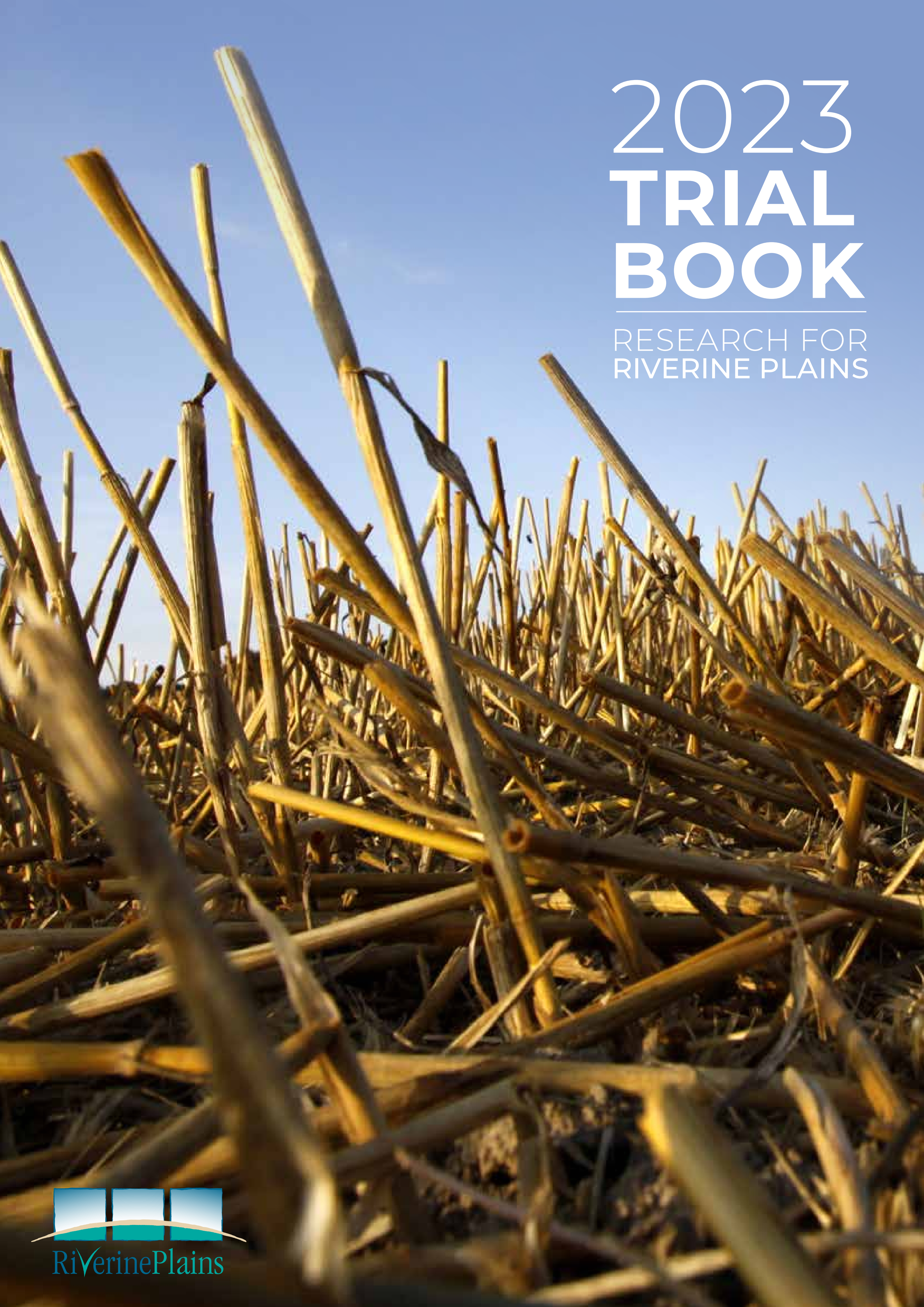

2023 TRIAL BOOK

RESEARCH FOR RIVERINE PLAINS

RiverinePlains

2022 PREMIER PARTNER

2022 SIGNATURE PARTNERS

2022 VALUED PARTNERS

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ACHIEVEMENTS AT A GLANCE - 2022

EVENTS

43 EVENTS

INAUGURAL EVENTS

- RIVERINE PLAINS INNOVATION EXPO 2022
- SPRAY EFFICIENCY WORKSHOP
- YOUTH IN AG DINNER
- HARVESTER WORKSHOP

2066 ATTENDEES AT EVENTS

36 CURRENT PROJECTS

6 COMPLETED PROJECTS

VALUE OF NEW PROJECTS **$5.9 MILLION**

COMMERCIAL PARTNERS **33**

RESEARCH PARTNERS **43**

MEMBERS

2021	426 MEMBERS
2022	472 MEMBERS

INDUSTRIES COVERED

- SOILS
- LIVESTOCK
- CLIMATE
- AG TECH
- GRAINS
- PASTURES
- COMMUNITY
- ENVIRONMENT

IMPACT CAPACITY AND CAPABILITY

SCHOLARSHIP RECIPIENTS **3**

2021 5 STAFF

2022 11 STAFF

RESEARCH SITES

7 IN 2021

27 IN 2022

SCHOLARSHIPS

In 2022 Riverine Plains Inc offered three scholarships of $5000 each to students currently in their first year of study for either a diploma or Bachelor's degree in Agriculture, Agricultural Science or Agribusiness. All three scholarships aim to recognise and encourage agricultural excellence by supporting students from the Riverine Plains in their agriculture-related studies.

In 2023 we are excited to announce another two $5000 scholarships thanks to the generosity of Alvan Blanch Australia.

THE HANRAHAN FAMILY SCHOLARSHIP

The Hanrahan Family Scholarship was established in honour of the late John Hanrahan, a valued member from Coreen. John's community spirit, passion for agriculture and thirst for knowledge was renowned.

2022 RECIPIENT
JAMES WHITE

James is from Springhurst and is studying a Bachelor of Agricultural Science at Charles Sturt University.

UNCLE TOBYS SCHOLARSHIP

The Uncle Tobys Scholarship was established in 2021 to support future leaders in agriculture, especially those from the local region, who are crucial to the success of the food industry.

2022 RECIPIENT
SAM MARSHALL

Sam hails from Rennie, NSW and is studying a Bachelor of Business Management (Agriculture) at Marcus Oldham College.

CORTEVA AGRISCIENCE SCHOLARSHIP

Corteva Agriscience is proud to be helping young people develop their passion for agriculture through the launch of its inaugural Scholarship in 2022.

2022 RECIPIENT
REILY MENHENETT

Reily grew up on a farm at Arcadia, Victoria, and is currently studying a Bachelor of Agricultural Science and Technology, as well as a Bachelor of Science majoring in Synthetic Chemistry at the University of Western Australia.

FUNDING ACKNOWLEDGEMENTS

Riverine Plains is proud to collaborate with the following research partners: Agriculture Victoria, Australian Government's National Landcare Program, Australian National University, Birchip Cropping Group, Brill Ag, Central West Farming Systems, Centre of eResearch and Digital Innovation, Charles Sturt University, Corson, CSIRO, Deakin University, Department of Primary Industries and Regional Development, Federation University, FAR Australia, FarmLink, Food Agility CRC, Food and Fibre Gippsland, First Nations Governance Circle, Foundation for Rural and Regional Renewal, Goulburn Broken Catchment Management Authority, Holbrook Landcare Network, Irrigated Cropping Council, Irrigation Research and Extension Committee, Kellogg's Group, La Trobe University, Local Land Services NSW, Mallee Regional Innovation Centre, Mallee Sustainable Farming, Manildra Group, Allied Pinnacle, Sustainable Food Lab, Mars Petcare, Meat and Livestock Australia, Murray Dairy, North East Catchment Management Authority, NSW Department of Primary Industries, Pratt Foundation, Rural Aid, Soil CRC, Southern Farming Systems, Southern Growers, South Australia Research and Development Institution, Southern Cross University, TechCrop, University of Canberra, University of Melbourne and University of Wollongong.

THANK YOU TO OUR HOST FARMERS

Thank you to the members who very generously donated their time and paddocks to enable Riverine Plains to undertake research, extension and validation locally. Your contribution to our region is noted, appreciated and impactful.

Paul and Melissa Brown; John and Sarah Bruce; Roy, Leanne and Michael Hamilton; Adam and Ingrid Inchbold; Nathan and Kara Lawless; Dean and Beverly Leslie; Beau and Rebecca Longmire; Andrew and Sue Russell; Curt and Steph Severin; The Spence Family; Wayne and Therese Thomas; Emily and Phil Thompson; Denis and Rebecca Tomlinson; Ian and Melanie Trevethan; Tim and Lara Trevethan

RESEARCH YEAR IN REVIEW

HIGHLIGHTS

Together as a team, we have been able to:

- **Increase our field trial and demonstration sites from seven to 24 with a wider geographic spread.**
- **Lead a high-profile project looking at farm management strategies that increase the resilience of soils to drought in collaboration with CSIRO, Grains Research and Development Corporation, the southern New South Wales Drought Resilience Adoption and Innovation Hub (sNSW Hub) and other farming systems groups.**
- **Double our research and field operations team.**
- **Increase the value of our projects to $5.9 million over the last 18 months.**
- **Commence and deliver our first livestock project.**
- **Increase the number of our projects to 36 and diversify sectors and topics.**

This year has seen rapid but sustainable growth in our research deliverables, partnerships, efficiency and impact. This has been led by our highly motivated team, in combination with our Research Advisory Council (RAC).

Our RAC consists of farmers, consultants and university researchers, who together provide well-rounded ideas based on the needs of farmers, current research and information from local consultants. The RAC ensures the research, extension, validation and adoption activities Riverine Plains embarks on are relevant to our members first and foremost. It gives us confidence knowing the projects we are building will be helpful to our members and bring prosperity into our region.

In 2022 we increased the diversity, structure and scale of our projects. We brought in commercial research partners, diversified into livestock and community projects and improved the geographical spread across our region. This increase in depth and breadth of projects has ensured benefit not only to our members, but also local researchers, further building capacity in the region.

In 2022 we had a total of 36 Projects valued at over $5.9 million to the region. This includes projects looking at climate variability, pasture resilience, containment feeding, community, soils extension, agronomy, social research looking at impacts of climate, agtech uptake and extension modelling.

The matrix below shows our projects have increased in diversity, directly aligned with our strategy over the past year.

Dr Sara Hely, Director of Research, Riverine Plains.

2022	SOILS	GRAIN	LIVESTOCK	PASTURES	CROSS SECTOR
Capacity building	✓	✓	✓		
Business	✓				
Production	✓	✓	✓		
Carbon	✓	✓			
Climate	✓	✓			✓
Traditional Owner					✓
AgTech (innovation)	✓	✓	✓	✓	✓
Biosecurity					
Environment/Natural Capital		✓			✓
Social					✓

NEW PROJECTS

Since the publication of the last trial book we have commenced the following new projects:

SMART FARMS SMALL GRANTS: SOIL EXTENSION ACTIVITIES

Term Date: 2022-2024

This project aims to support land managers by promoting the benefits of increased frequency of extensive soil sampling and testing to inform soil management decisions and take action to improve soil health. Two farmer discussion groups will work to identify high-priority soil issues through soil testing and will engage with soil scientists at field walks, workshops, and demonstrations.

This project is funded through the Australian Government's National Landcare Program Smart Farms Small Grants initiative and the Grains Research and Development Corporation (GRDC).

DROUGHT RESILIENCE PRACTICES IN MIXED FARMING SYSTEMS

Term Date: 2022-2023

This project aims to fast-track direct support to cropping and livestock farmers across Victoria, South Australia, and Tasmania, in the management of pastures, the use of livestock containment and different feeding systems for drought resilience.

The use of demonstrations, activities and outputs in this project will help improve farm decision making and lead to improvements in soil cover, livestock welfare and nutrition in periods leading into, during and post drought.

This is funded by the Australian Government's Future Drought Fund through the Victoria Drought Resilience Adoption and Innovation Hub (Vic Hub).

PHASE 2: PLANT-BASED SOLUTIONS TO IMPROVE SOIL PERFORMANCE THROUGH RHIZOSPHERE MODIFICATION (INCREASING PLANT DIVERSITY)

Term Date: 2023-2026

This project continues on from a previous project. Riverine Plains has established a fully replicated trial site at Burramine, in Victoria, to evaluate how green manures, different rotations, cover crops and companion crops affect soil performance.

Additional funding from Goulburn Broken CMA will enable at least five years of trials to look at the influence of alternative cropping practices on soil properties. This site connects with similar sites through Queensland, New South Wales, South Australia and Western Australia.

This is funded by the Soil CRC.

IMPROVED DROUGHT RESILIENCE THROUGH OPTIMAL MANAGEMENT OF SOIL AND WATER

Term Date: 2022-2024

This project will establish 12 demonstration sites across southern New South Wales and northeast Victoria, covering approximately 18 million hectares, with a range of soil types, environments, and land uses.

Three proven strategies that improve drought resilience compared to conventional farming will be demonstrated:

1. diverse legume rotations
2. early sowing of slower-maturing crops
3. measuring residual nitrogen in the soil

This is funded by the Australian Government's Future Drought through the Southern New South Wales Drought Resilience Adoption and Innovation Hub (sNSW Hub).

SILICON FERTILISER FOR DROUGHT RESILIENCE IN BROADACRE CROPPING

Term Date: 2022-2024

This project is led by The University of Melbourne and will be hosted on large plot demonstration/evaluation sites at four locations across northern Victoria. This is a region identified by the Australian Bureau of Agricultural and Resource Economics and Sciences (2020) as "one of only four regions in Australia at the highest level of drought risk nationally".

Around fifty small-scale replicated research trials will be used to evaluate a broader set of varieties and management options. There will be an evaluation of indigenous plant species at all sites under the guidance of experts from Black Duck Foods and Goulburn Broken Catchment Management Authority.

This is funded by the Australian Government's Future Drought Fund.

ASSESSING THE SUITABILITY OF SMALL FARM DAMS

Term Date: 2022-2024

This project is led by Southern Farming Systems and aims to create a spatial tool to rapidly calculate the likely runoff (frequency and volume under current future climate scenarios) into existing farm dams to help prepare, cope, and recover from drought. This type of calculator does not exist, with current approaches designed for flood rather than drought planning.

This is funded by the Australian Government's Future Drought Fund.

ORGANIC FERTILISERS FOR CROP NUTRITION

Term Date: 2022-2024

In partnership with FAR Australia, this two-year pilot project will look at the value of faba bean stubble with and without organic manures in restoring fertility and increasing yield in the following wheat crop. The impact of two different timings of nitrogen application on the faba crop in the subsequent wheat crop will also be assessed. This research coincided with increased nitrogen prices with growers increasingly looking for pulses to improve rotation fertility.

This is funded by the Grains Research and Development Corporation.

