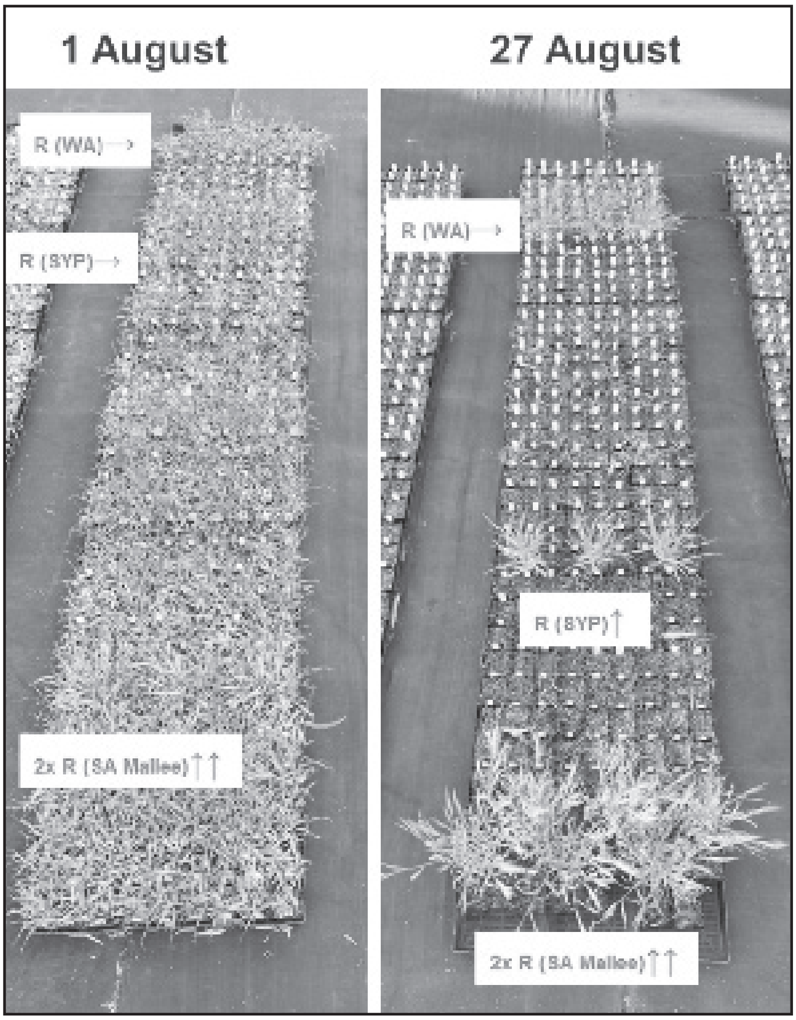


Figure 1. Brome grass populations confirmed as resistant to Intercept. One of these populations came from WA and 3 were from SA.

Weeds

What happened and what does this mean?

Most of the populations investigated did not exhibit resistance to any of the herbicides tested (Table 2). The only exception was group 2 (ALS inhibitors) where resistance was widespread. This included resistance to pyroxsulam (Crusader) to which nearly 2/3 of the populations showed at least partial resistance. Nearly half of the populations were resistant to this herbicide. Previous exposure to sulfonylurea herbicides in these cropping regions is likely to have contributed to the presence of a high level of resistance to this herbicide. Resistance to Intercept (imazamox + imazapyr) was less common but was identified in 4 brome grass populations (Table 2, Figure 1). One of these four brome populations came from WA and 3 were from SA. As Clearfield crops are such an important part of brome grass management programs, these results are a cause for concern. Even though the frequency of resistance detected was low (4%), growers using these systems need to be vigilant to detect early signs of resistance evolving on their farms. A previous random survey of brome grass also identified low levels of resistance to IMI herbicides in NSW and SA (Broster et al. 2023).

On a positive note, resistance was not detected in this study to the Group 1 (quizalofop and clethodim) or group 9 (glyphosate) herbicides (table 2) even though resistance to these herbicides has been previously reported (Malone et al. 2015).

Acknowledgements

This research was funded by GRDC through the ‘Effective control of brome grass in the southern and western cropping zones’ (UOA2303-006RTX). We also thank DPIRD WA, Liebe group, Facey group, WANTFA, AIR EP, SARDI-MAC, HART field site group, MSF, BCG and Nick Wells-Smith for collecting brome samples. Zarka Ramiz, Lesley Menzel and Tina McIntosh for their technical assistance.

References cited

Ouzman J, Azeem M, Llewellyn R (2025) Impact of weeds on Australian grain and cotton production. Grains Research and Development Corporation. p. 66. Accessible at: grdc.com.au

Malone JM, Morran S, Shirley N, Boutsalis P, and Preston C (2015) EPSPS gene amplification in glyphosate-resistant *Bromus diandrus*. Pest Manag Sci 2016; 72: 81–88

Broster JC, Boutsalis P, Gill GS and Preston C (2023) Frequency of herbicide resistance in wild oats (Avena spp.), brome grass (Bromus spp.) and barley grass (Hordeum spp.) as determined by random surveys across south-eastern Australia. *Crop and Pasture Sci* (2023) 74 (12): 1193 –1200.

Adelaide University

Section 5

Section Editors:
Jessica Gunn
SARDI, MAC

Pastures, Livestock & Water

Benchmarking and improving water quality for stock in extensive grazing systems

Alyce Lowe[1,2], Bianca Agenbag[1], Catherine Paterson[1] and Alice Weaver[1,2]
[1]SARDI; [2]Flinders University

Location
Minnipa Agricultural Centre
Rainfall
Av. Annual: 330 mm
Av. GSR: 244 mm
2025 Total: 281 mm
2025 GSR: 228 mm
Paddock history
Control group: North 6, barley stubble
HydroSmart group: South 1, barley stubble
Soil type
Red loam - Red sandy loam
Soil test
pH 7.6 ($CaCl_2$) in top 10cm
Plot size
~50 ha
Trial design - Livestock
- Randomised selection and allocation of 197 ewes (2024 drop) into two water quality treatment groups managed under normal Minnipa Agricultural Centre farm conditions
- Two hogget mobs (Control; 96 sheep versus HydroSmart-treated water; 97 sheep)
- HydroSmart shuttle installed on one water trough in the appropriate paddock

Key messages

- **Early results indicate that sheep provided with treated water had higher average daily weight gains compared with those on untreated water, suggesting a production advantage within the first three months of monitoring.**

Why do the trial?

Access to water is crucial for livestock production. The quality and cleanliness of water can impact feed intake, health, immunity, productivity and performance of stock. During periods of drought when water is scarce and water security is low, water quality may be compromised. Strategies to benchmark and improve water quality to ensure futureproofing of water supplies without compromising animal health need to be investigated.

The Minnipa Agricultural Centre component of the SA Discovery Farms project supports the broader SARDI program screening water sources and evaluating practical water-conditioning technologies (e.g. the HydroSmart "shuttle") to help improve livestock water suitability without compromising animal health.

How was it done?

Research is being conducted at SA Discovery Farms located across three climate regions - Turretfield, Minnipa and Struan. Water sources are being identified, screened for quality parameters, and then water treatment technology such as the HydroSmart "shuttle" are being trialled to improve quality. Water quality data will be paired with livestock production and health measures, such as growth, wool production, meat quality, reproductive parameters and immune function.

The Minnipa Agricultural Centre demonstration compared two mobs of ewes grazing medic pasture, with one mob receiving untreated control water in paddock S6 and the other consuming water conditioned through a HydroSmart shuttle in paddock S1.

Baseline measurements were collected on 15 October 2025, including liveweight (LW) and body condition score (BCS). Follow-up LW was then collected on 28 January 2026, representing a 105-day monitoring period. Average daily gain (ADG) was calculated for each animal using baseline and follow-up weights. Animal numbers at Minnipa included 96 control ewes and 97 HydroSmart ewes.

Animals were managed as commercial mobs rather than within a replicated experimental design. For the analytical component of this update, a fixed-effects general linear model (Normal distribution with Identity link function) was used to test for a treatment effect on follow-up LW, BCS and ADG.

What happened?

After 3 months LW with HydroSmart ewes were heavier compared to the Control ewes (73.8 kg versus 71.3 kg). In addition, HydroSmart ewes had a higher ADG compared to Control ewes (0.06 g/d versus 0.04 g/d). BCS did not differ between treatment groups.

Baseline and 3-month serum and water samples are yet to be analysed.

What does this mean?

Intensive trials at SA Discovery Farms sites, combined with producer insights, are helping the team identify and refine practical water treatment solutions to help optimise water quality and support healthy, productive livestock during dry conditions.

These interim Minnipa results show both groups gained liveweight between October 2025 and late January 2026, with the HydroSmart-treated mob showing higher LW gain and ADG.

As this is a mob-level demonstration (not replicated paddock treatments), these data should be interpreted as an indicative performance signal to be considered alongside water quality measurements, seasonal conditions, and any other management differences between mobs/paddocks.

Next reporting will incorporate data from similar trials currently being conducted at Turretfield Research Centre, and Kybybolite Research Centre. We anticipate producer demonstration sites being established within the later-half of 2026 once on-farm validation of technology has been conducted.