MORE ROBUST WEATHER STATION NETWORK TO SUPPORT CLIMATE RESILIENCE

Term Date: 2022-2024

The project is investigating the feasibility of bringing together five weather station networks and moisture probes across southern Australia into a single, standardised platform that will inform key stakeholders on a series of localised climatic information to assist with disaster planning.

This is funded by the Department of Industry, Science, Energy and Resources through the Preparing Australia Program.

NITROGEN BANKING PROJECT

Term Date: 2022-2023

This project, led by FarmLink, is establishing a replicated trial site that compares 'nitrogen banking' and 'nitrogen demand' based strategies for closing the nitrogen limited yield gap with nil and national average control treatments. It will also complete an economic analysis of scenarios for 'nitrogen banking' and 'nitrogen demand' based strategies compared to controls.

This is funded by the GRDC.

CREATING LANDSCAPE-SCALE CHANGE THROUGH DROUGHT-RESILIENT PASTURE SYSTEMS

Term Date: 2022-2024

Led by the Holbrook Landcare Network and the sNSW Hub, this project will establish a series of demonstration sites across the mid to high rainfall zone showcasing modern pasture species combinations and management practices known to build greater resilience across the landscape. Pasture species and the soils they protect are the major natural capital sources across 82 % of NSW land area, and even minor improvements can have a widespread impact.

Demonstration sites, workshops, publications, case studies, and on-farm consultations with farmers will achieve farmer adoption of findings and on-ground application of project outcomes.

This is funded by the Australian Government's Future Drought Fund Drought Resilient Soils and Landscapes Program through the sNSW Hub.

CURRENT PROJECTS

Projects that are continuing into this year are:

DROUGHT RESILIENCE ADOPTION AND INNOVATION HUB AGTECH INNOVATION PROJECT

Term Date: 2022-2023

The project supports activities focused on increasing the adoption of digital agriculture solutions, including the Drought Resilience Self-Assessment Tool and Climate Services for Agriculture. It is doing this by increasing digital agriculture awareness, education, improving data literacy, data collection, collation, permissions, data access and sharing practices. In addition, it is reducing barriers to the digitisation of Australian agriculture through the support for 'create, try, test and learn' opportunities such as mapping the farm.

Farmers and advisors are learning new approaches for combining and analysing historical and current spatially referenced data (soils, landscape, climate, yields, spectral imagery) to create new insights into the resilience and reliability of different parts of the farm examined across multiple seasons.

This is funded by the Australian Government's Future Drought Fund through the Agricultural Innovation Hubs Program with the Vic Hub.

IMPROVING SOIL TO OPTIMISE WATER USE ON-FARM

Term Date: 2021-2023

This project addresses soil quality parameters, storing more rainfall for crop production and how these are related. The aim is to provide farmers with a better understanding and knowledge base of their soil and how they can identify local constraints, improve production, and water retention, and build resilience for future droughts.

This is funded through the Australian Government's Future Drought Fund and the National Resource Management Drought Resilience Program.

VICTORIA DROUGHT RESILIENCE ADOPTION AND INNOVATION HUB

Term Date: 2021-2024

The Vic Hub will contribute $8 million over four years through the Future Drought Fund.

The Vic Hub is led by the University of Melbourne's Dookie Campus and is conducted in association with Deakin, La Trobe, and Federation University and Agriculture Victoria. Riverine Plains is a "Node" leader for northeast Victoria and will consult the agricultural industry through farmers, councils, businesses, health organisations, and community groups in their region about building drought resilience at the local level. This process will lead to the development of pilot projects to address specific knowledge or technical skill gaps identified through the hubs, capacity building and the brokering of knowledge between nodes.

This is funded through the Australian Government's Future Drought Fund.

SOUTHERN NEW SOUTH WALES DROUGHT RESILIENCE ADOPTION AND INNOVATION HUB

Term Date: 2021-2024

The sNSW Hub is a consortium of nine regional partners including primary producers, industry, Indigenous and community groups, researchers, entrepreneurs, education institutions, resource management practitioners and government agencies.

Riverine Plains has been funded to appoint a part-time knowledge broker who will assist in gathering and sharing knowledge to southern NSW members and their communities. The outcome of this partnership is user-driven innovation, research and adoption and the facilitation of transformational change through the co-design of research, development, extension, adoption, and commercialisation activities.

This is funded through the Australian Government's Future Drought Fund.

HYPER YIELDING CROPS

Term Date: 2020-2024

Riverine Plains established two focus farm sites in southern NSW in support of the NSW Centre of Excellence, Wallendbeen Centre, with a canola site established at Howlong and a wheat site based at Rutherglen. Riverine Plains Discussion Groups are being formed to link local growers with the focus farm paddock trials at these sites.

This is funded by the GRDC.

COOL SOIL INITIATIVE

Term Date: 2018-2023

The Cool Soil Initiative aims to increase the long-term sustainability and yield stability of southern New South Wales and northeast Victorian grain-producing regions, by adopting innovative agronomic strategies to improve soil health and related function.

This project seeks to create a platform for the food industry to support grain farmers in reducing greenhouse gas emissions and increasing soil carbon, leading to increased long-term sustainability.

This is funded by the Food Agility Cooperative Research Centre, Charles Sturt University, Mars Petcare, Kellogg's, Allied Pinnacle, The Manildra Group, Corson and supported by the Sustainable Food Lab.

FACILITATED ACTION LEARNING GROUPS TO SUPPORT PROFITABLE IRRIGATED FARMING

Term Date: 2019-2023

This project is led by the Irrigated Cropping Council and assisted the formation of the Riverine Plains Irrigation Discussion Group. This group aims to link new and innovative irrigated cropping research investments by the GRDC with local farmer-driven groups and to tie these research projects more closely with farmer needs.

This is funded by the GRDC.

MULTIPLE SMALLER PROJECTS LOOKING AT SOIL CONSTRAINTS AND ENHANCING SOIL MANAGEMENT

Term Date: 2021-2024

These projects combine biophysical modelling, artificial intelligence, and statistical approaches to diagnose multiple and interactive soil constraints using existing farm and public data at a sub-field level. They will also look at research methodology, decision modelling, bio-economic factors and the development of tools to support farmers, policy makers, financiers and suppliers.

These projects are funded by the Soil CRC. .

CLOSING THE YIELD GAP USING GRAIN LEGUME PRODUCTION

Term: 2021-2024

This project, led by FAR Australia is designed to deliver local development and extension to maximise farming benefits from grain legume production. This is to be achieved through grower-driven grain legume validation and demonstration trials across the region.

This is funded by the GRDC.

SOIL WATER STORAGE: INCREASED ACCESS AND TOOLS FOR ASSESSMENT

Term: 2022-2025

This project will build on the existing Soil CRC project at Burramine. Through installation of field sensors, the project will improve the understanding of crop access to water. It will give a better understanding of the competition for water and resources between mixed species cover crops and impacts on soil water availability for the cash crop.

This is funded by the Soil CRC.

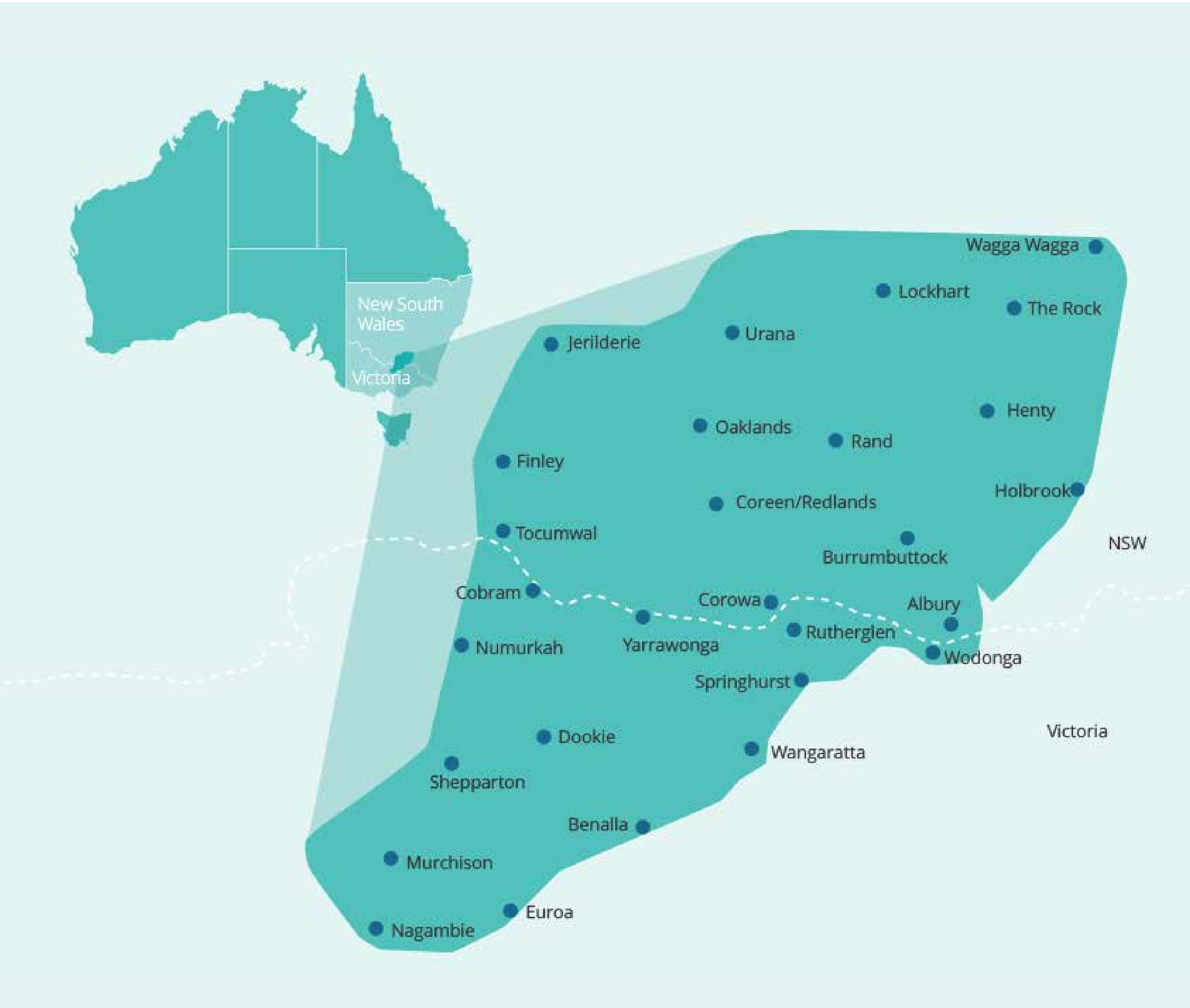
BEST PRACTICE LIMING TO ADDRESS SUB-SOIL ACIDITY

Term Date: 2021-2024

This project involves establishing a replicated lime treatment field trial at Lilliput, Victoria and aims to increase awareness of the speed of acidification and stratification of soils in the region and the availability of tools to assist in the decision management process.

The trial aims to demonstrate best practice liming methods and how the incorporation of top-dressed lime can improve its distribution down the soil profile, lessening the impacts of soil acidity on subsequent crops.

This is funded through the GRDC.



PROJECTS REACHING FULL TERM

Project that have now come to conclusion are:

BUILDING DROUGHT RESILIENCE THROUGH STOCK CONTAINMENT INITIATIVES

Term: 2021-2022 (pilot project)

This project delivered a gap analysis and a comprehensive plan for future investment in a larger cross-hub, national initiative. It has specifically addressed barriers to investment and adoption of stock containment and confinement strategies.

This is funded by the Australian Government's Future Drought Fund through the Vic Hub.

ENHANCING COMMUNITY NETWORKS FOR DROUGHT RESILIENCE IN THE RIVERINE PLAINS

Term Date: 2021-2022

This project was designed to help people in Riverine Plains' communities make personal and professional connections to better prepare for the next drought or future climate challenges.

This is funded through the Australian Government's Future Drought Fund.

INNOVATION UPTAKE PROGRAM

Term: 2021-2022

AgriFutures Australia provided funding to support the Innovation Expo in July 2022. The aim of the event was to look at four different technologies in the field and target the adoption of such technologies to improve farming practices.

This is funded by AgriFutures Australia.

FODDER FOR THE FUTURE

Term Date: 2020-2022

The project was designed to assist farmers adapt to a water-limited future by increasing the knowledge of both grain and dairy farmers by trialing different fodder options and connecting the two industries. This project highlights the value of 'closed loop' fodder production systems, which involves the transfer of high-quality fodder between businesses within the southern Murray Darling Basin, whilst retaining the value of production locally.

This is funded by Dairy Australia, through Murray Dairy.

THE YEAR IN REVIEW

Many Riverine Plains region farmers headed into 2022 with positivity and improved financial positions after two good seasons in a row (2020 and 2021). However, some were affected by significant flooding in late 2021, just as harvest was beginning to get underway, making for a difficult start.

Across the Riverine Plains, summer storm activity was driven by a persisting La Nina, which saw some exceptional rainfall events in January 2022. Albury recorded 306mm for the month, 223mm was recorded at Henty and totals of 100mm or more fell at Rutherglen, Dookie, Lockhart and Urana (all decile 10) (Table 1). February was considerably drier for the Victorian sites analysed (decile 1–2 rainfall), compared to the NSW sites (decile 2–7).

The summer rain encouraged weed growth, and storms caused localised damage to buildings and paddocks in some areas, but was useful for soil moisture and maintaining summer pastures in others. Summer spray programs added workload and cost to operations.

The costs of, and access to, inputs such as fertiliser, diesel and chemicals were volatile. Growers weighed up likely seasonal outcomes with the need to replace nutrients that were removed at high rates from hay and grain crops during 2020 and 2021, as well as maintaining pasture.

While La Nina eased during autumn, a persistently positive Southern Annular Mode from mid-autumn onwards generated regular rainfall events. Decile 6–10 rainfall in March, topped up soil profiles ahead of sowing and helped establish early-sown pastures and dual-purpose crops.

April–June rainfall deciles were between 5–10 and mild conditions saw early-sown crops and pastures establish well, however trafficability issues, pushed out sowing into June in some areas. Increased moisture over the past few seasons, as well as stubble and grain residues, contributed to slug damage in previously unaffected paddocks, as well as widespread mice and rat damage.

A dry July (decile 1–3) helped soils dry out and relieved the immediate threat of waterlogging in most areas.

The negative Indian Ocean Dipole in winter – spring, a La Nina event that redeveloped in early September and that lasted until the end of the year, plus the effects of the positive Southern Annular Mode phase, all combined to drive record rainfall across parts of the Riverine Plains in the last quarter of 2022.

The decile 8–10 rainfall that fell across the Riverine Plains during September fuelled optimism around the potential for high yielding crops and pastures, however trafficability and regular rain fronts quickly became problematic for growers who struggled with fungicide programs. Pulse growers were particularly affected, with many faba bean crops badly affected by chocolate spot outbreaks.