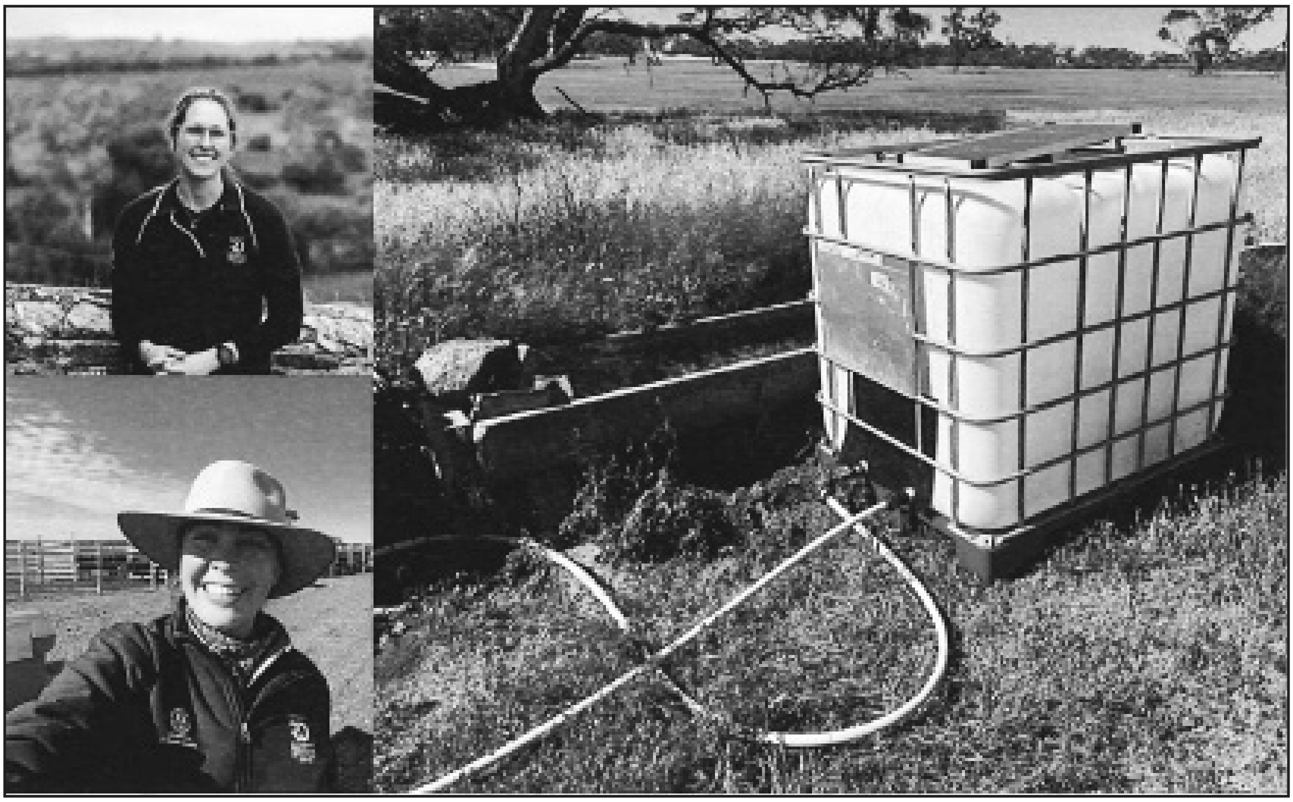


Figure 1. SARDI researcher Dr Alyce Lowe (top left) and Bianca Agenbag (bottom left); The HydroSmart "Shuttle" - a solar powered water conditioning unit that is being installed on water troughs in paddocks and evaluated in the project (right).

Project timeline

- 2025-2026: First round of intensive water-treatment demonstrations at Minnipa, Turretfield and Kybybolite, with preliminary production outcomes (LW, BCS, conception, and water-quality metrics) shared through updates like this one.
- Late 2026: Establishment of producer demonstration sites once the initial technology validation is complete. These sites will provide real-farm examples of how water-treatment solutions perform under commercial conditions.
- 2026-2027: Ongoing monitoring across all sites, with interim results reported annually, highlighting trends in livestock performance, water quality and system reliability.
- Summer 2027/2028: Final round of data collection across all locations.
- 2028: Project completion, integration of results across seasons and sites, and release of final recommendations for producers on water-treatment options to support livestock during dry conditions.

Acknowledgements:

Dr Alyce Lowe, a Senior Research Officer at SARDI, is leading a team within SARDI's Livestock Innovation and Welfare Division. Research partners included MacKillop Farm Management Group, Agricultural Innovation & Research Eyre Peninsula, Barossa Improved Grazing Group, HydroSmart.

The researchers would like to express our gratitude to all the farm support staff at each of SARDI's research centres. Their assistance has been essential, especially in the remote regions of SA. We would also like to acknowledge HydroSmart as a project partner for their design and installation of their units at SARDI Research Centres.

Eyre Peninsula Farm Water Security

Joshua Telfer[1], Jodie Reseigh[2] and Brian Hughes[1]
[1]SARDI; [2]PIRSA/AWI

Key messages

- **Water resources on Eyre Peninsula are under pressure with a hotter and drier climate reducing available sources and ground water allocations, and increasing demand.**
- **There are good examples of Eyre Peninsula primary producers developing innovative systems to improve water capture, storage and quality, and reduce costs, with the additional benefit of helping to reduce demand on SA Water supply.**
- **These examples are being used to develop fact sheets and case studies to help other Eyre Peninsula primary producers improve on-farm water supply and their own water security.**

Why do this project?

Eyre Peninsula (EP) is currently experiencing water security challenges due to drying conditions reducing available sources of water and increasing demand. With almost 40% of EP's water use coming from the agricultural sector, SA Water initiated a Primary Producer Roundtable, comprising peak agricultural bodies, government and regional stakeholders, and farmers from across the EP. The purpose of this forum was to help SA Water understand on-farm water use, identify potential efficiency measures, and co-design a balanced restrictions program across the sector.

EP farming is dependent on SA Water's supply, with the sector using the largest amount of the region's mains water. There are opportunities for farmers to develop complementary water systems, even while SA Water supply is available, and to improve water security and resilience, particularly in areas without access to the SA Water services.

How was it done?

One of the outcomes of the roundtable series was collaboration between SA Water, EP Landscape Board, PIRSA/SARDI, AWI Extension SA and Ag Communicators to develop an extension project. The EP Farm Water Security project was designed to create and collate resources, raise awareness of opportunities for improved farm water management, highlight some of the successful investments in water supply and security that are happening on the EP and elsewhere, and to encourage EP farmers to consider the value of similar investments in their businesses.

Project staff include Joshua Telfer as project officer, Brian Hughes and Jodie Reseigh also from SARDI/PIRSA, Nicole Arbon from SA Water and Andrew Solomon from EP Landscape Board. Ag Communicators have been engaged to assist with publications, workshops and extension. A wider project steering committee has also been established.

What happened?

The project team interviewed many farmers in 2025 who had made innovative investments in farm water infrastructure. These discussions informed the team about what farmers are already doing, identified knowledge and experience gaps, and explored how these approaches could be applied and communicated more broadly. The team also took some representative water samples to understand the different water qualities these systems' produce.

In light of the dry conditions in autumn 2025, the team worked with SA Water representatives to engage with the agricultural sector, so farmers on the EP could better understand the region's water supply system and water security considerations, and to offer insights to SA Water about the unique needs and water requirements of farmers on the EP. Two workshops covering strategies and technology to improve on-farm water security were run in August 2025 at Wharminda and Warramboo and with speakers including water experts from EP Landscape Board, SARDI, AWI Extension SA and DPIRD (WA), and most importantly, several farmers who showcased innovative examples of how they had improved on-farm water supply.

The workshops included examining local examples such as plastic-lined trench for low-cost water storage, plastic-lined dams, and sheeted catchments. The events also explored how on-farm desalination, combined with groundwater, is used in Western Australia to improve both the quality and quantity of water available for agriculture. The project also looked at decision tools to help drive the right investment into correctly sizing dam and sheeted catchment (e.g. https://waterevaluationplatform.app/dam/).

What does this mean?

The project team has engaged with Ag Communicators to identify information gaps and develop fact sheets and case studies. These resources aim to provide clear information and build confidence to support investment in improved farm water infrastructure. Key investment decisions include choosing the right type of water infrastructure and understanding the associated benefits. Throughout this initiative, SA Water has been an essential collaborator. Upgrading and investing in on-farm water infrastructure delivers mutual benefits. It improves both the quality and quantity of water available to farms at a modest cost, while simultaneously releasing additional capacity in the SA Water network to support other demands, including those from businesses, schools, hospitals, sporting clubs, and growing communities.

Several new fact sheets and case studies are now available on the PIRSA website including:

- Case study on rainwater capture from farm infrastructure
- Fact sheet on on-farm water capture options
- Fact sheet on storage options

There are more resources planned for future publication, including several fact sheets and case studies on water capture, quality, and smart meters.

Additional resources

https://pir.sa.gov.au/sardi/projects/eyre_peninsula_farm_water_security_project

https://waterevaluationplatform.app/dam/ (New tools for modelling evaporation for dams, likely performance of catchment areas over time at any GPS coordinates, performance of dam covers, and how often a dam might run dry)

https://www.gga.org.au/activity/watersmart-dams/ (example of on-farm water investments in WA)

https://agriculture.vic.gov.au/farm-management/water/farm-water-solutions/managing-farm-water-supplies (Good resources for estimating likely farm water needs)

Water Security - Barossa Improved Grazing Group - various fact sheets

Water Security | Coorong District Council - various fact sheets

Acknowledgements

Eyre Peninsula farmers who have shared their innovative on-farm water security improvements, including the Prime, Otten and Mullen families, as well as others.

Coorong LAP staff and information including Grahan Gates and Tracey Strugnell.

Barossa Inproved Grazing Group (BIGG) technical staff including Brett Nietschke.

Implementing virtual fencing to support drought resilience across diverse South Australian livestock systems

Bianca Agenbag[1] and Megan Willis[1,2]
[1]SARDI; [2]Adelaide University

Key messages

- **Virtual fencing enables targeted grazing management to protect vulnerable land, water resources and pastures during dry conditions.**
- **Virtual Fencing allows producers to adapt grazing pressure in real time without reliance on physical fencing infrastructure.**
- **Early demonstrations indicate virtual fencing can be implemented with success in South Australian beef systems.**

Why do the trial?

Drought remains one of the most significant challenges facing Australian livestock producers with increasing pressure on land condition, water availability, labour and animal welfare. Current work funded by the Future Drought Fund Long-term Trials (FDF LTT) is investigating how virtual fencing (VF) could be implemented as a long-term management tool to improve the capacity of producers to prepare for and respond to drought.

VF has been demonstrated in short-term trials to assist with livestock management, particularly for excluding animals from environmentally sensitive areas such as riparian zones, regenerating vegetation and erosion-prone landscapes. However, limited information is available on how VF technology performs across multiple production systems, environments and seasons, particularly over a long-term period. This project aims to address this gap by implementing VF across a range of commercial beef enterprises as well as a sheep enterprise in South Australia, each facing unique environmental and management challenges. This project provides an opportunity to focus on how VF can improve drought resilience, land condition and enterprise/management flexibility in real-world conditions.

How was it done?