Decile 10 to highest-on-record October rainfall fell on already saturated catchments and led to waterlogging and major flooding. This was exacerbated by follow-up decile 9-10 rainfall in November and many paddocks spent long periods under water, especially those near waterways. This checked yield potential for grain crops and caused areas of complete loss in some paddocks. Livestock producers also had difficulty managing animal health and welfare needs.

The cool and wet conditions over spring also interfered with hay and silage-making programs. While there was plenty of pasture feed available through spring and into summer 2023, livestock producers battled scald and hoof conditions, with a range of worm and mineral deficiencies also observed.

The conditions saw some growers switch to direct-heading canola for the first time given trafficability and contractor availability. Grain harvest was drawn-out due to initial trafficability issues, frequent rainfall events and cooler-than-average temperatures.

Grain yields were variable, depending on the level of waterlogging. In general, pulses yielded poorly, canola was lower than expected, while wheat performed better than expected. Strong commodity prices did help compensate for lower yields.

Table 1: 2022 monthly and growing season rainfall totals and deciles across the Riverine Plains

	EUROA	DEC	RRI	DEC	DOOKIE#	DEC	YARRAWONGA AP	DEC	COBRAM GM	DEC
Station ID	82016		82039		n/a		81124		80109	
Jan 2022	65	9	134	10	111	10	76	9	89	10
Feb 2022	0	1	5	2	2	1	1	2	0	1
Mar 2022	42	7	47	7	44	7	46	7	55	7
Apr 2022	100	10	46	7	47	7	44	7	74	9
May 2022	46	5	50	6	38	5	38	5	38	6
June 2022	75	6	60	7	53	6	49	6	41	5
July 2022	46	3	24	2	24	2	12	1	13	1
August 2022	85	7	87	9	58	6	51	6	76	9
Sept 2022	81	8	105	10	90	10	88	10	84	10
Oct 2022	221	HOR	183	10	156	10	152	10	164	10
Nov 2022	81	9	157	HOR	77	9	120	10	99	10
Dec 2022	48	7	36	6	34	6	24	6	40	7
GSR Apr-Oct	654	10	555	9	467	9	434	9	490	10
Year (Jan- Dec)	891	10	934	10	735	9	701	9	773	10
Summer Jan-Mar (2021)	107	5	186	9	157	9	123	7	144	8
	ALBURY AP	DEC	HENTY	DEC	COROWA ^	DEC	LOCKHART RP	DEC	URANA PO	DEC
Station ID	72160		74053		74034				74110	
Jan 2022	306	10	223	HOR	168	10	117	10	137	10
Feb 2022	10	2	41	6	10	2	33	7	10	4
March 2022	69	8	70	9	38	6	53	8	102	10
Apr 2022	33	5	59	8	40	7	49	8	74	9
May 2022	69	7	55	7	46	6	52	8	52	7
June 2022	73	6	58	6	68	7	34	4	31	4
July 2022	38	2	29	2	25	2	26	3	11	1
August 2022	110	9	83	8	77	9	57	7	56	8
Sept 2022	144	10	114	10	113	10	62	9	108	10
Oct 2022	198	10	146	10	172	HOR	151	10	161	10
Nov 2022	192	HOR	144	10	129	10	69	9	128	10
Dec 2022	23	4	30	5	40	6	37	7	50	7
GSR Apr-Oct	665	10	544	10	541	10	431	9	493	10
Year (Jan-Dec)	1265	HOR	1052	10	926	10	740	10	920	10
Summer Jan-Mar (2022)	385	10	334	10	216	10	203	10	249	10

Notes: # Dookie monthly totals averaged from Dookie Land Management Group weather stations
^ Corowa Jan, March, May & August figures taken from Howlong on-farm weather station data
Decile analysis conducted using Rainman Streamflow

Overall, 2022 was the second wettest year on record for New South Wales while Victoria had its fifth wettest year on record. For both New South Wales and Victoria (overall), it was the wettest spring on record since 1900. Annual rainfall deciles for both NSW and Victoria are shown in Figure 1.

a. Victorian rainfall deciles
1 January to 31 December 2022
Australian Gridded Climate Data

b. New South Wales rainfall deciles
1 January to 31 December 2022 Australian Gridded Climate Data

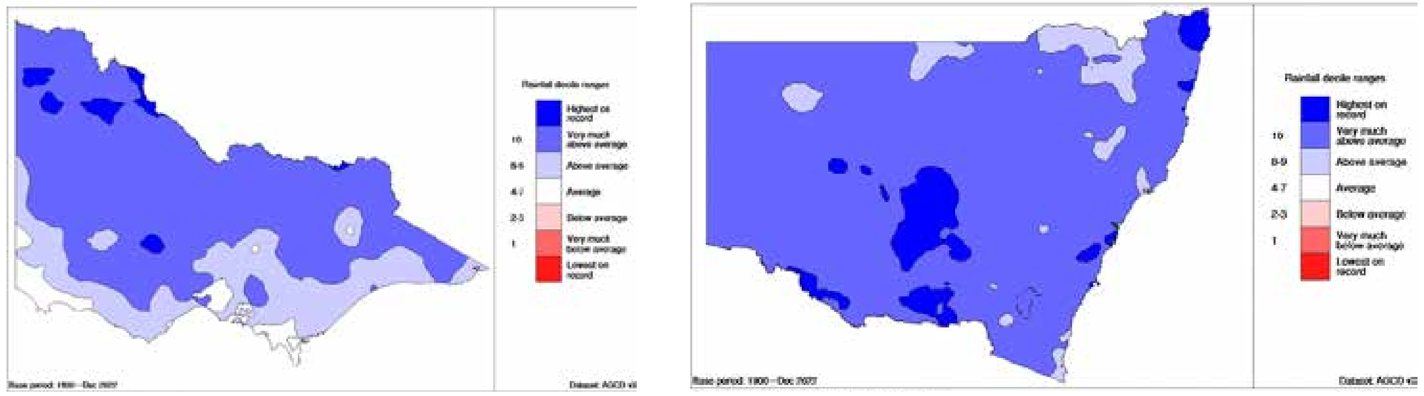


Figure 1a and 1b. Full-year rainfall deciles across Victoria and NSW during 2021 (Source: BoM, 2022)

TEMPERATURE

Australia's national mean temperature was 0.50°C warmer than the 1961–1990 average, making 2022 the equal-22nd-warmest year on record. For New South Wales, it was the coolest year since 1996, however the annual mean temperature was 0.13°C above average. For Victoria, the annual mean temperature was 0.45°C above average. For most of the Riverine Plains, mean temperature deciles for 2022 were average (Figure 3).

a. Mean Temperatures Deciles
1 January to 31 December 2022
Distribution Based on Gridded Data
Australian Gridded Climate Data

b. Mean Temperatures Deciles
1 January to 31 December 2022
Distribution Based on Gridded Data
Australian Gridded Climate Data

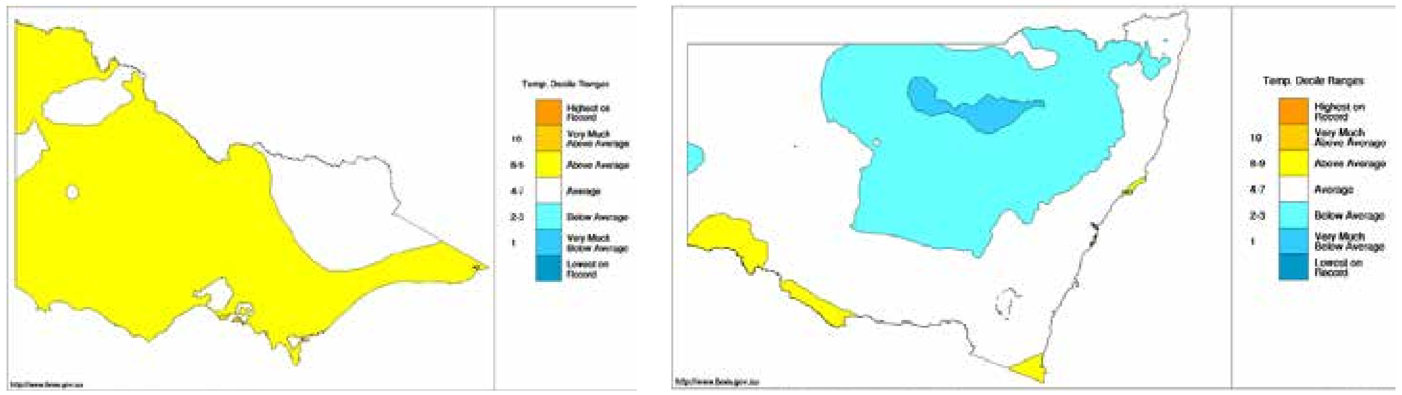


Figure 2 a and b. Mean annual temperature deciles for Victoria and NSW, 2022. (Source BoM, 2022)

The very wet October also saw both lower daytime temperatures and warmer nights due to increased cloud cover, high humidity, and saturated soils.

Figure 3 shows the number of frost days (days with a minimum temperate below 2.2°C) experienced at Rand, Dookie and Yarrawonga during the 2022 winter–spring period. For Rand, frost days were about average for July, lower-than average for August and about average in September. While there may have been some localised frost damage, there was not a widespread damaging frost event in the Riverine Plains during 2022.

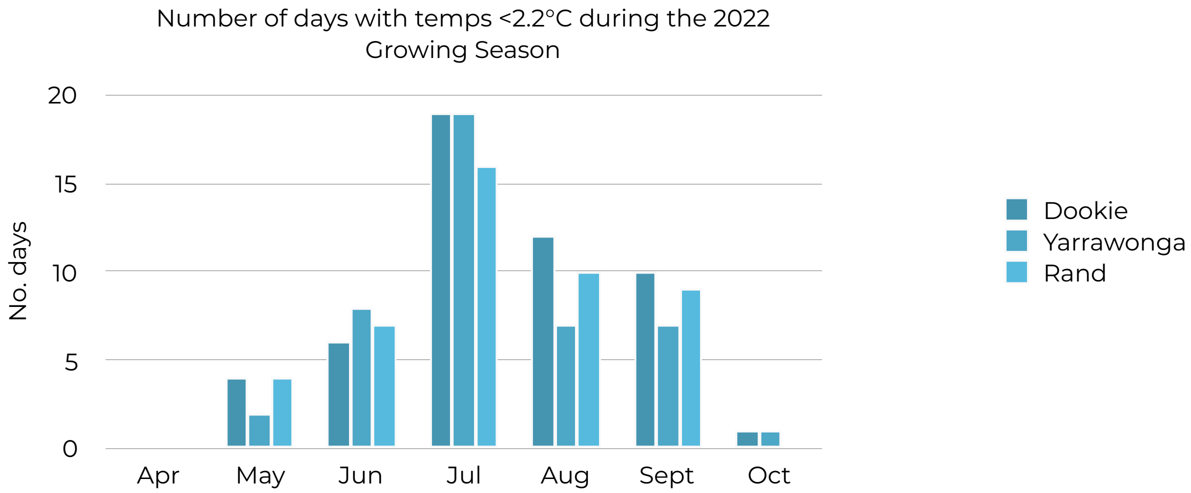


Figure 3. Number of frost days (with temperatures less than 2.2°C) at Dookie and Yarrawonga (Victoria), and Rand (NSW) during the 2022 growing season (April – October). Source: Dookie Land Management Group Soil Moisture and Weather Monitoring Sites, www.riverineplains.org.au and www.bom.gov.au.

SUMMARY

After a promising growing season, an exceptionally wet spring and harvest period was stressful and difficult for many. For those that were able to harvest crops, yield and quality was sometimes not as bad as expected. High input pricing, and lower-than-predicted yields have been partially offset by strong commodity pricing for grains, however livestock pricing is weaker than 12 months ago.

Author: Michelle Pardy, Riverine Plains.

TRIAL RESULTS

COOL SOIL INITIATIVE

BACKGROUND

This program is the first of its kind in Australia, connecting farmers with end users in support of the industry. Through Riverine Plains and Central West Farming Systems (CWFS) in 2018, this project originally aimed to provide connections with farmers that are located within the area of supply to the Mars Petcare, Bathurst and Wodonga factories.

In 2020 the program evolved to become the *Cool Soil Initiative* (CSI), with Kellogg's, Manildra Group, Allied Pinnacle, Mars Petcare, Charles Sturt University and the Food Agility Cooperative Research Centre (CRC) participating partners. As such, this project connects across the supply chain in a unique pre-competitive partnership of corporate investment to provide benefit across the cropping industry.

The reach of farmer engagement also increased, with FarmLink joining the program in 2020, and the Irrigated Research and Extension Committee (IREC) coming on board in 2021 to support irrigated farmers in the Murrumbidgee Irrigation Area (MIA)/ Coleambally Irrigation Area (CIA). The emphasis in dryland systems is still on wheat production, a commodity shared by all partners. While the irrigated systems of the MIA/CIA are focused more on maize and soft wheat production. In 2022, Corson joined the program, expanding the reach further into maize production on the Darling Downs.

Farmer engagement is a key component, with each farming group supporting members and the community to participate in the project, at the same time as advocating to ensure that the project continues to deliver value back to those involved. While each farming group knows which farmers are participating in the project, to maintain their privacy (which is highly important to participants) data is anonymised for any external parties.

Across the CSI project the farmer participation grew from 20 farmers in 2018 to 185 farmers in 2022.

AIM

The *Cool Soil Initiative* aims to increase the long-term sustainability and yield stability of the grain-producing regions of southern New South Wales and northeast Victoria, through the adoption of innovative agronomic strategies and enhancing understanding of greenhouse gas (GHG) emissions to increase soil health and related function.

METHOD

Forty-five growers in the Riverine Plains region participated in the *Cool Soil Initiative* in 2021—22 with an additional 10 participating in the maize part of the program.

All participating growers identified up to five wheat paddocks each season for inclusion in the project, with GPS-located soil tests (0–10 cm) taken for each paddock.

Each soil sample was air-dried and analysed for a range of soil properties, including soil pH (CaCl2), soil organic carbon (SOC), cat-ion exchange capacity (CEC) and nutrients. Soil samples were taken from specific locations in each paddock based on ease of access and the known location of representative soil types.

Anonymised soil test results, farm input data and yields are captured in a simple database and processed through the Cool Farm Tool, which generated predictions of greenhouse gas emissions for each paddock.

The wet season of 2022 made soil sampling quite difficult. As a result not all sampling results were available at the time of publishing. The combination of a delayed, wet harvest and a rebuild of the data entry system has meant that data collection from the 2022 season will not be completed until after sowing, 2023.

HOW ARE EMISSIONS CALCULATED?

There are two ways to consider GHG emissions on-farm. The first is to consider the whole farming system, which is highly complex, and considers the emissions footprint required to grow crops, cut hay, grow livestock, feed grain to livestock, tree plantings etc. At present there are no straightforward tools available for farmers to generate this information, so this is still a future focus.

The second way is to consider the energy/ emissions footprint required to grow each commodity, which considers the energy and related emissions connected to each input. This method is used for any supply chain reporting, whereby farmers can demonstrate that the commodity is produced with a low emissions footprint. This is the approach taken in the *Cool Soil Initiative*, with farmers provided with the emissions footprint for their grain grown on a per tonne, and per hectare basis. This approach is internationally recognised, with standardised methods.

The emissions footprint of grain (or any commodity) is reported on a CO2e basis (carbon dioxide equivalents), which is based on the GHG emissions related to the manufacture and use of all crop inputs (fertiliser, crop protection, weed control), energy/diesel usage and soil disturbance. Nitrogen usage is of particular interest, as:

(i) the manufacture process for urea is highly energy intensive (with high GHG emissions)

(ii) the addition of urea results in N2O and CO2 losses from the soil

(iii) urea is generally the single largest input.

All of which means that urea application is a significant driver of emissions.

So, while accurate on-farm emission reporting for Australia is a moving target, the *Cool Soil Initiative* is contributing to refinement of the methods and calculations, to improve the relevance and accuracy of internationally relevant emission calculations for the Australian systems. As new learnings are generated over the coming years, all on-farm emission calculations will be re-run, to ensure farmers have access to the most accurate figures available.

RESULTS

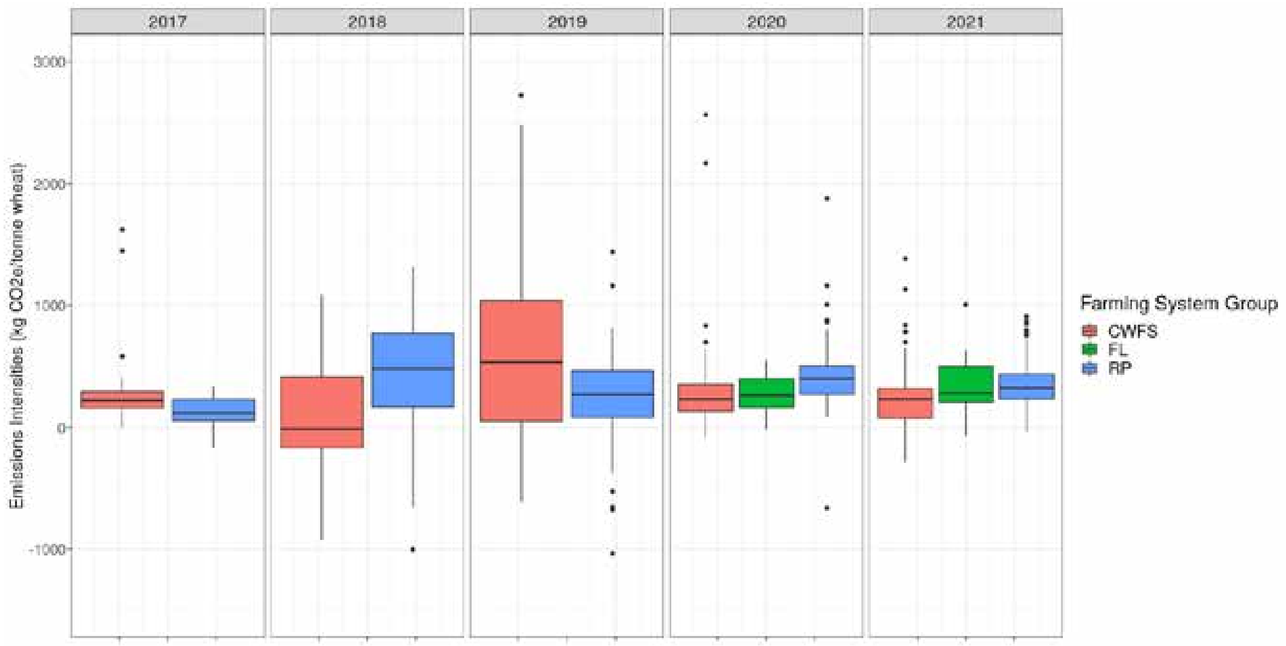


Figure 1. GHG emissions per tonne (CO2e/t) for wheat grown the Riverine Plains, FarmLink and Central West Regions.

Figure 1 displays the emission intensities per tonne of wheat grown, while Figure 2 shows GHG emissions per hectare. The data is represented as box plots, the centre line in each box showing the median, the box showing 50% of the values, and the lines and dots showing the degree of variance. If a value is below 0, the emissions associated with the production of that crop are less than the offsets.

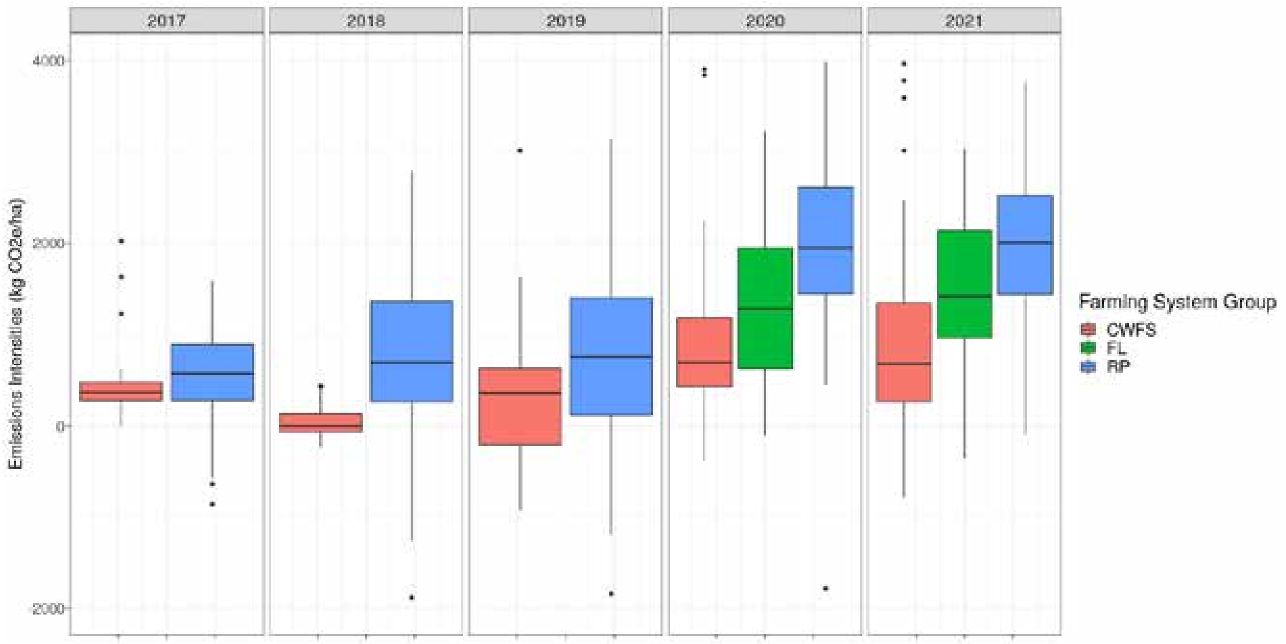


Figure 2. GHG emissions per hectare (CO2e/ha) for wheat grown the Riverine Plains, FarmLink and Central West Regions.

SOIL CARBON VALUES

Soil carbon values are an important parameter in the emissions calculation, providing significant offsets. However, more importantly, they are a crucial consideration in understanding the resilience of the farming system, as higher carbon values mean higher amounts of soil organic matter, which means greater nutrient cycling, greater water-holding capacity, and greater diversity of microbes.

The range of soil carbon values measured in this program far exceeded expectations. As these values are GPS-referenced, they represent measurements at a single point in the paddock, rather than averaged samples taken from across the paddock. This also means they can be tracked over time.

As shown in Figure 3, the soil carbon values vary significantly both within, and between regions. As each value on the graph represents a paddock in the program, the crop-data relating to each value can be used to understand if there are any similarities between points. This data has been assessed to specifically understand if there are simple similarities between the points at the high end of each curve.

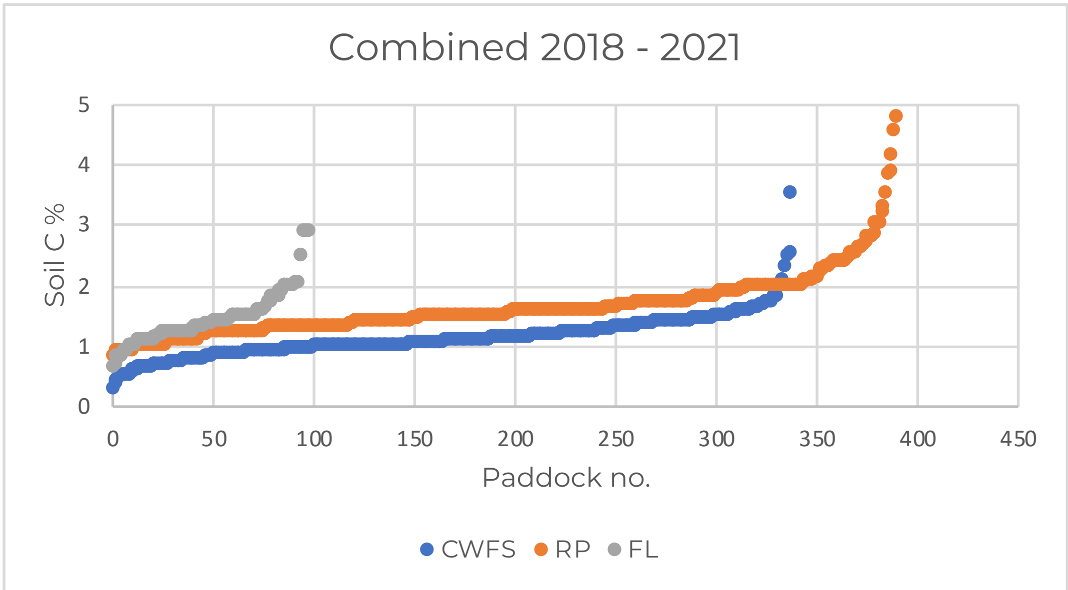


Figure 3. Soil organic carbon (SOC) (%) values (0-10cm depth) from 827 paddocks across three regions, sampled from 2018 – 2021. Median values for each region are: Riverine Plains SOC = 1.51%, FarmLink SOC = 1.36%, Central West Farming Systems (CWFS) SOC = 1.07%.

While the ongoing economic component of the program will continue to pull out more detailed relationships, the key similarities that came out from each region are listed below:

Riverine Plains: 35 paddocks had SOC > 2%. Of these, 26 had a history of a pulse or pasture phase. All yielded well in 2021, unless they experienced waterlogging.

FarmLink: 12 paddocks had SOC > 2%. Of these, nine had a history of lucerne, clover-based pasture or pulses. Only one paddock had a pH value < 4.8.

CWFS: 20 paddocks had SOC > 1.5%. Of these, 15 had a history of lucerne or clover-based pasture, only 1 with pH <4.8 and good yields in 2021 (unless flooded).

The role of legumes in the system were also well highlighted. When farmers grew a legume in 2019 in both CWFS and Riverine Plains, the wheat yield in 2020 was consistently high, with a tighter range of yields, compared to a broad spread of yields when they did not. This trend was not clear in 2021, likely due to yield penalties due to the wet harvest, and less legumes grown in 2020 due to likely emphasis on crops with strong commodity pricing, to recoup the poor returns of the drought years.

The common themes from this very basic assessment, is that there is a strong connection between the background soil fertility, SOC values and yields. This is a key area of interest for the program, which we will continue to explore further.

CONCLUSION

The *Cool Soil Initiative* is a pre-competitive, collaborative approach to understand the key drivers of on-farm emissions, while supporting the food industry partners to learn more about the farming systems that produce their grain. Farmer engagement and feedback is pivotal to the success of this program, with farming system groups providing strong support and advocacy for participating farmers. This means the *Cool Soil Initiative* is continuing to learn and grow, which improves the on-ground benefit of the program to support farmers in the sustainable production of food from productive, profitable farming systems.

ACKNOWLEDGEMENTS

Riverine Plains acknowledges the investment for this year's results by Mars Petcare, Kellogg's, The Manildra Group, Corson, Allied Pinnacle, Charles Sturt University and Food Agility CRC, as well as the project support from the Sustainable Food Lab (SFL). Thankyou also to all our farmer co-operators, whose support for this project is greatly appreciated.

Authors: Dr Cassandra Schefe, Agrisci Pty Ltd; Jane McInnes, Riverine Plains.

OPPORTUNITIES TO CLOSE THE YIELD GAP IN FABA BEAN WITH IMPROVED DISEASE MANAGEMENT, NUTRITION AND CANOPY MANIPULATION

KEY POINTS

- **Foliar diseases were a massive driver of faba bean (cv. PBA Samira) yield in 2022, so much so that trial treatments were not enough to control disease.**
- **Additions of urea or trace elements did not increase faba bean yields.**
- **Strategies used to manipulate the faba bean canopy provided no yield increase and in one instance saw a yield decrease.**

AIM

A Grains Research and Development Corporation (GRDC) investment across eastern Australia aims to increase pulse adoption and close the economic gap in grain legume production through identifying the best varieties and combining them with the best fungicide, nutrition and inoculation, and canopy management practices. The NSW component is led by Brill Ag, the Victorian component by Agriculture Victoria, and the South Australian component is led by South Australian Research and Development Institute (SARDI). Other regional partners are contributing to the investment, including FAR Australia who managed a pulse 'spoke' site at Buraja/Coreen, Bundalong, and Gnarwarre in the high rainfall zone (HRZ) in 2021. As part of the GRDC Southern grain legumes project we are targeting 6-8t/ha dryland yields in faba beans in northeast Victoria and southwest Victoria, and 4-6t/ha at Buraja in New South Wales.

METHOD

A research trial site was established at Bundalong in northeast Victoria (Table 1). The site contained three faba bean trials looking at various aspects of faba bean agronomy, these include disease management, canopy management and nutrition.

Table 1. Bundalong pulse research site details.

SOWING DATE	26 APR
Cultivar	PBA Samira
Sowing Rate	140kg/ha (22 plants/m2 established)
Inoculant	Peat slurry + 3kg/ha Granular (Group F)
Fertiliser	60kg/ha Monoammonium phosphate (MAP)
	5t/ha manure
Harvest Date	23 Dec

Trial 1 on site was the faba bean disease management trial which consisted of six treatments with different fungicide timings and products (Table 2). Due to the large canopy produced by the faba beans, access to plots to apply late fungicides by hand was restricted and is the reason for no applications post early September.

Table 2. Treatment details for trial 1.