VF is currently being implemented across four innovator sites within South Australia (Minnipa, Kangaroo Island, Karoonda and Mt. Jagged – specific applications are described below). VF technology collars were fitted on cattle between February and August 2025 on all four properties. Each property is using the technology to reflect the enterprise's own unique challenges and management systems including:

- Excluding livestock from sensitive or high-risk areas (sandhills, native vegetation, riparian zones: vegetated, transitional ecosystems bordering rivers, creeks, lakes, and wetlands) and/or
- To support rotational or strategic grazing systems to improve pasture utilisation and groundcover retention.

Initially, livestock undergo a training period of 4 to 10 days to learn the association between the audio cues and electrical pulse stimuli before introducing VF technology as part of the management system. After the training period, virtual boundaries can be implemented and adjusted in response to seasonal conditions, feed availability and management objectives. VF will remain implemented on these properties until late 2027 to demonstrate the longer-term environmental and production responses.

Trial site specific VF technology applications:

- Minnipa: Integration of VF into a large mixed farming system to manage breeding cattle grazing on pasture and crop stubbles, exclude cattle from recovering sand hills and native shrubbery while supporting both livestock production and cropping outcomes in a low rainfall environment.
- Kangaroo Island: Application of VF to facilitate intensive rotational grazing while protecting creek lines and native vegetation.
- Karoonda: Assessing the use of VF as a replacement for labour-intensive temporary electric fencing in lucerne-based grazing systems, with the aim to improve pasture utilisation and reducing labour demands in low rainfall conditions.
- Mt Jagged: Use of VF to exclude breeding cattle from vineyards and creek lines where physical fencing is limited, while supporting rotational grazing and landscape regeneration in a medium rainfall environment.

Additionally, between February and April 2025, 100 VF collars were fitted to Dorper ewes at Pernatty Station to test the VF technology as a sheep grazing management tool in the South Australian rangelands. After a 4-day training period, the Dorpers were mustered to a northern water point with the aim to keep them around an under-utilised water point for 1 month.

Data collected throughout the trials include production, land, conservation and VF technology measures. These data (where applicable) include; production measures (cow liveweights, calf weaning weights, calving and weaning percentages, crop yields, sheep liveweights and body condition scores), land and conservation measures (biomass, soil compaction, water quality in creeks and rivers, soil characterisation), VF technology performance (GPS locations and spatial distribution of livestock, time spent in inclusion versus exclusion zones, frequency of animals entering exclusion zones, Audio:Pulse ratios as an indicator of learning and system efficacy, collar retention, failure rates and injury rates) and supporting data (weather -rainfall and temperature, producer insights and experience).

What happened?

Across sites, VF has successfully controlled livestock movement and enabled targeted exclusion of sensitive areas without reliance on permanent or temporary fencing infrastructure. Livestock adapted to the VF systems following training, with most interactions with the VF boundary occurring via audio cues rather than the consequential electrical pulses.

Producer feedback has highlighted some positive experiences using the VF technology, including:

- VF has allowed producers to redistribute grazing pressure as seasonal conditions changed, particularly during periods of low feed availability.
- VF has increased livestock management flexibility, with the additional benefit of the producer not requiring to be on the property to make changes/move livestock.
- GPS capabilities have been highly regarded for individual animal monitoring especially during times of high stress such as calving and mustering.

Specifically, the Dorper VF trial achieved a 90% containment within the VF zone after 1 month of containing the sheep around an under-utilised water point. This level of containment is much higher than if no VF had been used. The result from this short-term study shows promise for containment strategies especially when development of a sheep specific VF technology is achieved. This trial showed that VF can be an effective tool in the rangelands areas to achieve more uniform landscape utilisation, prevent overgrazing, take advantage of under-utilised water points and increase animal productivity.

What does this mean?

This project is demonstrating that VF has strong potential as a drought preparedness and response tool across a range of South Australian livestock systems with strong producer feedback. By enabling proactive, flexible grazing management, VF is showing promise in supporting land condition, excluding livestock from sensitive areas, maintaining stock around under-utilised pasture and water points and reducing labour requirements during especially challenging times such as drought.

This project continues to highlight the value of long-term research projects that incorporate producer collaboration. Having demonstration sites set up in commercial conditions also allows the opportunity for other producers/land managers/ stakeholders to interact with the VF technology and continue to build confidence and networks within this space. Continued monitoring and data collection will provide critical insights into how VF can be integrated into drought resilience strategies at scale.

A special note: Since December 2025 VF was officially legalised in South Australia for cattle management only. An amendment to the Animal Welfare Regulations 2012 has been approved allowing manufacturers to apply to the government for approval of their VF technology and systems from early 2026. For more information, contact PIRSA.

At this point in time, there is currently no sheep specific VF technology or systems. This is an exciting space to watch as interest around this technology is growing.

Acknowledgements

This project is funded by the Australian Government Future Drought Fund Long-term trials program with further contributions from the South Australian No-Till Farmers Association, Sheep Industry Fund (Livestock SA), Charles Darwin University, SA Arid Lands Landscape Board, PIRSA KI AgTech Demonstration program and the South Australian Research and Development Institute. The authors want to thank all the funding and contributing bodies for their on-going support. The authors want to also thank the participating producers for their collaboration and contribution to this research.

Achieving adequate nodulation of French serradella when hardseeded pod segments are dry sown in mid-autumn

David Peck[1,2]

[1]SARDI; [2]Adelaide University

Location
Karoonda (K)
Farmer: Andrew Radloff
Lameroo (L)
Farmer: McMahon Brothers
Wynarka (W)
Farmer: Peter Blacket

Rainfall
Karoonda
Av. Annual: 334 mm
Av. GSR: 232 mm
Lameroo
Av. Annual: 382 mm
Av. GSR: 270 mm
2025 Total: 227 mm
2025 GSR: 164 mm
Wynarka
Av. Annual: 334 mm
Av. GSR: 232 mm
2025 Total: 216 mm
2025 GSR: 156 mm

Paddock history
2023 (K): Wheat
2024 (L): Grass
2024 (W): Wheat

Soil type
Sandy soils with pH < 7.0

Yield limiting factors
2024 had late weak break and very dry winter and early spring
2025 had late weak break, dry start to the growing season with wet October & November

Key messages

- **French serradella is a promising ley pasture legume for sandy soils with pH <7.0.**
- **Hardseeded pod segments can be harvested with a grain harvester and sown in late summer to early autumn to soften over autumn and germinate with the opening rains.**
- **Inoculating hardseeded pod segments with peat inoculum at 2x the standard rate achieved adequate nodulation levels in 2024 but not in 2025.**
- **Serradella and lupin have the same rhizobia requirement, and if an inoculated lupin crop has previously been grown, FS can be sown without the need to inoculate.**
- **If interested in trialling FS, we recommend initially using small areas to learn about the agronomy of the species and if it has a fit on your sandy soils.**

Why do the trial?

Farmers in low rainfall areas in South Australia report low performance of ley pasture legumes on sandy soils, which in turn results in reduced performance of following grain crops. French serradella (FS) is a widely grown ley pasture legume in Western Australia. Research in South Australia in the last decade has found FS to be a promising alternative ley pasture for mildly acidic sandy soils (EPFS Summary 2016 p. 155, 2019 p. 230, 2020 p. 211 and p. 197, 2023 p. 155, 2024 p. 145). For example, 1-1.5 t/ha higher biomass was measured in FS compared to vetch on sandy dunes (EPFS Summary 2021 p. 197).

Pod segments of FS can be readily harvested with a grain harvester, sown at 1-2 cm in late summer to early autumn, they then soften over autumn and emerge with the opening rains. This provides a cheap way of establishing a ley pasture, completes pasture sowing before the busy crop sowing period, provides increased early feed, and in a dry year fixes more nitrogen and sets more seeds than conventionally sown FS. FS flowers indeterminately, and in a wet spring, provides late green feed (EPFS Summary 2024 p.145).

In 2023, seven 10 ha paddocks were sown with hardseeded French serradella pod segments along with clay rhizobia granules in late March to mid-April and plants established well (EPFS Summary 2023 p. 155, 2024 p.145). However, unless the paddock had previously grown lupins (lupins and serradella have the same rhizobia requirements), poor nodulation levels were observed on all occasions. The researchers recommended that further rhizobium research be done to develop method/s that achieve adequate nodulation with dry sowing.

When sowing FS in late summer and early autumn, you need to achieve two factors; seed softening and rhizobia survival to nodulate plants when they emerge. Delayed sowing reduces the time that rhizobia need to survive, but the recommended sowing time is March (mid-April is the latest) and in low rainfall areas the season break may be several weeks later. When dry sowing legumes, it is recommended to double the standard inoculation rate (Farquharson et al. 2022). Our hypothesis is that we can dry sow hardseeded pod segments in early April and obtain adequate nodulation levels with high rates of peat inoculum and/or granules.

How was it done

In 2024, a small plot trial (plots were 10 m x 1.5 m with four replicates) was established on a sandy soil near Karoonda with pH of 6.31 ($CaCl_2$) in the top 10 cm. Hardseeded pod segments of French serradella cv Fran2o were sown on 12 April. Rhizobia treatments (Table 1) were nil, rhizobia added in bentonite clay granule at 1x, peat granules at 1x, 2x and 4x standard rate, or in peat slurry applied to pod segments at 1x, 2x and 4x standard rate. Scarified seed of Fran2o inoculated with peat was planted at the break to the season (5 June). Commercial seed of Medic (cv. Seraph) was also planted without rhizobia on 12 April and with rhizobia at the break. Common Vetch (cv. Studenica) was planted with rhizobia at the break. 12 weeks after establishment plants were dug up, roots washed and number of nodules counted.

In 2025, two farmers, located at Lameroo and Wynarka, sowed a 5 ha paddock each with pod segments of Fran2o in mid-April. The Lameroo site did not have a lupin history, which was confirmed by no rhizobia being detected in a Predicta rNod test. 2x peat inoculum rate was applied to pod segments prior to sowing at this site. The Wynarka site had lupin history confirmed by a rNod test and was sown with uninoculated pod segments. Plants were dug up, roots washed, and number of nodules counted.

What happened?

Both years experienced late breaks and drought in the first half of the growing season. In 2024, all the vetch died, the medic had poor growth and seed set, while FS responded to rain that occurred mid-October and late November. In 2025, establishment was poor and trials were abandoned after nodule assessment.