TRT	DESCRIPTION	4 NODES	1ST FLOWERS OPEN ON MAIN STEM	1ST FLOWER (GS 203) + 14 - 21 DAYS
1	Untreated control	-	-	-
2	1 fungicide	-	-	Chlorothalonil Carbendazim
3	2 fungicide	-	Mancozeb + Procymidone	Chlorothalonil Carbendazim
4	3 fungicide	Tebuconazole	Mancozeb + Procymidone	Chlorothalonil Carbendazim
5	1 fungicide (Flexible)	-	-	Miravis Star
6	3 fungicides (Inc. SDHI)	Tebuconazole	Mancozeb + Procymidone	Miravis Star
Date Applied		**17-Jun**	**2-Aug**	**5-Sep**

Rates of fungicide applied; Tebuconazole @145ml/ha, Mancozeb @2kg/ha, Procymidone @240g/ha, Chlorothalonil @2.3L/ha, Carbendazim @500ml/ha, Miravis Star @750ml/ha.

Trial 2 on the site was the faba bean nutrition trial (Table 3). In this trial we looked at ways to increase faba bean yield by adding different levels of nitrogen (as urea) in combination with or without trace elements to the crop during the vegetative growth period.

Table 3. Treatment description for trial 2

TRT	DESCRIPTION
1	Untreated control
2	50kg N/ha
3	50kg N/ha + trace elements#
4	Trace elements#
5	100kg N/ha + trace elements#
6	100kg N/ha
Date Applied	**17 Jun**

Trace elements = smart trace triple @2.5L/ha + Boly @2L/ha

Trial 3 on site was the canopy management trial (table 4). In this trial we looked at some experimental ways in which we can manage large faba bean canopies to increase yield and/or harvestability.

Table 4. Treatment details for trial 3

TRT	DESCRIPTION	DATE APPLIED
1	Untreated control	
2	PGR* (vegetative)	17 Jun
3	PGR* (flowering)	2 Aug
4	Mechanical defoliation# (vegetative)	17 Jun
5	Mechanical defoliation# (flowering)	2 Aug
6	Mechanical defoliation# (flowering + 14 days)	22 Aug
7	Chemical defoliation^ (flowering)	2 Aug
8	Chem defoliation^ (first flowers + 14 days)	22 Aug

* Experimental plant growth regulator. Product not registered for use.
# Mechanical defoliation was removing canopy biomass just above ground level with a lawn mower, except at flowering +14 days which was done with a whipper snipper just below flower height.
^ Experimental approach to remove canopy biomass with the use of a contact herbicide.

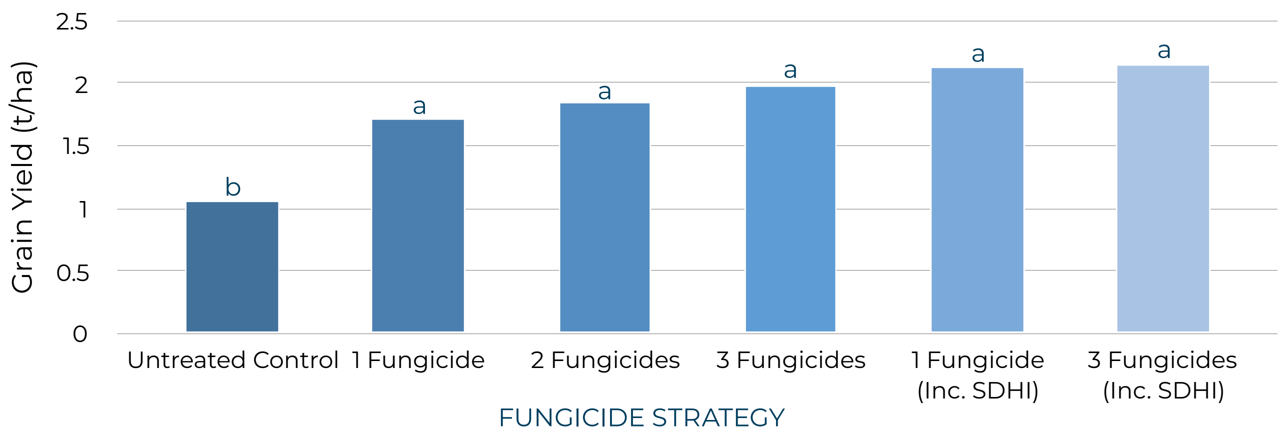


Figure 1. Influence of fungicide strategy on faba bean grain yield (t/ha) at Bundalong Vic. P=0.001, LSD at P=0.05 0.45t/ha

RESULTS AND DISCUSSION

The application of fungicides to PBA Samira during the flowering period significantly increased yield compared to the untreated control (Figure 1).

Even with three fungicides, the yield of all treatments was limited by disease, this is evident in Figure 2 where all treatments were shown to still have significant levels of chocolate spot infection throughout the canopy. With a high disease pressure like 2022, more frequent fungicide applications were required to maximise grain yield. Current fungicides have very limited curative action and are relying on preventive action to keep the canopy clean, this means the fungicide needs to be applied before the disease can develop symptoms. Our fungicides were mostly a month apart and there was significant canopy growth in those periods which were unprotected by fungicide resulting in yield losses.

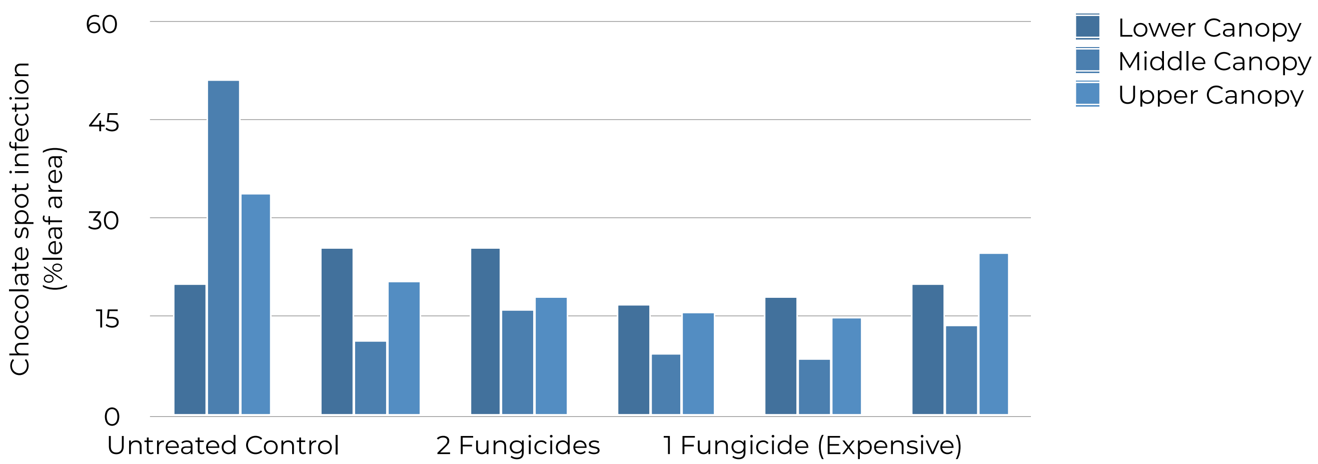


Figure 2. Infection levels of chocolate spot at different canopy sections at Bundalong Vic. Assessed 30 September 2022.

We also have a pulse site for a similar project at Coreen. While it was subject to flooding and was not machine harvested, we were still able to extract information from it. Cultivar choice can make large differences to the fungicide strategy required. Figure 3 shows different levels of chocolate spot infection of untreated canopies of PBA Bendoc (rated S), PBA Samira (rated MS) and PBA Amberley (rated MRMS). The more susceptible cultivar PBA Bendoc had higher levels of chocolate spot in all canopy levels compared to the other two cultivars highlighting the importance of genetic resistance.

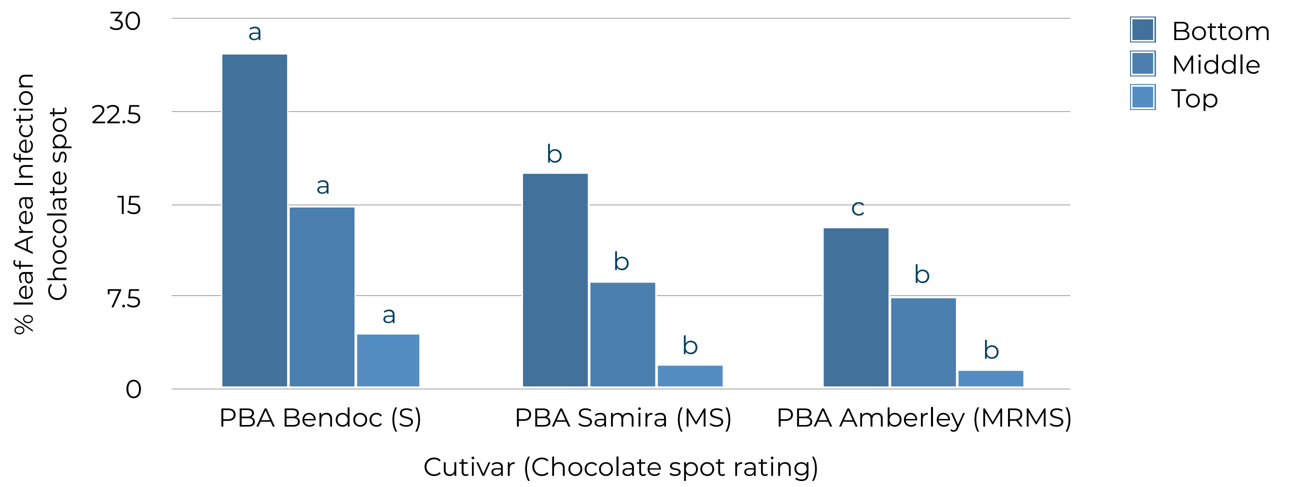


Figure 3. Chocolate spot infection (% leaf area infected) at Coreen, NSW 2022 of three different cultivars. Different canopy levels (top, middle and bottom of canopy) assessed 29 September 2022. Bottom pval= <0.001, LSD= 3%. Middle pval= <0.001, LSD= 3%. Top pval= <0.001, LSD=0.5%

The addition of nitrogen and/or trace elements did not significantly increase grain yield of faba beans, and in some cases caused a yield reduction although not significant (Table 5). Previous work in New South Wales has shown that correctly inoculating pulses is far more important than worrying about applying trace elements (Figure 4). The work completed in 2021 at Coreen also shows that the application of high rates of nitrogen (100kg N/ha) to faba beans reduced nodulation.

Table 5. Influence of in-crop nutrition of grain yield of faba beans (t/ha).

TREATMENT		GRAIN YIELD (T/HA)
1	Untreated control	4.31 -
2	50kg N/ha	4.22 -
3	50kg N/ha + TE	3.39 -
4	Trace elements	3.65 -
5	100kg N/ha + TE	3.83 -
6	100kg N/ha	3.65 -
Grand mean		**3.84**
Treatment prob(F)		0.469
LSD P=.05		ns

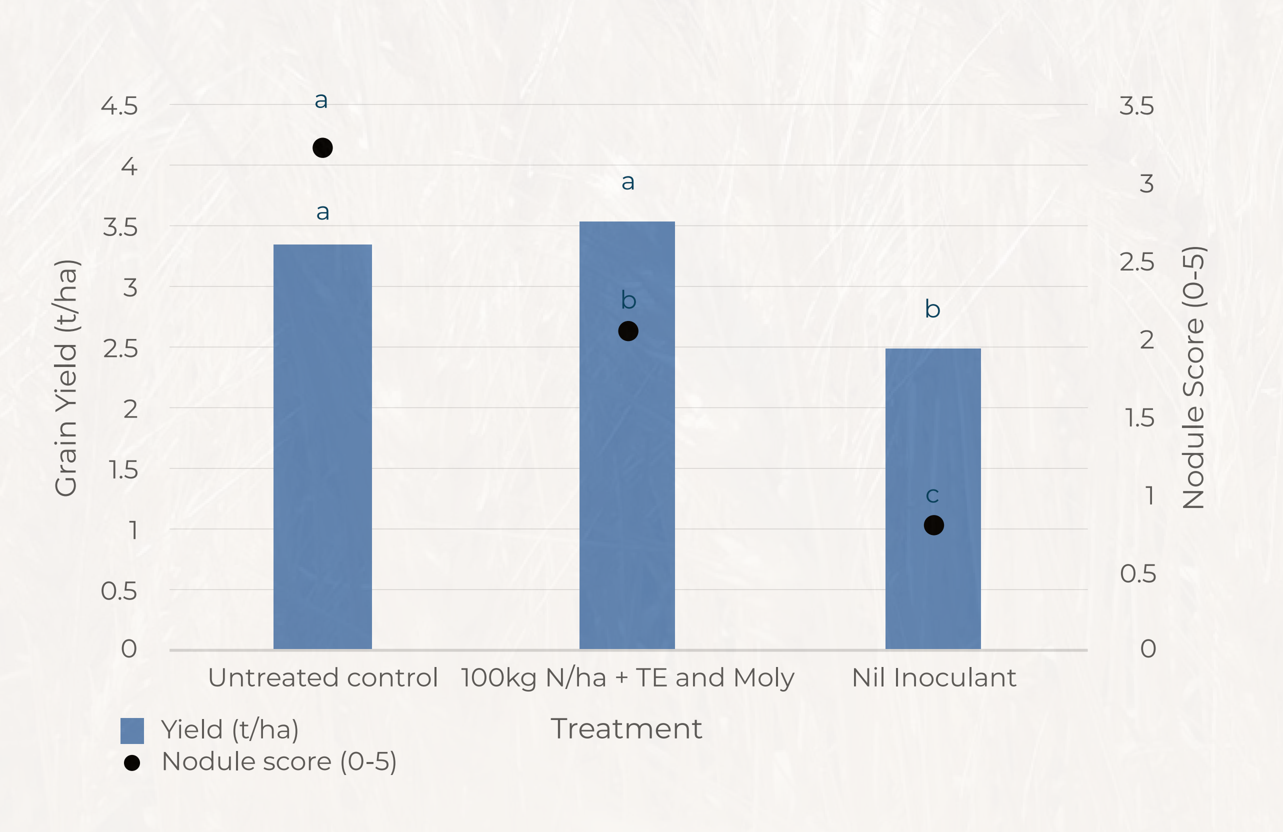


Figure 4 Results from 2021 NSW Pulse project showing the influence of inoculant and nitrogen application on grain yield (t/ha) and nodule score. Grain yield P val= <0.001, LSD=0.43t/ha. Nodule score p val= <0.001 LSD=0.7.