Extent of nodulation in 2024 at Karoonda is shown in Table 1. Uninoculated FS had no nodules. Adding clay granule inoculum resulted in very low nodulation (2%), peat granules increased nodulation to 13% and at 4x standard rate, nodulation was 20%. Peat slurry inoculation increased nodulation to 43% and higher rates achieved 77-84% nodulation. When planted at the break, FS had 45% nodulation, while medic and vetch were >95% nodulation.

In 2025, without a lupin history (Lameroo), 24% of FS was nodulated with a mean of 1.7 nodules/nodulated plant. With a lupin history 98% plants had nodules, with a mean of 5.7 nodules per plant.

Table 1. Extent of nodulation in French serradella with various rhizobia inoculation strategies at Karoonda in 2024.

Trt No.	Species	Rhizobia formulation	Rate (x standard)	Planting time	% plants nodulated	nodules per total plant	nodules per nodulated plants
1	Serradella	nil	0	early	0	0.0	0.0
2	Serradella	Clay Granules	1	early	2	0.0	0.5
3	Serradella	Peat Granules	1	early	13	0.1	0.8
4	Serradella	Peat Granules	2	early	6	0.2	0.8
5	Serradella	Peat Granules	4	early	20	0.6	2.8
6	Serradella	Peat	1	early	43	0.9	2.0
7	Serradella	Peat	2	early	84	2.1	2.4
8	Serradella	Peat	4	early	77	3.4	4.1
9	Medic	nil	0	early	100	5.3	5.3
10	Serradella	Peat	1	break	45	1.0	2.1
11	Medic	Peat	1	break	100	5.7	5.7
12	Vetch	Peat	1	break	96	4.2	4.3

What does it mean?

Both 2024 and 2025 had late breaks, which therefore provided a good test for the ability of rhizobia to survive a long dry period. In 2024, inoculating pod segments with peat slurry at 2x the standard rate achieved 80% of plants nodulated, but in 2025 only 24% of plants were nodulated. The low number in 2025 means 2x is not a reliable method, and rhizobia needs to be introduced by a different method. At Wynarka, a prior lupin crop resulted in 98% of plants nodulated, which agrees with prior research (EPFS Summary 2023 p. 155). If sowing hardseeded pod segments in late summer to early autumn it is recommended to have grown a prior lupin crop. Good growth of a prior lupin crop will also be an indicator that the soil type is suitable to FS.

FS cultivars can be either hardseeded (HS, Fran2o, Margurita) for use as a ley pasture or softseeded (SS, Eliza, Cadiz) which needs to be sown every time. Inoculated pod segments (or seed) of soft seeded FS cultivars could be sown at the break and in subsequent years in that paddock, hardseeded cultivars could be sown in late summer and early Autumn without the need for rhizobia inoculum. Revell (2007) and Anon (2021) provide agronomic information about FS, including herbicide options and that FS is susceptible to native bud worm. If interested in FS, we recommend trialling on a small area to determine if it performs on your sandy soil, which also allows you to learn about its specific agronomic needs. FS is sold as pod segments or scarified seed. Recommended sowing rate of pod segments of HS cultivars is 20-30 kg/ha and takes into account that ~50% of weight of pod segments is seed and partial seed softening. Sowing needs to be completed by end of March (mid-April at the latest) to ensure enough seed softening occurs, with the higher sowing rates being required as sowing is delayed. Seeds soften more in the dark and hence need to be sown rather than broadcast. Sowing in the second half of March or early April will minimise the time soil is vulnerable to wind erosion. Pod segments of SS cultivars can be sown at 14-20 kg/ha and scarified seed can be sown at 7-10 kg/ha. If sowing ahead of the break, we recommend applying rhizobia at 2x the standard rate unless lupins have been grown previously.

In NSW work, Lupin rhizobia can build up on the prior wheat crop (Evans et al. 2001). In 2026 we plan to test this in South Australia. If interested in testing this yourself, we recommend trailing a small area and using the rNod to determine if it has worked before sowing pod segments.

The focus of this work is FS, as it is the species that has a long history of being sown in WA in late summer and early winter. However, the species yellow serradella (YS) is also grown. Often farmers/advisors will refer to serradella, but it is important to distinguish between the two species. YS cultivars are hardseeded, and older YS cultivars are problematic to harvest and do not have enough seed softening for late summer/early autumn sowing. The new YS cultivar SerraMax pods can be harvested with a grain harvester, break into pod segments (but not as readily as FS) and are suitable to sowing in early autumn. We have not tested SerraMax in South Australia.

References

Anon 2021 French serradella https://www.agric.wa.gov.au/pasture-species/french-serradella?page=0%2C0

Evans J, Eberbach P, Luckett D, Cormack S 2001 Pre-season soil establishment of legume inoculant rhizobia is not effective for the nodulation of lupin and faba bean crops in acidic soils Australian Journal of Experimental Agriculture 41(8) 1149 - 1160

Farquharson EA, Ballard RA, Herridge DF, Ryder MH, Denton MD, Webster A, Yates RJ, Seymour NP, Deaker RJ, Hartley E, Gemmel LG, Hackney B, O'Hara GW. 2022. Inoculating Legumes: Practice and Science, Grains Research and Development Corporation, Australia.

Revell 2007 French serradella https://keys.lucidcentral.org/keys/v3/pastures/Html/French_serradella_-_soft_seeded.htm

Acknowledgements

This is a long term trial project delivered with partners Mallee Sustainable Farming

Adelaide University

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Section Editor:
Amanda Cook
SARDI

Section 6

Disease

Understanding the impact of soil amelioration and amendments on Rhizoctonia

Amanda Cook[1,2,3] and Karyn Reeves[4]
[1]SARDI; [2]Adelaide University; [3]Flinders University; [4]DPIRD, Western Australia.

Location
Piednippie/Streaky Bay
Rainfall
Av. Annual: 289 mm (Wirrulla - Pimbena BOM Site)
Av. GSR: 208 mm
2025 Total: 248 mm
2025 GSR: 206 mm
Paddock history
2025: Barley (trial)
2024: Barley (trial)
2023: Wheat
2022: Medic pasture
Soil type
Grey highly calcareous sandy loam
Soil test
High pH and corbonate, low P reserves
Plot size
15 m x 1.7 m
Trial deisgn
RCBD wit 4 replicates
Yield limiting factors
Nutrition, rhizoctonia

Key messages

- **Deep ripping reduced barley establishment and root growth.**
- **Crown roots per plant were reduced by deep ripping but the level of crown root infection varied depending on the seasonal conditions.**
- **Deep ripping, with or without amendments had little impact on Rhizoctonia.**

Why do the trial?

Rhizoctonia (*Rhizoctonia solani AG8*) remains a significant constraint to crop production in low and medium rainfall zones of the Southern and Western regions, especially on calcareous soils of upper Eyre Peninsula (EP). *Rhizoctonia solani AG8* has a range of hosts, including cereals, grasses, broadleaf crops, and weeds. Crop rotation with non-cereals like canola and soil- or seed-applied fungicides have shown potential to decrease Rhizoctonia in the field for the short term.

In some regions, farmers are using mechanical soil improvement techniques to address issues such as compaction and water-repellent topsoil. Methods include turning the soil upside down (e.g. using Plozza and mouldboard ploughs), thorough soil blending (mainly through spading), or deep ripping. However, the effects of these soil improvement methods and the addition of soil amendments on Rhizoctonia remain unclear.

A field trial was conducted at Piednippie near Streaky Bay, with two similar trials undertaken in Western Australia (Merredin and Wongan Hills research stations, Department of Primary Industries and Regional Development (DPIRD), WA) to investigate the impact of soil amelioration and amendments on disease severity and level of *Rhizoctonia solani AG8* inoculum on barley.

How was it done?

Colonised millet inoculum was prepared with R. solani AG8 isolate (W19), which was isolated in 2006 from infected wheat roots in Lowbank, SA. In 2023, the inoculum was applied at sowing with Scepter wheat to increase the level of R. solani AG8 for soil amelioration trials in 2024.

Soil amelioration (deep ripping and amendments) was undertaken on 15 April 2024 at Piednippie. The soil type is a grey calcareous sand over limestone. Deep ripping (to 30 cm) was conducted with 3 tines at 50 cm spacings using a three-point linkage straight shank deep ripper. After deep ripping, plots were rolled to consolidate the seedbed.

Amendments added during the deep ripping operation through a tube attached to the bottom of the shank were;

- Biochar with phosphoric acid (used at Poochera demonstration 2020) (0.38 t/ha)
- Neutrog (1 t/ha)
- Nil

The trials were designed in a split-plot layout.

In 2024, barley cultivar, cv. Maximus CL was dry sown at 75 kg/ha on 8 May with 75 kg/ha of MAP (10:22). See SARDI EPFS Summary 2024 p.156 for treatments and results.

In 2025 the trial was sown with Maximus barley at 75 kg/ha and 75 kg/ha of MAP on 30 May to assess the impacts of soil amelioration strategies from 2024. Two L/ha of trifluralin was applied pre-sowing. Plant counts were undertaken on 3 July. NDVI and late dry matter were assessed on 30 September.

Assessments in 2025 included plant emergence, tillers per plant, number of spear tips on seminal and crown roots, root disease score (0-10), shoot and root dry weight per plant, late dry matter, grain yield and quality. Plant sampling was conducted using the zigzag method, sampling five plants from each random point.

Disease severity was assessed on 30 September using 15 plants from each treatment using a score (0-10) developed by the project team. The ratings are: 0=no disease, 2-3=<25% roots damaged, 4-5=25-50% roots damaged, 6-7=50-75% roots damaged, 8-9=>75% roots damaged,10=all roots highly diseased and truncated. The shoots and roots of the fifteen plants sampled were dried and weighed to calculate shoot and root weight per plant. The trial was harvested on 8 December. Grain quality assessments included test weight, screenings, protein, moisture and 1000 grain weight.

Statistical analyses were performed in Rstudio v2024.4.2.764 (Posit Team 2024) using R v4.3.3 (R Core Team 2024). The data was analysed through ASReml-R v4.1.0.176 (Butler 2022) using linear mixed-effects models. Fixed effects included the full interaction of amelioration, amendment, and inoculation. Random effects consisted of the formula Rep/Amelioration/Inoc + RowRep to represent the split-plot trial blocked in two-ways. An auto-regressive 1 correlation was applied to trial rows for all models except visual score (July), visual score (August), NDVI, crown infection, seminal score, and root health. Visualisations were primarily made using the ggplot2 v3.5.1 package (Wickham 2016).

What happened?

In 2024, initial rhizoctonia levels in 0-10 cm pre-seeding averaged 15 pg DNA/g soil in uninoculated plots compared to 312 pg DNA/g soil in the inoculated treatments. This shows the inoculated millet seed tripled initial Rhizoctonia inoculum in the following season.

Conditions on upper Eyre Peninsula in the western regions were poor and the two closest BOM sites to the trial both recorded below average annual rainfall.

Barley establishment without inoculum was reduced to 144 plants/m^2 by deep ripping in 2024 compared to 165 plants/m2 without ripping. Deep ripping from 2024 did not affect crop establishment in the presence of inoculum and averaged 152 plants/m^2.

Shoot and root weights and crop vigour were not affected by deep ripping or rhizoctonia inoculum in 2024 or 2025 at any stage.

Grain yield in 2025 averaged 1.62 t/ha regardless of treatments. The only grain quality parameter affected by treatments was 1000 grain weight (GW). The 1000 GW was lower in the deep ripped treatment compared to the Nil treatment in the Nil inoculated treatments (Figure 1).

Disease

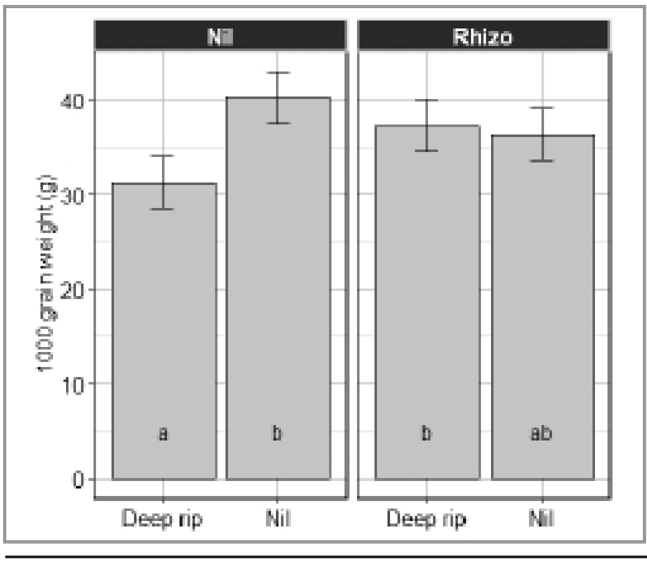


Figure 1. Thousand grain weight for deep ripping and inoculated treatments. Error bars indicate LSD of 5.4. Significance letters are provided to show significant differences at the 5% level.

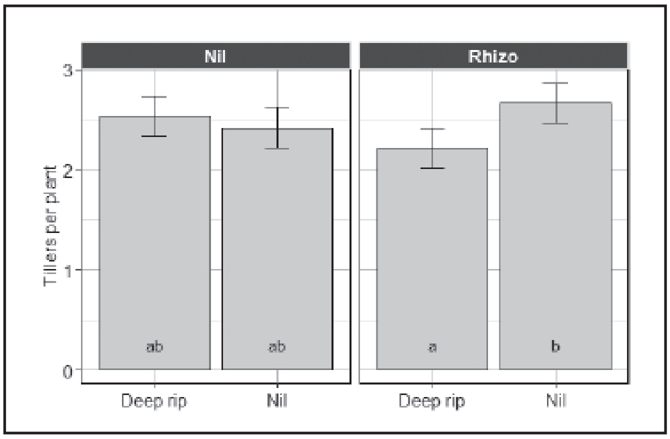


Figure 2. Tillers per plant between deep ripping and inoculated treatments. Error bars indicate LSD of 0.4. Significance letters are provided to show significant differences at the 5% level.

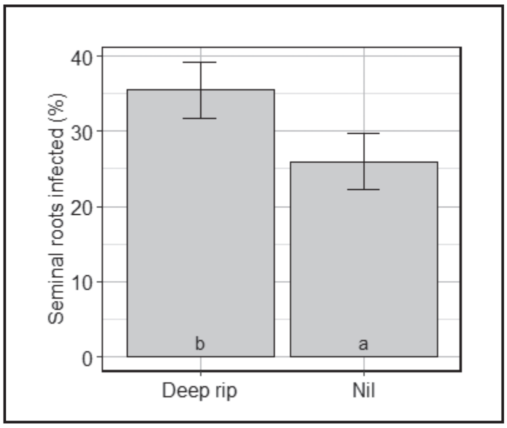
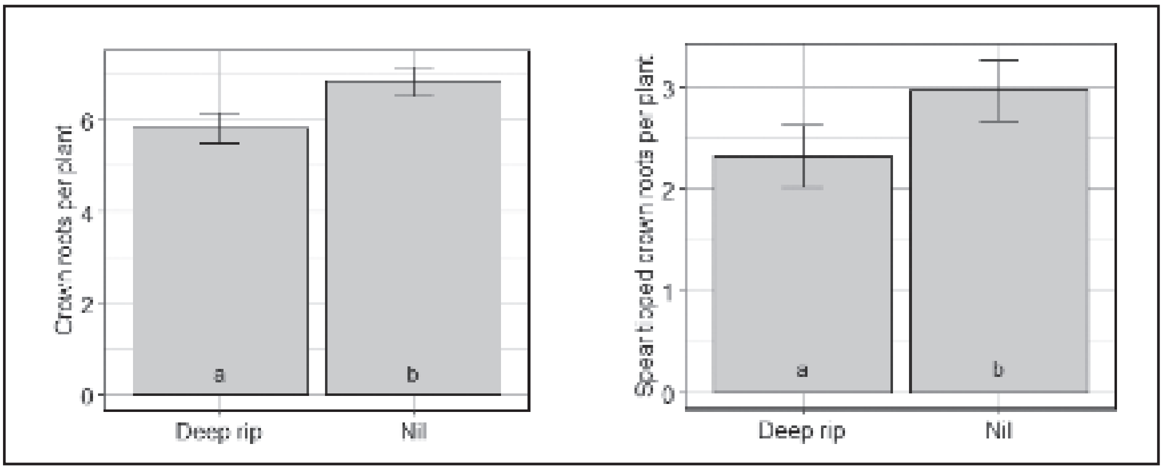


Figure 3. Seminal root infection between amelioration types. Error bars indicate LSD 7.5. Significance letters are provided to show significant differences at the 5% level.



Figures 4a and 4b. 4a) Crown roots per plant and 4b) Spear tipped crown roots per plant between amelioration types. Error bars indicate LSD of 0.6. Significance letters are provided to show significant differences at the 5% level.

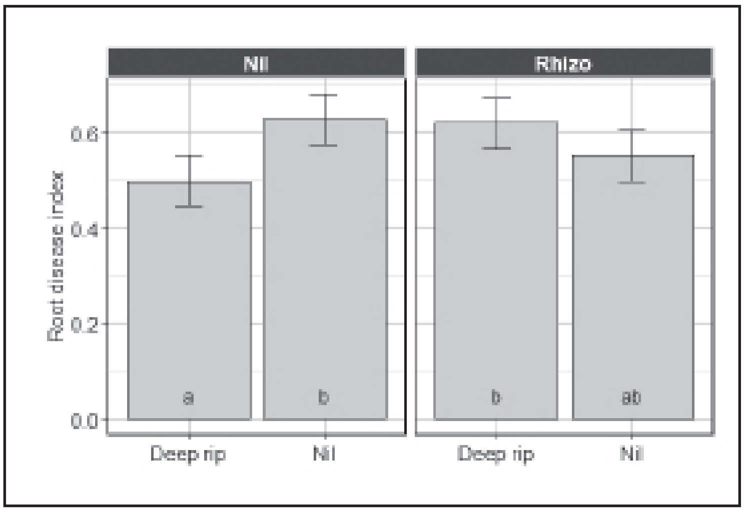


Figure 5. Root disease index between amelioration types and inoculum levels. Error bars indicate LSD of 0.11. Significance letters are provided to show significant differences at the 5% level.

The number of tillers measured on the plants sampled for root and shoot assessment was lower in the deep ripped and Rhizoctonia inoculated treatment compared to the non-ripped inoculated treatment (Figure 2).

Soil amelioration increased seminal root infection from 27% without ripping to 34% with deep ripping (Figure 3).

Deep ripping decreased the number of crown roots per plant compared to no soil amelioration (Figure 4a) and increased the number of spear tipped crown roots per plant (Figure 4b).

The root disease index rating showed lower root disease levels in the deep ripped Nil inoculum treatment compared to the Nil ripped Nil Rhizoctonia inoculum treatment and the Deep rip with Rhizoctonia inoculum treatment (Figure 5).

What does this mean?

2024 was an extremely poor Decile 1 season. The 2025 season had a late and dry start to the season in the Piednippie area with very little stored soil moisture. The trial was dry sown on 30 May two weeks before the first rainfall event.

In both 2024 and 2025, soil amelioration, the soil amendments (Biochar and Neutrog) and inoculation with Rhizoctonia had little impact on Rhizoctonia. In both seasons the deep ripping treatment reduced plant establishment in the absence of Rhizoctonia inoculum.

Deep ripping had a negative effect on plant root growth, and in 2024 this reduced plant biomass and grain yield (0.12 t/ha yield decline), but not in 2025 with a wet winter and milder grain filling conditions.

In both seasons the number of crown roots was reduced by deep ripping but the level of crown root infection varied depending on the seasonal conditions. In 2024 despite the increase in initial Rhizoctonia disease inoculum there were no differences measured for seminal root score and crown root infections, but in 2025 there was an increase in seminal root infection.

Deep ripping on grey calcareous soils, which normally have a higher incidence of Rhizoctonia disease, has not improved disease management. Overall, deep ripping in 2024 in dry conditions may have reduced initial soil moisture by increased evaporation, which in 2024 and 2025 potentially increased plant root exposure to soil constraints such as boron or other salts.