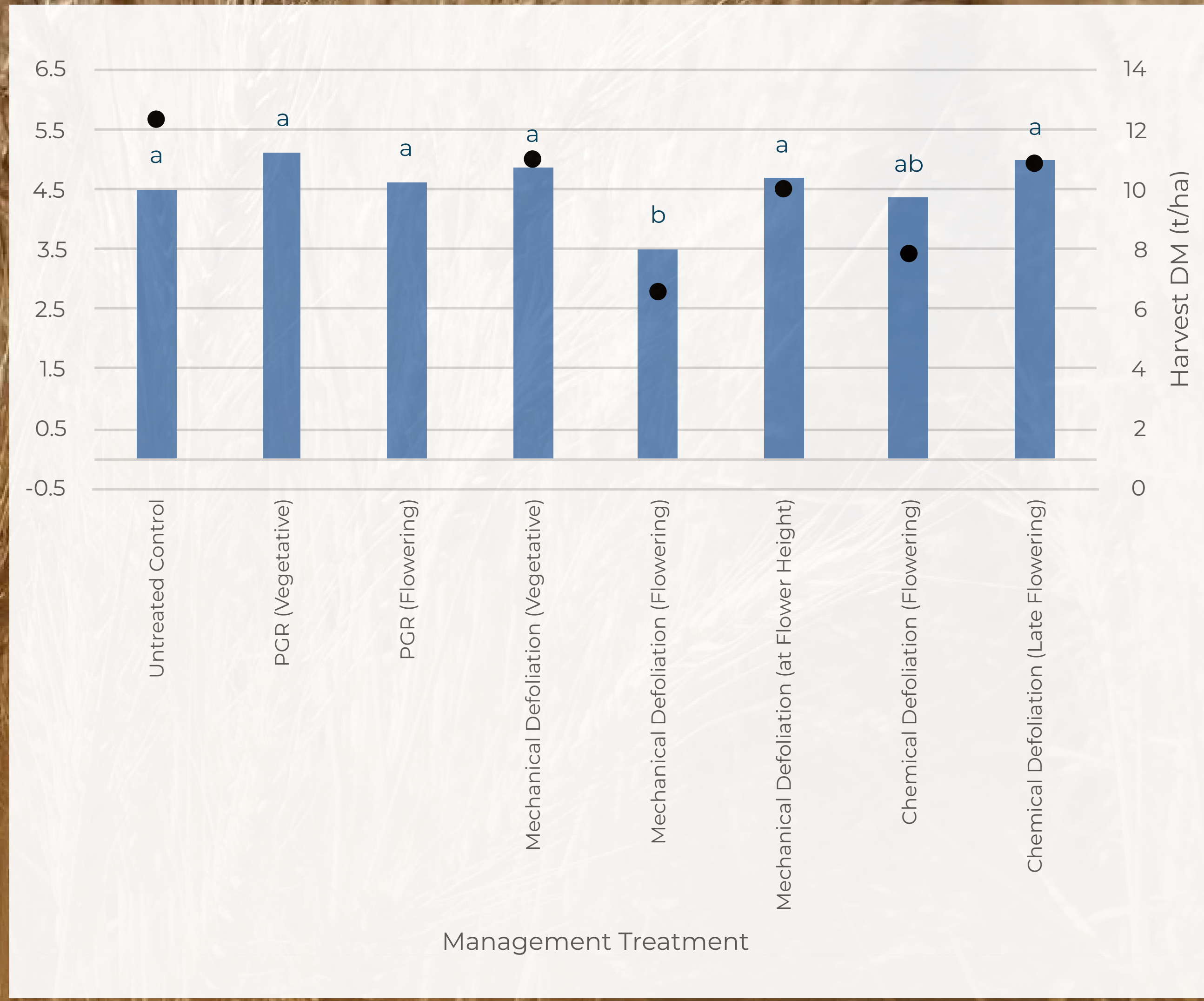


Figure 5 Influence of canopy management strategy on grain yield (t/ha) and canopy biomass at harvest. Bundalong VIC 2022. Grain yield p val =0.034, LSD= 0.9t/ha. Biomass p val = 0.130, LSD=ns.

In 2021 and 2022 we experienced large faba bean canopies growing above head height (if standing) with significant lodging. Experimental methods to manipulate the canopy to keep it upright or to make it smaller without compromising on grain yield were tested.

Most methods of canopy management did not have a statistical impact on yield given the long, wet season of 2022 (Figure 5). The indeterminant growth habit of faba beans allowed them to make full use of the soil moisture available and the cool finish to the season to re-grow significant amounts of biomass and yield. Removing most of the biomass during the vegetative period or by cutting it high during flowering resulted in minor yield increase (not statistical). Similarly, the use of Plant Growth Regulators and chemical defoliants did not impact yield. The only approach that reduced grain yield was through completely removing canopy biomass at flowering, even though it did grow back a reasonable canopy to still yield 3.5t/ha.

ACKNOWLEDGEMENTS

FAR Australia gratefully acknowledges the investment support of the GRDC in order to generate this research, project partners and the host farmers Adam Inchbold at Bundalong, Dennis Tomlinson at Coreen.

Author: Tom Price, FAR Australia; Ben Morris, FAR Australia.

FACILITATED ACTION LEARNING GROUPS TO SUPPORT PROFITABLE IRRIGATED FARMING

KEY POINTS

- **High rainfall (decile 10) significantly impacted on yield and disease of faba beans.**
- **Due to the season, faba beans were largely unprofitable, even though there is evidence in dry years they can be profitable.**
- **Dry matter measurements indicate that the nitrogen fixed could save up to $413/ha the following year in nitrogen costs (based on January 2023 pricing).**

BACKGROUND

A local Grains Research and Development Corporation (GRDC) and Field Applied Research (FAR) Australia research trial has shown that higher planting densities in irrigated faba beans are correlated to higher yields. Faba beans are not regularly grown in local irrigation systems, so in 2022, a demonstration was sown to test and discuss the results with the Riverine Plains Irrigation Discussion Group.

AIM

To demonstrate that higher seeding rates in irrigated beans provides higher yields and to compare the economics of irrigated beans to irrigated canola and wheat.

METHOD

The site was soil tested on the 17 May 2022 to provide background information for the site (Table 1). Treatments were decided in consultation with FAR Australia and the host farmer, to test two varieties and a range of plant populations (Table 2). Treatments were two seeder widths wide (24m) and 1000m long. Yields were measured by the host farmer's yield monitor.

A gross margin analysis was completed at the end of the season to compare the profitability of irrigated winter crops in the region. The analysis used actual grain prices, irrigated yields, irrigation water (Table 3) and the following input prices: MAP $1,300/t, Urea $1,500/t.

Table 1. Site description

IRRIGATION TYPE	CENTRE PIVOT
Rainfall (mm): Jan – March **Rainfall (mm): April – October**	258 498
Sowing date	22 April 2022
Row spacing	165mm
Soil type	Clay loam
pH CaCl2 (0-10cm)	5.9
Soil Mineral N kgN/ha (0-30cm) **Soil Mineral N kgN/ha (30-60cm)** **Total Mineral N kgN/ha (0-60cm)**	101.6 22.1 123.7
Phosphorus (Colwell)	39
Potassium (Colwell)	240
Sulfphur (KCl40)	10

RESULTS

Dry matter samples were taken from three treatments at mid-pod fill on the 17 October 2022. At this stage, the plants were badly lodged, and chocolate spot disease was causing loss of green leaf. Visual inspection indicated that the conditions had greatly reduced the number of pods on the faba beans.

The highest yielding treatment was four, the Paddock Amberley site (26 plants/m2), which yielded 0.98t/ha. The second highest yielding treatment was one, Bendoc (25 plants/m2) and the lowest yielding treatment was two, Bendoc (29 plants/m2). Refer to Table 2.

Due to the waterlogging and diseased conditions, the case study paddock of faba beans yielded approximately 1t/ha, dramatically reducing the gross margin to a loss of $349/ha. As these results were not representative of all faba bean crops in the region, farmers were interested in the economics of faba beans in a situation where they were less waterlogged. As such, in consultation with farmers, the economic analysis was based on actual prices, yields achieved in the region on irrigated paddocks (no irrigation water was applied in 2022) refer Table 3. The yields achieved were about 25% below the target set at the beginning of the year, due to the waterlogged conditions. The analysis showed that faba beans were significantly less profitable in 2022 compared to canola, due to lower yields and poorer prices (Table 3).

Table 2. Treatments

TREATMENT	SEEDING RATE KG/HA*	ACTUAL PLANT POPULATION PLANTS/M2	DRY MATTER AT MID-POD FILL TONNES/HA	GRAIN YIELD TONNES/HA	ESTIMATED NITROGEN FIXATION KG N/HA **
Control: Bendoc 22 plants/m2	150	21	11.9	0.68	190.4
1: Bendoc 25 plants/m2	170	25	#	0.71	#
2: Bendoc 29 plants/m2	200	29	8.4	0.26	134.4
3: Amberley 25 plants/m2	235	40	10.8	0.64	172.8
4: Paddock Amberley	170	26	#	0.98	#

*Seeding rates were calculated based on Bendoc 300 grain weight 148g, Amberley 300 grain weight 215g.
#These plots were not measured.
**Based on 16kgN/t of above ground DM (Glover et al, 2013).

Table 3. Economic parameters

CROP TYPE	ACTUAL PRICE $/T	ACTUAL YIELD (IN THE REGION) T/HA	IRRIGATION WATER APPLIED MM/HA	GROSS MARGIN $/HA
Wheat	$350	5.2	0	$800
Canola	$700	2.8	0	$976
Faba beans	$300	3.0	0	$458

OBSERVATIONS AND COMMENTS

The purpose of the demonstration was to show that higher planting densities for irrigated faba beans produce higher yields. However, the demonstration was affected by excessive rainfall, water logging and disease, which meant that the crop could not reach its potential.

In the 2022 scenario of high disease pressure, the highest seeding rates had the most disease pressure, and were lower yielding. The narrow row spacing of the paddock also provided conditions that favoured the spread of disease, as the large crop and narrow row spacing did not allow much airflow through the canopy. The Amberley variety did appear to perform better than Bendoc, which may be due to its higher disease resistance. However, Amberley is a long season variety compared to Bendoc and not really suited to the Riverine Plains region, particularly when the region experiences a hot, dry spring.

If yields of 5.5t/ha plus can be achieved in irrigated faba beans, the returns are similar to irrigated wheat, however lower than canola. Historically, high gross margins of irrigated faba beans have been demonstrated over several years in the irrigated cropping trials at Kerang (Pers.comm D Jones, 2022) however there is very low adoption by growers. The results of this demonstration have shown that disease can be devastating in faba beans for both yield and gross margin, which explains the reluctance of growers to adopt them in irrigated cropping systems. If the faba beans can fix 190kgN/ha, this is equivalent to 413kg urea per hectare. Based on urea prices as of January 2023 of $1,000/t this represents a financial benefit in the following years of $413/ha. If this benefit can be realised, by the following crops, it may provide farmers with more incentive to grow beans.

A lower risk option of incorporating a nitrogen fixing legume is to sow a high-density legume pasture option. This option has more flexibility as it can be made into hay or grazed by livestock. The ability to terminate the pasture early, by making hay or brown manuring, also makes it an effective option to then double crop with maize in an irrigated cropping system.

ACKNOWLEDGEMENTS

The Optimising Irrigated Grains project is part of the GRDC investment in ICF1906-002RTX, FAR1906-003RTX and UOT1906-002RTX, which is led by the Irrigated Cropping Council. Riverine Plains would like to thank the Trevethan family who hosted this trial and provided the economic analysis. Riverine Plains would also like to thank Seednet for supplying some of the Amberley seed for the trial.

Author: Kate Coffey, Riverine Plains

FODDER FOR THE FUTURE

Riverine Plains Youarang demonstration site

KEY POINTS

- **Vetch grown as a 'companion crop' with a small amount of oats increases the harvestability of the fodder, while decreasing the quality of the fodder for dairy cows.**
- **If growing a cereal with legume, match the time of maturity of the cereal with the legume.**
- **Be proactive with using fungicides rather than reactive.**
- **Balance quantity and quality of fodder, the Benetas variety had a greater biomass to the detriment of quality.**

BACKGROUND

Fodder for the future is designed to assist agricultural communities adapt to a water-limited future. The use of fodder in dairying systems has become an increasingly important component of dairying across the southern Murray Darling Basin (MDB) for both dairy businesses and fodder and grain producers. This project is highlighting the value of 'closed loop' fodder production systems, which involves the transfer of high-quality fodder between businesses within the Southern MDB, whilst retaining the value of production locally. The project will also aim to increase the knowledge and skills of dairy farmers who are increasingly growing fodder to support their overall feedbase systems.

This project aims to be a cross-sectoral collaboration designed to support the development of complementary farming systems that optimise the use of both irrigated and dryland forages across the southern MDB by:

1. Increasing the quality and yield of fodder produced on both dairy, hay and grain farms.
2. Brokering long-term relationships between dairy and hay producers to increase risk management options, diversification of income and resilience in business management.

Riverine Plains together with Birchip Cropping Group, Irrigated Cropping Council, University of Melbourne, Southern Growers and Agriculture Victoria are working with Murray Dairy to deliver the project by:

1. Establishing six demonstration sites which will provide farmers and service providers with an opportunity to look at economic and biophysical performance of different cereals and under a range of climatic and market conditions in Murray region. This includes wheat, barley, oats, triticale, vetch, sorghum and maize, comparing the suitability of varieties within each species for fodder production.
2. Working directly with 400 – 500 farmers and service providers to deliver a range of communication and engagement activities, extension resources, workshops and other activities centred around the demonstration sites across the region, with further dissemination of learnings into the broader community and wider southern MDB.

AIM

To demonstrate the harvestability and quality of silage and or hay on a crop of vetch with and without a standing crop.

DEMONSTRATION DETAILS

A 60ha paddock, in Youarang Victoria was used as the demonstration site for 2022. The site was sown on 24 May 2022. There were two varieties of vetch – Morava and Benetas. The vetch was sown individually as well as with a small amount of oats (var, Mitika). The sowing rates and varieties can be seen in Table 1, while the demonstration set up can be seen in Figure 1.

During the season the following fungicides were applied:

28 July 2022 – 400mL/ha Veritas Opti

21 September 2022 – 400mL/ha Veritas Optii

RESULTS

Soil Samples

Prior to sowing, a soil sample with full chemical analysis was taken in two places in the demonstration site. There were also two samples taken in 5cm increments from 0-20cm depth.

Results are displayed in Tables 2 and 3.

Figure 1. Layout of plots at Youarang demonstration site.

Table 1. Species and variety with target sowing rates for Youarang demonstration site

SPECIES	VARIETY	SOWING RATE (KG/HA)
Vetch	Morava	42
Oats/ Vetch	Mitika/Morava	8/42
Vetch	Benetas	35
Oats/Vetch	Mitika/Benetas	8/35

Table 2. pH results of soil at Yourang demonstration site sampled at 5cm increments

	SAMPLE 1	SAMPLE 2
Depth	**pH (CaCl2)**	**pH (CaCl2)**
0 – 5 cm	4.7	NA
5 – 10 cm	4.7	5.7
10 – 15 cm	4.7	5
15 – 20 cm	4.8	5.7

Table 3. Chemical analysis of soil from Youarang demonstration site

SAMPLE NAME	pH (1:5 CaCL2)	ELEC. COND. (SAT. EXT.) (dS/M)	NITRATE NITROGEN (MG/KG)	PHOSPHORUS (COLWELL) (MG/KG)	PHOSPHORUS BUFFER INDEX (PBI-COL)	ORGANIC CARBON (W&B) (%)	SOIL COLOUR	SOIL TEXTURE
Fodder for the Future Project – 1	4.6	0.2	9.6	48	74	0.8	Brown	Clay
Fodder for the Future Project – 2	5.1	0.5	13	49	36	0.7	Brown	Clay Loam

Figure 2. Plots with Morava vetch (front and left) were sprayed out and brown manured due to wet conditions. Benetas vetch (green in image) was taken to grain.