Acknowledgements

This research was funded by an extension of the GRDC Epidemiology and management of Rhizoctonia in low and medium rainfall zones (DAW2206-006RTX). Thank you to the host family for having the field trials on their property. Thank you to Kym Zeppel, Katrina Brands, Rebbecca Tomney, Tammie Mullen and Cayley Gray for undertaking field work and processing the samples.

Management of net form of net blotch of barley in low and medium rainfall zones of South Australia

Tara Garrard[1,2], Catherine Paterson[1], Kaidy Morgan[3], Mark Butt[1], Entesar Abood[1], Hari Dadu[1,2] and Kul Adikari[1,2]

[1]SARDI, [2]Adelaide University, [3]Hart Field-Site Group

Location
Calca
Rainfall
Av. Annual: 377 mm
Av. GSR: 302 mm
2025 Total: 346 mm
2025 GSR: 292 mm
Paddock history
2024: Scepter wheat
2023: Volga vetch
2022: Potaroo oats
Soil type
Grey sandy loam
Plot Size
20 m x 20 m

Location
Hart Field-site (near Clare)
Rainfall
Av. Annual: 420 mm
Av. GSR: 309 mm
2025 Total: 234 mm
2025 GSR: 207 mm
Paddock history
2024: Bale awnless wheat
2023: Kingbale oaten hay
2022: Scepter wheat
Soil type
Clay loam
Plot Size
12 m x 1.7 m

Key messages

- **In 2025, low net form of net blotch pressure meant disease did not cause economically significant yield losses in either medium or low rainfall zones.**
- **Fungicide applications, particularly at GS31 and GS39, reduced NFNB severity in susceptible varieties, however this did not consistently translate into yield benefits under low disease pressure.**

Why do the trials?

Net form of net blotch (NFNB) is now a widespread foliar disease commonly observed across southern Australian barley regions. Surveillance shows it occurs in most crops, is often severe in high rainfall zones (HRZ), and can also cause losses in medium (MRZ) and low rainfall zones (LRZ) when conditions favour infection. The disease is most problematic in areas where susceptible varieties are grown widely and in areas where fungicide resistance has developed.

Despite its prevalence, little is known about yield losses in the MRZ and LRZ, the conditions required to cause losses, or the level of varietal resistance needed to minimise risk.

Fungicides remain an important management tool, but their reliability has declined due to increasing resistance. Widespread resistance to group 7 and group 3 fungicides is commonly observed, however recently, a triple resistance involving group 11 has been identified. As a result, growers will need to adopt more strategic, integrated management approaches.

To address this, trials in South Australia evaluated the roles of varietal resistance and fungicide timing at Hart (MRZ, Mid North) and Calca (LRZ, Eyre Peninsula).

How was it done?

At both the low rainfall zone (LRZ; Calca) and medium rainfall zone (MRZ; Hart) sites, replicated field trials were established using a randomised complete block design with six replicates. At each site, three commonly grown barley varieties with differing levels of resistance to NFNB were selected and infected with NFNB spore inoculum using a knapsack sprayer at tillering stage (Z25). Fungicide treatments were applied at two growth stages: stem elongation (Z31) and flag leaf emergence (Z39).

NFNB severity was visually assessed at key growth stages by estimating the percentage of leaf area affected on ten representative plants per plot. An average disease severity score was calculated for each plot by averaging scores across the ten plants. Grain yield and quality were measured at harvest on 12 November 2025 at Hart and on 8 December 2025 at Calca.

Statistical analyses were conducted using Genstat (VSNi 23), with fungicide treatments and varietal responses compared using standard analysis of variance (ANOVA) procedures.

Barley varieties used in the trials:

- **Hart (MRZ):** #Maximus CL (MRMS), Commodus CL (MSS), RGT Planet (SVS)
- **Calca (LRZ):** #Maximus CL (MRMS), Beast (S), Spartacus CL (VS)

MRMS - Moderately resistant to moderately susceptible; MSS - Moderately susceptible to susceptible; S - Susceptible; SVS - Susceptible to very susceptible.

Fungicide treatments:

Four treatments were imposed at each site:

1. **Foliar application at Z31:** Prosaro 420 SC (Prothioconazole 210 g/L + Tebuconazole 210 g/L) at 150 mL/ha
2. **Foliar applications at Z31 and Z39:** Prosaro 420 SC at 150 mL/ha at Z31 followed by Amistar Xtra at 200 mL/ha at Z39 (Azoxystrobin 200 g/L + Cyproconazole 80 g/ha)
3. **Foliar application at Z39:** Amistar Xtra at 200 mL/ha
4. **Untreated control:** ***No fungicide applied.***

What happened?

Seasonal conditions in 2025 were generally unfavourable for the development of NFNB, and disease development was slow at both trial sites.

At Hart, fungicide treatments reduced NFNB severity in the susceptible variety RGT Planet at flag leaf emergence (Table 1). The application of Prosaro 420 SC® at Z31 followed by Amistar Xtra® at Z39 had the greatest reduction in disease severity, reducing pressure from 10% in the untreated control (UTC) to 1% at grain filling stage (Z73) in RGT Planet. However, disease pressure was transient, and disease levels at flag-leaf emergence had no significant effect on final yield. Disease levels were negligible in the moderately resistant varieties Commodus CL and Maximus CL, regardless of fungicide treatment. At Calca (LRZ), NFNB severity remained low across all varieties and fungicide treatments throughout the season. As a result, no significant differences in grain yield were observed between treatments (Table 2).

Grain quality was similar for all treatments (data not shown).

Table 1. Net form net blotch (NFNB) severity (%) at Z73 and grain yield (t/ha) of three barley varieties in response to different fungicide treatments at Hart, Mid North, South Australia, 2025.

Variety/Treatment	RGT Planet (SVS)		Commodus CL (MSS)		Maximus CL (MRMS)	
	NFNB severity	Yield (t/ha)	NFNB severity	Yield (t/ha)	NFNB severity	Yield (t/ha)
Untreated control	10[c]	2.0	2	2.7	0	2.7
Foliar spray at Z31	7[b]	2.1	2	2.7	0	2.8
Foliar spray at Z39	7[b]	1.7	5	2.4	0	2.4
Foliar spray at Z31 and Z39	1[a]	1.8	1	2.6	0	2.6
LSD (0.05)	*3*	*ns*	*ns*	*ns*	*ns*	*ns*

Table 2. Net form net blotch (NFNB) severity (%) at Z73 and grain yield (t/ha) of three barley varieties in response to different fungicide treatments at Calca, Eyre Peninsula, South Australia, 2025.

Variety/Treatment	Spartacus CL (VS)		Beast (S)		Maximus CL (MRMS)	
	NFNB severity	Yield (t/ha)	NFNB severity	Yield (t/ha)	NFNB severity	Yield (t/ha)
Untreated control	5	3.16	3	3.69	2	3.34
Foliar spray at Z31	4	3.21	2	3.80	2	3.10
Foliar spray at Z39	5	3.11	2	3.67	2	3.16
Foliar spray at Z31 + Z39	4	3.03	2	3.96	2	3.33
LSD (0.05)	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

What does it mean?

In 2025, seasonal conditions were not favourable for the development of NFNB, resulting in low disease pressure at both the medium (Hart) and low rainfall (Calca) sites. The application of Prosaro 420 SC at Z31 followed by Amistar Xtra at Z39 had the greatest reduction in disease severity, however all fungicides reduced NFNB severity in RGT Planet (SVS). This did not result in higher yields, as disease pressure declined later in the season.

At Calca, NFNB levels were low across all varieties and fungicide treatments, and no yield benefits from fungicide application were measured.

Overall, results indicate that under low to moderate NFNB pressure, fungicide applications are unlikely to deliver consistent economic returns, even in susceptible varieties. Growing moderately resistant varieties, such as Maximus CL, reduced disease risk and further limited the need for fungicides.

These findings highlight the importance of aligning fungicide use with seasonal disease risk and varietal resistance. In low rainfall zones and low disease pressure seasons, avoiding unnecessary fungicide applications can help reduce costs and slow the development 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. Funding for this work was provided by the South Australian Government (SARDI) and the GRDC (DAQ2304-008RTX). Thanks to the Hart Field-Site Group and Minnipa Agricultural Centre for field trials and to our research collaborators across the country.

Identifying soil-borne disease risks for cereal crops: Crown rot, Rhizoctonia, Cereal Cyst Nematode and Take-all

Buddhi Chaudhary[1] and Margaret Evans[2]

[1]SARDI; [2]Evans Consulting

Basic identification methods

PREDICTA® B

This is a commercial service provided by SARDI (Plant Research Centre, Urrbrae). Soil cores (+stubble) are submitted for DNA analysis to identify and quantify levels of many diseases of broad-acre crops.

PREDICTA® B predicts the ***risk*** of yield loss, but the severity of disease expression and associated yield loss will depend on seasonal conditions etc.

Advantages: quantifies the risk for multiple soil-borne diseases; can be used at any time; can be used on or between row or at random; usually has a fast turn-around.

Disadvantages: small cores means samples come from a relatively small area of the paddock; samples must be taken correctly; labour intensive; might be considered expensive.

Notes: selecting the paddock area to sample (e.g. best yielding; area with poor growth) can be more effective than sampling the whole paddock.

Visual inspection

Advantages: immediate; very specific; minimal investment.

Disadvantages: risk of misdiagnosis; may require an expert to identify symptoms; can only be used in-crop.

Notes: check plants from good areas to see what healthy plants and roots should look like; consider other possible causes e.g. herbicide damage; toxicities; deficiencies; frost; insect damage; strong winds.

Ask an expert - descriptions, photos and/or samples

Advantages: direct identification of visual symptoms.

Disadvantages: samples and information need to be good to get an accurate diagnosis; if samples need to be placed on agar plates it may take a while to get an answer.

Notes: the expert will need to know the variety; the paddock history; the herbicide history; as well as what good and poor crop areas, healthy and poor plants look like.

The most important soil-borne diseases in cereals

Crown rot, *Fusarium pseudograminearum/F. culmorum*

Hosts: cereals and many grassy weeds.

Inoculum carryover: occurs on infected cereal and grass residues and it can take many years for the infected residues to decay, making this disease very difficult to manage.