YIELD

Due to the wet seasonal conditions, the demonstration sites were too wet to cut for hay or silage. As a result the variety Morava was sprayed out and brown manured. The variety Benetas was taken to grain harvest.

Before the demonstration was sprayed out and brown manured, it was estimated that the Morava would have yielded 7.5t/ha while the Benetas was greater at 8.5t/ha. The grain yield of the vetch averaged 0.8t/ha.

There was a visual difference in the vetch stature between the vetch-only and the vetch with oats, as well as between vetch varieties. The oats kept the vetch off the ground and gave the plant greater opportunity to dry out. The vetch-only created a wet mat on the ground floor giving disease an opportunity to take over. The thick layers of vetch were more pronounced in the Morava (plots 1 and 2) due to Benetas having a tougher, thicker stem and standing taller. Part of the reason for not harvesting the Morava was that it formed a wet mass that would be difficult to pick up off the ground cleanly. When cuts were taken for sampling, the vetch measured 155cm for Morava and 180cm for the Benetas.

NUTRITION

Biomass samples were sent to FeedTest for analysis and showed that the samples from each plot had generally good quality. Results can be seen in Table 5.

Table 5. Feed analysis taken when vetch was at BBCH (Biologishe Bundesanstalt, Bundessortenamt und Chemical Industry) growth stage 61-63. A full copy of the results can be found in Appendix A. Results on a % Dry Matter (%DM) basis.

PLOT	VARIETY	SAMPLE TAKEN	% CRUDE PROTEIN	SOLUBLE % CRUDE PROTEIN	ACID DETERGENT FIBRE	NEUTRAL DETERGENT FIBRE	NEUTRAL DETERGENT FIBRE DIGESTIBILITY@ 30HRS
Plot 1	Vetch (Morava)	29/09/2023	25.0	45.9	27.6	37.6	71.4
Plot 2	Vetch (Morava)/ Oat (Mitika)	29/09/2023	19.4	40.7	28.6	39.8	56.1
Plot 3	Vetch (Benetas)/ Oat (Mitika)	20/10/2023	17.9	52.2	38.2	48.7	43.3
Plot 4	Vetch (Benetas)	20/10/2023	24.6	53.6	36.6	41.9	51.1

OBSERVATIONS AND DISCUSSION

Growth during the season looked promising, however with steady rainfall it became one of the wettest springs on record. Opportunities to dry out the forage once it was cut, were minimal. Towards the end of the season a decision between making very poor-quality hay or silage or utilising the legume and incorporating the nutrients into the soil for the nitrogen boost in the next season, needed to be made. As a result, Morava was brown manured with the decision to take the Benetas to seed being based on lack of supply of the seed. The farmer was also being optimistic to harvest enough for stores for next season.

The harvestability of vetch-only, especially in a wet year like 2022 is challenging. The vetch mulching just above ground level created a 'wet mass'. The vetch grown with a small amount of cereal stood much taller and would allow for cleaner cutting. Morava vetch was much shorter in stature than the Benetas. The Benetas companion cropped with a cereal created an even larger amount of biomass.

The site was very well managed with a proactive response to disease rather than a reactive one, despite the wet conditions creating an increased risk of disease. Two applications of fungicide were used during the season, which managed to keep the diseases at bay. A late application of fungicide on 21 September saved the vetch from disease.

When taking samples, it was noted that the oat variety (Mitika) selected matured earlier than the vetch. The Morava vetch matured around three weeks earlier than the Benetas. An oat variety to the match the timing of the vetch variety would be ideal to increase the quality of fodder.

Dairy farmers look for a combination of nutritional characteristics such as Metabolic Energy (ME), Crude Protein (CP%) and Neutral Detergent Fiber (NDF) when assessing fodder options. Feed was tested for NDF which indicated that the Benetas variety had higher biomass, and high stem to leaf ratio. The combination of all nutritional values indicate that Plot 3 is marginal for milking quality feed and Plot 4 results, just acceptable for milking quality. Plot 1 met nutritional value requirements, and Plot 3 was ideal for harvestability.

It was clear from the trial that farmers need to have a clear quality objective in mind when growing fodder. If harvested, both varieties in the trial would have produced over 7.5 t/ha of biomass, however due to the Benetas quality in this demonstration, it was sacrificed for biomass.

Australian Government
Murray DAIRY
Dairy Australia

ENHANCING COMMUNITY NETWORKS

BACKGROUND

The *Enhancing Community Networks for Drought Resilience* used a series of workshops to help people in the region better prepare for future droughts. Its aim was to assist communities in the Riverine Plains region to build capacity, share knowledge and help improve resilience to future droughts. This project was supported by FRRR, through funding from the Australian Government's Future Drought Fund.

The workshops resulted in the following drought preparation strategies.

LIVESTOCK

- improve stock water by updating water systems to every paddock and cleaning out dams
- identify "backup systems" for water supply
- fence off dams to improve water quality and increase biodiversity
- update farm layouts and management zones
- carry out fire management and pathways around house and sheds
- have strategies to stop paddocks eroding
- have a plan for when to start feeding stock, and know the trigger point for off-loading stock
- update sheepyards
- create a stock containment area, a small paddock with good water and shade
- increase silage and pasture stores to two years' supply
- invest in good dogs for ease of stock management
- focus on soil health and fertility
- establish drought tolerant pasture species

GRAIN PRODUCTION AND IRRIGATION

- focus on soil health and fertility by testing your soils and monitor crops to identify the most limiting factor and address that immediately
- trial multispecies and cover crops
- have strategies to stop paddocks eroding
- complete silage/hay planning
- maintain high phosphorus levels
- build or upgrade on-farm grain storage
- upgrade weigh bridges and trucks
- have bores rather than relying on irrigation water allocation from the river
- carry over irrigation water to the next year when you don't need it
- build water storage to take advantage of off-allocation irrigation water
- buy more water for irrigation
- consider crop choice and water use of irrigated summer crops
- improve the uniformity of application and infiltration of water from the irrigation system.

BUSINESS

- have a long-term strategic plan and implement it
- be flexible
- have a cashflow budget and regularly review it
- upskill on the impacts of climate change
- have good networks around you, such as small farmer groups to help plan
- be proactive with succession transitions, start a conversation now with the next generation as a family
- plan ahead for purchase of inputs and capital items to get work done in a timely manner
- have a conversation with your bank now
- review if the business has the appropriate management structure
- utilise government grants and low interest rate loans on new or existing infrastructure that can help prepare for future droughts
- put money aside considering taxes and what is needed now
- consider Farm Management deposits (FMDs) to ensure payments can be made in a bad year
- communicate with family members
- restructure loan repayments
- consider off-farm investment versus on-farm
- utilise houses on the farm for younger generation or additional income
- expand the operation or take on a new enterprise for diversity

- look for opportunities to diversify income streams before and during a drought e.g., contracting, off-farm income
- better equity due to high land values provides an opportunity to invest in drought management strategies
- have a plan of your business triggers e.g., when do you not plant a particular crop, or when do you start destocking?
- maintain equipment to ensure it is in a usable state at all times to maximise efficiency and minimise risk
- strategically diversify locations of farms if and when you can afford it
- know when it is time to exit farming
- make key decisions when times are good
- consolidate debt

PERSONAL

- enjoy the good years
- find something you enjoy doing
- stay connected and keep communication open
- look after yourself; good eating and sleeping habits
- look for kids' support programs
- check in on people through regular phone calls
- plan a holiday to get away
- keep physically and mentally fit
- advocate for occasional counsellor training for service providers.

Thank you to all the community groups who hosted the workshops, and to the industry professionals who contributed their time and expertise.

Author: Kate Coffey, Riverine Plains.

HYPER YIELDING CROPS

FOCUS PADDOCKS: 2021 AND 2022 UPDATED RESULTS

KEY POINTS

- **Focus paddock 1 – the application of excess levels of nitrogen in 2020 statistically increased the yield of wheat crops in 2021. This indicates the previous year's unused nitrogen can be "banked" for the current year's crop.**
- **Focus paddock 2 – lime was incorporated to target the subsurface acidity in 2021 and those areas had an increase in yield compared to areas where the lime was not incorporated. The incorporation increased pH values across the profile.**
- **Focus paddock 3 – the Green Area Index (GAI) can be used to quantify the size of the canopy and may be more accurate with rates and timings of nitrogen application. In 2021, using the GAI to determine the timing and rate of nitrogen application gave a significant yield benefit compared with the farmer application.**
- **The Hyper Yielding Focus paddocks provide an opportunity for farmers and advisors to evaluate hyper yielding research results in a paddock situation.**

BACKGROUND

The *Grains Research and Development Corporation (GRDC) Hyper Yielding Crops* project, led by FAR Australia, is a research and extension project designed to push the boundaries of wheat, canola and barley yield in the higher rainfall zones of Australia. Under the guidance of Jon Midwood from TechCrop, Riverine Plains is engaging with local farmers, through focus and award paddocks, to benchmark and push yield potential based on research results.

Some of the causes of crops not achieving yield potential were inherent soil fertility, nitrogen levels, low soil pH in the root zone and variety (winter vs spring wheats).

The project will take a take a detailed look into these potential limitations and provide recommendations on how they can be managed. Results presented in the 2022 trial book were from demonstration strips only and were indicative results. The results presented in this report have been statistically analysed using a paired-t test.

FOCUS PADDOCK 1. DS BENNETT WHEAT: NITROGEN APPLICATION

AIM

To ascertain the impact of prior year nitrogen application on the yield of the current year's crop.

METHOD

DS Bennett wheat was sown with tillage radish at Gerogery, on the 18 March 2021. Soil nitrogen was measured prior to sowing in 2021, following the application of different rates of nitrogen to canola during the previous year's strip trials. The paddock was grazed by sheep and cattle for a period of approximately six weeks and stock were removed by the end of July. A total of 210kg/ha of urea (97kgn/ha) was applied to the paddock in three applications.

RESULTS AND DISCUSSION

Since the publication of last year's Trial Book, the yield results of this trial have been analysed (Table 1). The results show a significant yield increase in the wheat crop (2021) from the additional application of nitrogen in the canola crop (2020). An additional 36kgN/ha applied in 2020 to canola compared to Treatment 1, resulted an additional 0.44t/ha in wheat in 2021. With urea priced at $800/t at the time, the investment of $29/ha gave a benefit of $140/ha (wheat price $320/t). An additional 73kgN/ha applied in 2020 to canola compared to Treatment 1, resulted in an additional 0.65t/ha in wheat in 2021. With urea priced at $800/t, the investment of $58/ha gave a benefit of $208/ha (wheat price $320/t).

CONCLUSION

The data suggests that excess application of nitrogen to a canola crop is still available for the following year's wheat crop, provided the nitrogen is not lost due to waterlogging or leaching. In this case when soil nitrogen was assessed on 24 May 2021 it did not reveal the additional nitrogen in the soil. The reason it did not show up in the soil test is unknown. Based on the input and commodity price scenarios of 2020 and 2021 there was an economic return from the previous year's excess nitrogen. In 2022, fertiliser prices doubled, which makes it less economically viable to apply excess nitrogen. Also the extremely wet conditions have increased the potential for the nitrogen to be lost due to waterlogging conditions.

Table 1. Urea applied 2020 to Hytec Trophy and Deep N and plant counts Bennett 2021

	2020 CANOLA			2021 WHEAT		
	Urea applied* kg/ha	DM harvest (t/ha)	Yield **(t/ha)	Soil N 0-60cm (kgN/ha)	Plant counts (plants/m2)	Yield **(t/ha)
Treatment 1 Target 2.5t/ha	217 (100)	12.86	2.73b	176	142	6.32(a)
Treatment 2 Target 2.95t/ha	296 (136)	9.63	2.86a	137	110	6.76(b)
Treatment 3 Target 3.41t/ha	2.73b	15.18	2.87a	153	137	6.97©

*Total nitrogen applied shown in brackets

** Yields were analysed using a paired T test (p=0.05). Yields with a different letter are statistically different from each other.

FOCUS PADDOCK 2. T4510 CANOLA: LIME INCORPORATION – UPDATED RESULTS

AIM

To ascertain the impact of ameliorating sub-surface acidity by incorporating lime.

METHOD

The paddock was identified by the grower as having limitations, which he suspected were subsoil acidity. Maps of average crop vigour over a five-year period gave an indication that there were under-performing zones of the paddock, which can be seen in Figure 2. Sites one and two were in the high performing area, three and four in the low performing area with five and six in the medium area. The paddock was extensively soil tested through the *Cool Soil Initiative* project to gain an understanding of the limiting soil conditions.

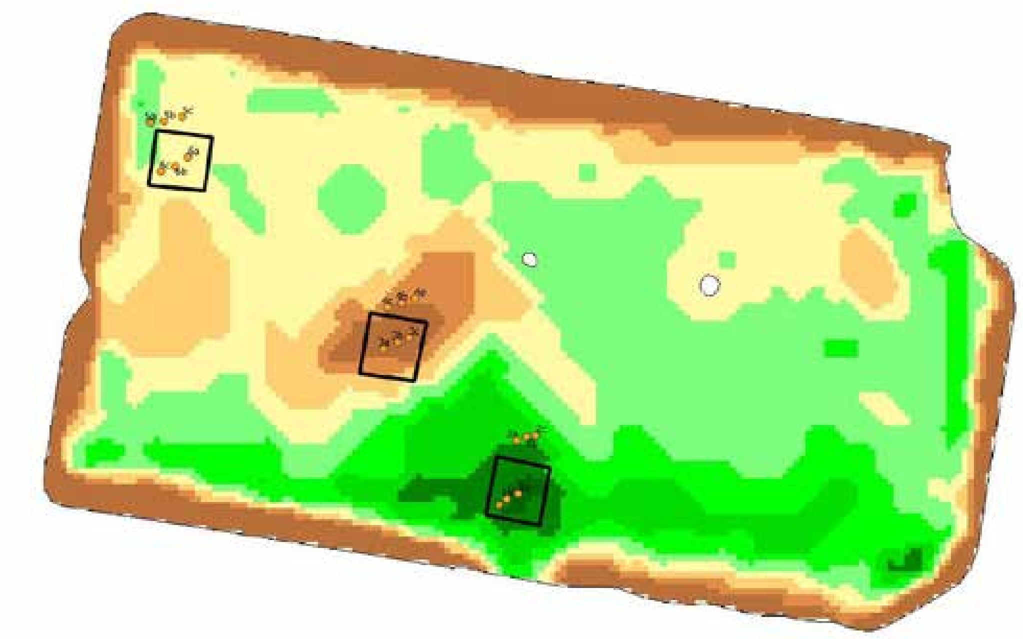


Figure 2. Average crop vigour in the paddock from 2016-2020.