Check at: around flowering to early grain filling (earlier if crown rot is bad and cutting for hay is being considered). Plants can also be checked soon after harvest. Browning on leaf sheaths can be detected as early as 6 leaf.

Paddock symptoms: scattered white heads - not diagnostic! Check stem bases for crown rot.

Plant symptoms: pull up plants - a) look inside stems and under leaf sheaths for pink staining and fluffy pink or white hyphal growth; b) select the main stem, remove the leaf sheaths and check the stem base for the honey to dark brown discolouration typical of crown rot.

Yield loss: can occur without white heads being present and can be up to 80% in durum wheat, 40% in bread wheat and 30% in barley.

A new management option: VICTRATO (with Tymirium chemistry) is a Syngenta seed applied fungicide that has recently been registered for assisting with crown rot management. Work undertaken in 2022 and 2023 at Buckleboo and Mitchellville (see EPFS Summary trial results book 2024 pp. 170-175) has provided efficacy data for the low rainfall conditions of Upper Eyre Peninsula.

Findings for VICTRATO show that it:

- Should only be used where the risk of yield loss due to crown rot is known to be medium or high.
- Improves average bread wheat yield in low rainfall (1%-11%) in most instances. Use t/ha not % yield increases to calculate economics.
- Can improve barley yield in low rainfall (7%-12%), but may decrease yield if reduced crown rot expression encourages excellent early growth and a very poor season finish occurs.

- Reduces severity of crown rot expression (but not infection rates)
- Helps to limit inoculum carryover.
- Is not a "silver bullet" and management options should still be pyramided.
- Will not increase yield back up to the level expected if crown rot were not present and that white heads may occur even if VICTRATO® is applied to seed.
- Seeding rates should be higher, so a bit more cost is incurred.

Rhizoctonia root rot, *Rhizoctonia solani AG8*

Hosts: Winter cereals and grasses are the main hosts, but a broad range of species can host rhizoctonia at very low levels.

Inoculum carryover: occurs on decaying crop residues.

Check at: early tillering to flowering.

Paddock symptoms: wavy, uneven growth - easy to confuse with variability due to changes in soil type and depth.

Root symptoms: dig up plants from good and poor areas; wash out roots and float in water against a white background. Spear tips on primary and secondary roots are a classic symptom but browning and rotted areas on roots also occur. Where secondary roots are badly affected, plants become unstable and can be badly affected by high winds.

Yield loss: Can be more than 50% in susceptible crops, with barley most susceptible then wheat then triticale and then oats.

The "sleepers"

Now that management methods (resistant crops/varieties; rotation etc) for CCN and take-all are in place, these diseases are not common. However, given the right conditions both of these diseases can increase extremely quickly to cause large yield losses.

Cereal cyst nematode (CCN), *Heterodera avenae*

Hosts: cereals and wild oats (other grassy weeds are not good hosts).

Inoculum carryover: via egg-filled brown cysts (mostly 5-10 cm below the soil surface). Where cysts numbers are high, a 2 year break from hosts is needed to manage this nematode.

Check at: 6-8 weeks post-sowing.

Paddock symptoms: patches or areas of stunted growth.

Root symptoms: dig up plants from good and poor areas; wash out roots and float in water against a white background. Roots of wheat, barley, triticale and show knotting (white cysts visible around anthesis), but roots of oat do not. Oat roots look stunted and swollen.

Yield loss: can be significant, with losses greatest in oats, less in wheat and least in barley.

Take-all, *Gaeumannomyces graminis var. tritici* (Ggt)

Note - *G. graminis var. avenae* (Gga) is rare in SA. The information below relates to Ggt.

Hosts: wheat, barley, triticale (and Bevy rye).

Mainly a problem: in alkaline soils - pH>5.5 (water); >pH 4.7 ($CaCl_2$).

Inoculum carryover: is in dead roots & crowns. Inoculum declines quickly in moist soil with no hosts present, meaning take-all can be effectively controlled with one break crop.

Check at: 6-8 weeks post-sowing.

Paddock symptoms: patches of poor growth before head emergence; small to large patches of white heads (premature haying off).

Plant symptoms: badly affected plants pull out of the ground easily due to poor root systems.

Plant base symptoms: black ("black socks") with greyish, distorted leaf sheaths above.

Root symptoms: dig up plants from good and poor areas; wash out roots. Break roots and hold up to view across the cut area against good light to see the black central core surrounded by a ring of light-coloured tissue. Affected roots may also show black lesions.

Yield loss: can exceed 60% in wheat. Yield loss in symptomless crops can be up to 25%.

Further information

PREDICTA® B - contacts, courses, accreditation, submitting samples etc: https://pir.sa.gov.au/sardi/services/molecular_diagnostics/predicta_b

Ask an expert (SARDI Plant Research Centre – phone 8303 9400).

https://pir.sa.gov.au/sardi/crop-sciences/plant_health_and_biosecurity

GRDC fact sheets - for identification and management of specific diseases are available here:

https://grdc.com.au/resources-and-publications/all-publications/factsheets?collection=grdc-meta&profile=publications&form=wrapperf.Content+Type|ctype= factsheet&sort=offContent+Type|ctype=factsheet&sort=off

Chemical product trademark list

Knock Down + Spikes

Alliance - registered trademark of Crop Care Australasia Pty Ltd
Boxer Gold - registered trademark of Syngenta Australia Pty Ltd
BroadSword - registered trademark of Nufarm Australia Limited
Brodal Options - registered trademark of Bayer
Bromicide 200 - registered trademark of Nufarm Australia Limited
BS1000 - registered trademark of Nufarm Australia Limited
Buttress - registered trademark of Nufarm Australia Limited
Goal - registered trademark of Dow Agrowsciences
Gramoxone - registered trademark of Syngenta Group Company
Hammer - registered trademark of FMC Corporation
Hasten - registered trademark of Vicchem
Hot-Up spray additive - registered trademark of Vicchem
Jetti Duo - registered trademark of Imtrade Australia Pty Ltd
Kyte 700 WG - registered trademark of Nufarm Australia Limited
Liase - registered trademark of Nufarm Australia Limited
Nail 240EC - registered trademark of Crop Care Australasia Pty Ltd
Nuquat - registered trademark of Nufarm Australia Limited
Revolver - registered trademark of Nufarm Australia Limited
Roundup Attack - registered trademark of Monsanto Australia Limited.
Roundup PowerMax - registered trademark of Monsanto Technology LLC used under licence by Nufarm Australia
Roundup Ultra MAX - registered trademark of the Bayer Group
Spray Seed - registered trademark of Syngenta Group Company
Striker - registered trademark of Nufarm Technologies USA Pty Ltd
TriflurX - registered trademark of Nufarm Australia Limited
Volley SG - registered trademark of Sipcam Australia
Voraxer - registered trademark of BASF
Weedmaster DST - registered trademark of Nufarm Australia Ltd

Cereal Broad Leaf

2,4-D amine - registered trademark of Dow AgroSciences
Agritone 750 - registered trademark of Nufarm Australia Limited
Ally - registered trademark of Du Pont (Australia) Ltd or its affiliates
Amicicde625 - registered trademark of Nufarm Australia Limited
Archer - registered trademark of Nufarm Australia Limited
Broadside - registered trademark of Nufarm Australia Limited
Broadstrike - registered trademark of the Dow Chemical Company or an affiliated company of DOW
BromicideMA - registered trademark of Nufarm Australia Limited
Dual Gold - registered trademark of a Syngenta Group Company
Ecopar - registered trademark of Sipcam Pacific Australia Pty Ltd
Logran 750WG - registered trademark of Syngenta Group Company
Lontrel - registered trademark of Dow AgroSciences
Lontrel Advanced 600 - registered trademark of Corteva Agriscience
LV Ester 680 - registered trademark of Crop Care Australasia. Pty Ltd
LVE MCPA - registered trademark of Dow AgroSciences
Tigrex - registered trademark of the Bayer Group
Velocity - registered trademark of the Bayer Group

Clearfield Chemical
Intervix - registered trademark of BASF

Triazine Tolerant (TT)
Gesaprim 600Sc - registered trademark of Syngenta Group Company
Lexone - registered trademark of Du Pont (Australia) Ltd or its affiliates
Supercharge - registered trademark of Syngenta Group Company

Adjuvants
Bonza - registered trademark of Nufarm Australia Limited
Chemwet 1000 - registered trademark of Nufarm Australia Limited
Hasten - registered trademark of Victorian Chemical Company Pty. Limited
Kwicken - registered Trademarks of Third Party SST Australia Pty Ltd
LI 700 - registered trademark of United Agri Products.
Spreadwet - registered trademark of SST Australian Pty Ltd

Grass Selective
Avadex Xtra - registered trademark of Nufarm Australia Limited
Clethodim - registered trademark of Syngenta Group Company
Elantra Xtreme - registered trademark of Sipcam Pacific Australia Pty Ltd
Factor - registered trademark of Crop Care Australasia Pty Ltd
Hoegrass - registered trademark of the Bayer Group
Luximax - registered trademark of BASF
Mateno Complete - registered trademark of the Bayer Group
Monza - registered trademark of Monsanto Technology LLC used under license by Nufarm Australia Limited
Overwatch - registered trademark of FMC Australia
Propyzamide - 4 Farmers Australia Pty Ltd
Raptor - registered trademark of BASF
Reflex - registered trademark of Syngenta Group Company
Rustler - registered trademark of Cheminova Aust. Pty Ltd.
Sakura - registered trademark of Kumiai Chemical Industry Co. Ltd
Select - registered trademark of Arysta Life Sciences and Sumitomo Chemical Co. Japan
Targa - registered trademark of Nissan Chemical Industries, Co Japan
Ultro 900 - registered trademark of ADAMA
Verdict - registered trademark of the Dow Chemical Company or an affiliated company of DOW

Broadleaf
Aspect Options - registered trademark of Sipcam Australia
Flagship - registered trademark of ADAMA
Biffo - registered trademark of Nufarm Australia
Terrain - registered trademark of Nufarm Australia
Associate - registered trademark of Nufarm Australia
Sharpen - registered trademark of BASF
Amicide Advance - registered trademark of Nufarm Australia
Thistle Killem - registered trademark of Orion Agriscience

Insecticide
Alpha Duo - registered trademark of Syngenta Group Company
Astound Duo - registered trademark of Nufarm Australia Limited
Dimethoate - registered trademark of Nufarm Australia Limited
Dominex Duo - registered trademark of Crop Care Australasia Pty Ltd
Karate Zeon - registered trademark of Syngenta Group Company
Lemat - registered trademark of the Bayer Group
Lorsban - registered trademark of Dow AgroSciences

Fungicide

Amistar Xtra - registered trademark of Syngenta Group Company
Avior Gold - registered trademark of Kenso Agcare
Baytan - registered trademark of the Bayer Group
Cruiser Maxx - registered trademark of a Syngenta Group Company
ECHO - registered trademark of Sipcam Australia
EverGol - registered trademark of the Bayer Group
Gaucho - registered trademark of the Bayer Group
Helix - registered trademark of a Syngenta Group Company
Impact - registered trademark of Cheminova A/S Denmark
Jockey - registered trademark of the Bayer Group
Maxentis - registered trademark of ADAMA
Mightyzole - registered trademark of AXICHEM
MIRAVIS - registered trademark of a Syngenta Group Company
Prosaro - registered trademark of the Bayer Group
Rancona Dimension - registered trademark of UPL
Raxil - registered trademark of the Bayer Group
Spin Flo - registered trademark of Nufarm Australia Limited
Stayer - registered trademark of the Bayer Group
TYMIRIUM - registered trademark of a Syngenta Group Company
Uniform - registered trademark of a Syngenta Group Company
Veritas - registered trademark of ADAMA
Vibrance - registered trademark of a Syngenta Group Company
VICTRATO - registered trademark of a Syngenta Group Company

Other

ProGibb - registered trademark of Valent Biosciences 2019
GALA - registered trademark of VICCHEM Victorian Chemical Company

Acronyms and abbreviations

AB	Ascochyta blight
ADF	Acid Deterent Fibre
AH	Australian Hard
AIREP	Agricultural Innovation & Research Eyre Peninsula
APG	Australian Pastures Genebank
APW	Australian Premium Wheat
AWW	Ausralian White Wheat
BCG	Birchip Cropping Group
BFIG	Buckleboo Farm Improvement Group
BGA	Bluegreen Aphid
BGM	Botrytis grey mould
BLR	Barley leaf rust
BYDV	Barley yellow dwarf virus
CCM	Carbon Coated Mineral
CL	Chicken litter
CMD	Community metabolic diversity
CP	Crude protein
CV	Coefficient of variation
DAP	Di-ammonium Phosphate
DLPS	Dryland Legume Pasture Systems
DM	Dry Matter
DMD	Dry matter digestibility
DPIRD	Department of Primary Industries and Regional Development
DSE	Dry sheep equivalent
EP	Eyre Peninsula
EPR	EPR - End point royalties
Ex-GST	Goods and Service Tax exclusive
FDF	Future Drought Fund
FHB	Fusarium head blight
GA	Gibberellic Acid
GDD	Growing degree days
GPE	Grain number per ear
GRDC	Grains Research and Development Corporation
GS	Growth Stage
GSR	Growing Season Rainfall
HEI	Plant height at maturity
HI	Harvest index
HS	Head Scab
HSW	Hundred seed weight
IBS	Incorporated by sowing
IDM	Integrated disease management
IHM	Indian Hedge Mustard
IMI	imidazolinone
LAA	Leaf affected area
LD50	The dose of a test substance that is lethal for 50% of the animals in the test group
LOD	Lodging
LoRaWAN	Long range wide area network
LR	Leaf rust
LRZ	Low rainfall zone
LSD	Least Significant Difference
MAC	Minnipa Agricultural Centre
MAP	Monoammonium Phosphate
ME	Metabolizable Energy
MJ	Megajoules
MJ ME/kg D	Megajoules of metabolizable energy per kilogram of dry matter
MLA	Meat and Livestock Australia
MR	Moderately Resistant
MR#	Moderately Resistant (Warning more susceptible to alternate pathotypes)
MRMS	Moderately Resistant - Moderately Susceptible
MRMSp	Moderately Resistant - Moderately Susceptible (Provisional rating)
MRp	Moderately Resistant (Provisional rating)
MS	Moderately Susceptible
MSp	Moderately Susceptible (Provisional rating)
MSS	Moderately Susceptible to susceptible
ns	not significant
NAP	Nucleic Acid Preservation
NDF	Neutral detergent fibre
NDVI	Normalised difference vegetation index
NFNB	Net form net blotch

NIR	Near-infrared spectroscopy
NVT	National Variety Trials
OC	Organic Carbon
OM	Organic Matter
PBI	Phosphorus Buffer Index
PIRSA	Primary Industries and Regions South Australia
PM	Powdery Mildew
PSPE	Post-sowing pre-emergent
R/S	Resistant pathotype differences susceptible
RF	Rainfall
RMR	Resistant to Moderately Resistant
RMRp	Resistant to Moderately Resistant (Provisional rating)
RP	Relative performance
S	Susceptible
SAA	Spotted alfalfa aphid
SAGIT	South Australian Grains Industry Trust
SANTFA	South Australian No-Till Farmers Association
SARDI	South Australian Research and Development Institution
SFNB	Spot form net blotch
STB	Septoria tritici blotch
SU	tolerance of Sulfonylurea
SVS	Susceptible to very susceptible
TBC	To be confirmed
TDS	Total dissolvable salts
TE	Trace Elements
TGW	Thousand grain weight
TOS	Time Of Sowing
TW	Test weight
UEP	Upper Eyre Peninsula
WGD	White grain disorder
WUE	Water use efficiency
YLS	Yellow leaf spot
ZnP	Zinc phosphide

Contact list for authors

Name	Position	Location	Phone Number	E-mail
Adhikari, Kamal	Research Scientist	Agriculture Victoria, Horsham	0488 742 339	kamal.adhikari@agriculture.vic.gov.au
Agenbag, Bianca	Senior Research Officer	SARDI, Turretfield Research Centre	(08) 8429 4433	bianca.agenbag@sa.gov.au
Barr, Dr Andrew	Chair / Trustee	SAGIT	0428 277 085	arhebarr@baonline.com.au
Butt, Mark	Technical Officer	SARDI, Waite	(08) 8429 2226	mark.butt@sa.gov.au
Cook, Amanda	Research Leader	SARDI, Minnipa Agricultural Centre	(08) 8680 6217	amanda.cook@sa.gov.au
Dadu, Hari	Sub Program Leader - Pulse Pathology	SARDI, Waite	(08) 8429 2294	hari.dadu@sa.gov.au
Evans, Dr Margaret	Research Scientist	Evans Consulting	0427 604 168	margevans33@gmail.com
Fleet, Benjamin	Research Agronomist	Adelaide University, Roseworthy	(08) 8313 7950	benjamin.fleet@adelaide.edu.au
Fleming, Nigel	Senior Research Scientist	SARDI, Waite	(08) 8429 2224	nigel.fleming@sa.gov.au
Garrard, Tara	Research Scientist	SARDI, Waite	(08) 8429 2247	tara.garrard@sa.gov.au
Hughes, Brian	Soils Team Leader	SARDI, Nuriootpa	0429 691 468	brian.hughes@sa.gov.au
Keeley, Amy	Senior Research Officer	SARDI, Port Lincoln	(08) 8429 0572	amy.keeley@sa.gov.au
Kupke, Brendan	Research Officer	SARDI, Waite	0429 411 032	brendan.kupke@sa.gov.au
Lowe, Alyce	Senior Research Officer	SARDI, Turretfield Research Centre	(08) 8429 0291	alyce.lowe@sa.gov.au
Luo, Zhaohan (Elijah)	Research Officer	SARDI, Minnipa Agricultural Centre	0491 944 866	zhaohan.luo@sa.gov.au
McBeath, Therese	Principal Research Scientist	CSIRO Agriculture & Food, Waite Campus	(08) 8303 8544	therese.mcbeath@csiro.au
Nickolai, Jacob	Research Officer	SARDI, Waite	0407 353 809	jacob.nickolai@sa.gov.au
Paterson, Catherine	Research Officer	SARDI, Minnipa Agricultural Centre	(08) 8680 6227	catherine.paterson2@sa.gov.au
Pearce, Amanda	Research Officer	SARDI, Struan	(08) 7085 1774	amanda.pearce@sa.gov.au
Peck, David	Senior Research Officer	SARDI, Waite	(08) 8429 0475	david.peck@sa.gov.au
Petrie, Dr Paul	Acting Research Director, Crop Sciences	SARDI, Waite	(08) 8429 0787	paul.petrie@sa.gov.au
Rose, Michael	Associate Professor	Southern Cross University		mick.rose@scu.edu.au
Schilling, Rhiannon	Associate Professor - Agricultural Sciences (Agronomy)	Flinders University	0407 815 199	rhiannon.schilling@flinders.edu.au

Name	Position	Location	Phone Number	E-mail
Scholz, Naomi	Executive Officer	AIR EP	0428 540 670	eo@airep.com.au
Shi, Andong	Senior Research Officer	SARDI, Waite	(08) 7133 7553	andong.shi@sa.gov.au
Simpson, Luke	Operational Officer	SARDI, Waite	(08) 8429 4478	luke.simpson@sa.gov.au
Telfer, Joshua	Senior Research Officer (Soils)	SARDI, Port Lincoln	0460 000 290	joshua.telfer@sa.gov.au
Telfer, Simeon	Project Manager - AFDRS	South Australian Country Fire Service/Keswick	0477 300 144	simeon.telfer@eso.sa.gov.au
Turner, Emma	Research Officer	SARDI, Port Lincoln	(08) 7133 8916	emma.turner@sa.gov.au
Wilhelm, Dr Nigel	Farming Systems Leader	SARDI, Waite	0407 185 501	nigel.wilhelm@sa.gov.au
Woodard, David	Soil and Land Management Consultant	SARDI, Nuriootpa	(08) 7085 1707	david.woodard@sa.gov.au

Zhaohan (Elijah) Luo presenting at the SARDI Farmer Meeting at Minnipa.

NOTES:

NOTES:

NOTES:


SAGIT
Investing for your future
SARDI
SA DISCOVERY FARMS
Innovator Site

Government
of South Australia

Department of Primary
Industries and Regions

SARDI

SOUTH AUSTRALIAN
RESEARCH AND
DEVELOPMENT
INSTITUTE