A Lemken Rubin 12 was used to incorporate variable rates of lime (rather than applying to the surface) targeting a pH (CaCl2) of 5.8 in the top 10cm. The NSW Department of Primary Industries pH (CaCl2) target of 5.8, ensures there is sufficient lime applied to address acidity in the 0-10cm layer, as well as allowing for some lime to penetrate below 10cm). The lime was applied at a variable rate with a range of 2.5t/ha to 4.5t/ha and an average application rate of 3.4t/ha. Three areas were left uncultivated, to test the benefit of incorporating lime compared to surface application. Figure 3 illustrates the trial design with the black boxes representing the area where no incorporation took place. The paddock was sown to T4510 Canola at Brocklesby, on the 30 April 2021. Throughout the 2021 season a total of 162kgN/ha was applied to the paddock in four applications: 8kgN/ha at sowing, 37kgN/ha on the 20/04/21; 25kgN/ha on the 20/05/21, 46kgN/ha on the 09/07/21 and 46kgN/ha on the 9 August 2021. In 2022 the paddock was sown to wheat.

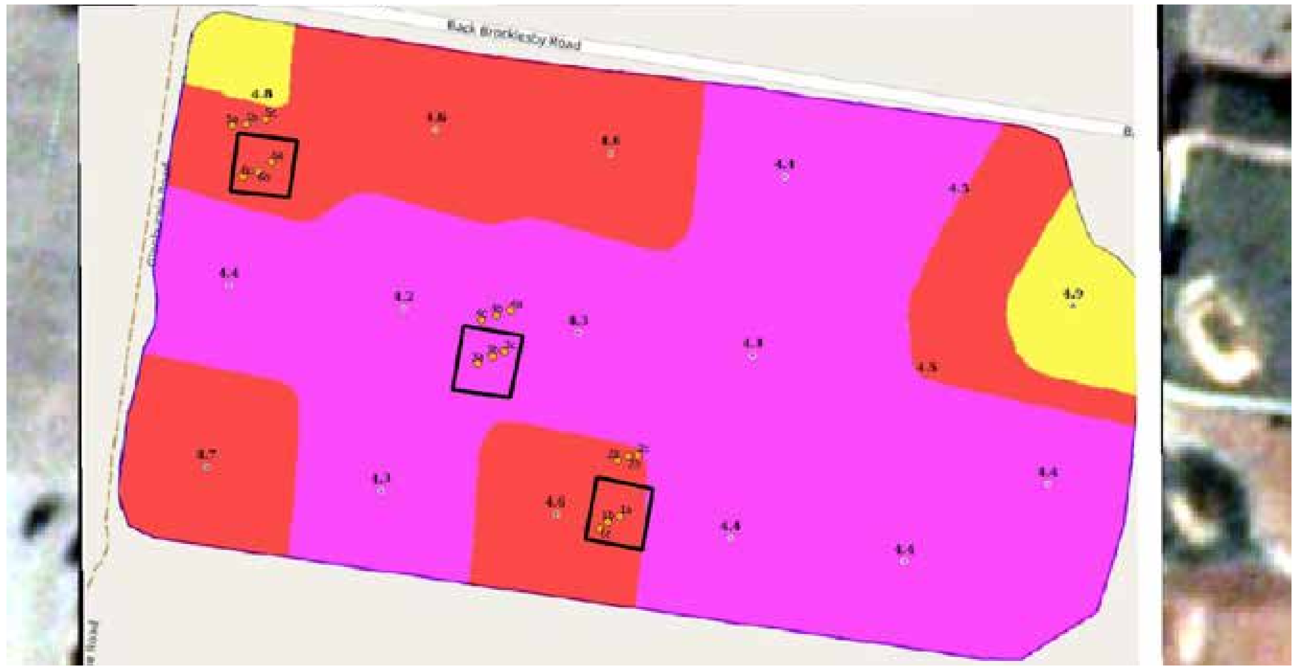


Figure 3. Surface (0-10cm) pH (CaCl2) values with the sampling sites and incorporation areas (black boxes).

RESULTS AND DISCUSSION

2021 results can be found in the previous Trial Book. Comprehensive soil testing was re-done in September 2022, due to the very wet season, the sampling was postponed from April. Results indicate that the lime has been incorporated where the treatment was applied. Throughout the 2021 season, the NDVI showed that the small areas of surface applied lime had less dry matter compared to the incorporated areas (surface applied areas are located inside the squares in Figure 5). During 2022 this re-occurred, while not as obvious, the low yield unincorporated area was visible to have lower biomass and slower growth in the paddock (Figure 4) however yield maps were unavailable. NDVI imagery from 2022 showed similar results to 2021. A comparison between years can be seen in Figure 5.

Figure 4. The untreated area is visible in the paddock. Photo taken (05/09/2022)

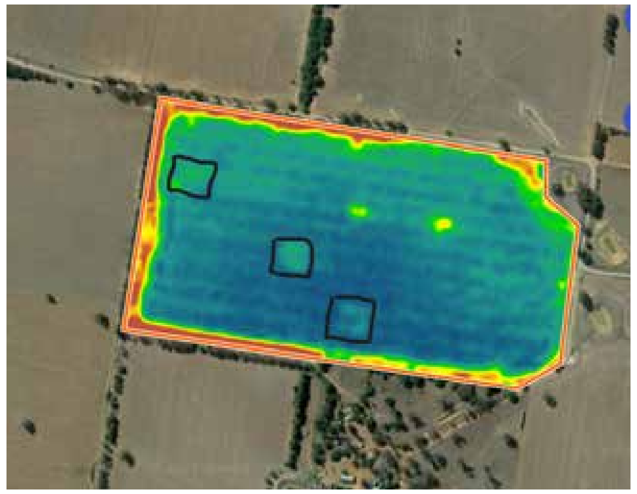
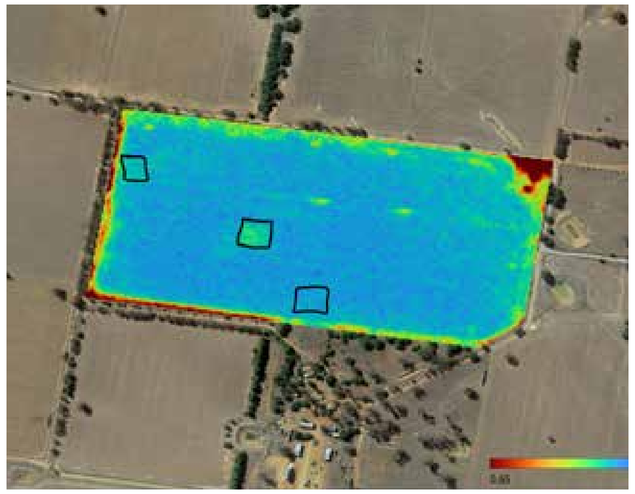


Figure 5. a) NDVI of canola (10 August 2021)



b) NDVI of wheat (8th August 2022)

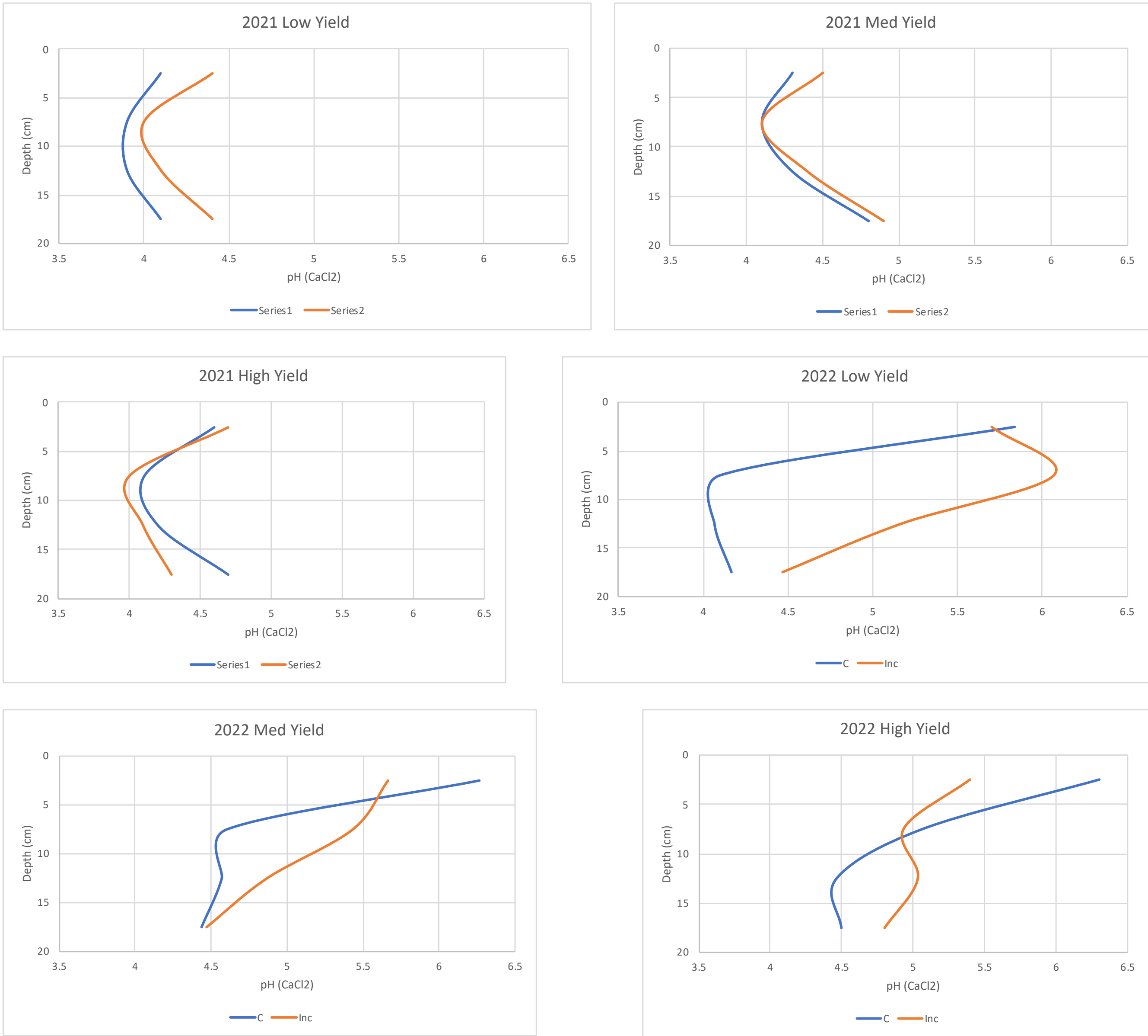


Figure 6. Comparison of original detailed soil sampling and samples taken in September 2022.

The soil testing completed in 2022 was analysed in 5cm increments from 0-20cm. Figure 6 shows where the lime was incorporated has increased the pH of the profile down to 15cm. The pH values at 20cm show little increase meaning the incorporation did not reach this depth. The incorporation mixed the lime through the profile, removing the stratification of pH. The increase in pH down to 15cm will provide significant benefit to microbial activity and nutrient availability in that zone, while reducing aluminium below toxic levels. Some lime will continue to move down to 20cm depth, especially in the low yielding zone, where there is excess alkalinity in the 5-10cm zone.

Incorporating and applying lime has a long-term benefit, aiding the movement of lime beyond the surface. This demonstration shows that the incorporation has distributed the lime through the profile, increasing the pH.

The key learning from this methodology was that the machinery used for incorporation can leave the paddock rough and can cause some issues with sowing and post incorporation. Adjustments have since been made by the grower to put a grader board on the machinery to level and firm up the surface after mixing. Yield is a stand out benefit for incorporation and could be visibly seen in the two years following incorporation.

FOCUS PADDOCK 3: RAPTOR CANOLA, NITROGEN RATES

AIM

To determine the optimum rate of nitrogen for canola.

METHOD

The paddock was sown to Raptor Canola on 26 April 2021. The demonstration (Figure 5), based on farmer input, included five treatments with varying rates and timings of nitrogen application (Table 1). The Green Area Index (GAI) method trialled by Jon Midwood from TechCrop used soil nitrogen measurements and drone technology to assess the amount nitrogen required. GAI is the ratio of green leaf and stem area to the area of ground on which the crop is growing. The GAI protocols are based on a target of 5t/ha dry matter, which equates to a GAI of 3.5 at early flowering to optimise yield. It takes 50 – 60kgN/ha to make 1 GAI, therefore 3.5 GAI equates to 175 – 210kgN/ha. The GAI is measured at set growth stages in the season, to enable nitrogen rates to be adjusted to ensure the dry matter target is reached. For further information on how the GAI was calculated and nitrogen rates determined, refer to Riverine Plains Trial Book, 2022.

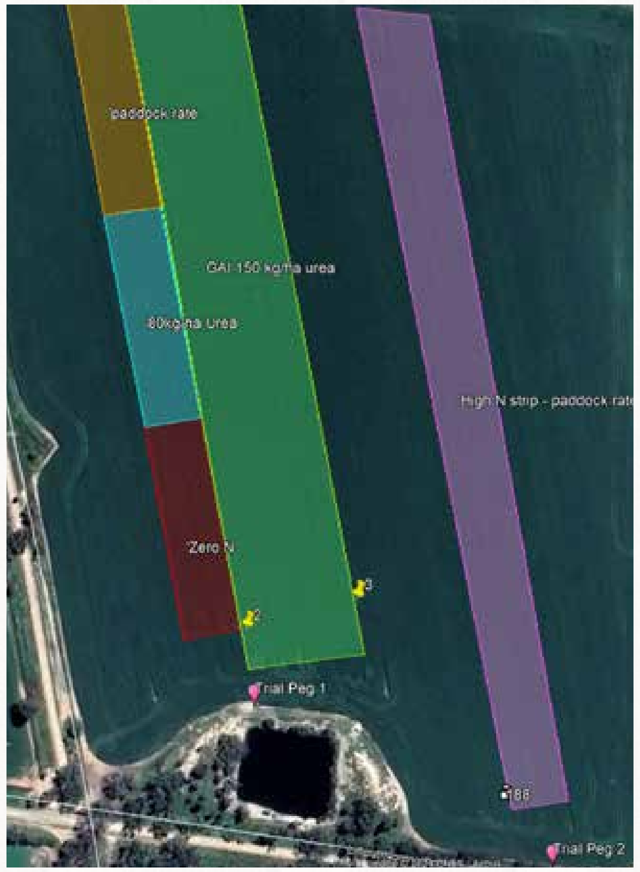


Figure 5. Paddock treatments canola nitrogen demonstration.

RESULTS AND DISCUSSION

A range of nitrogen application rates were tested in consultation with the host farmer, including application using the GAI index to determine application rates. Deep soil Nitrogen (0-60cm), taken prior to sowing (5/04/21) showed soil levels between 33 and 54kgN/ha. Compared to the paddock control, representing farmer practice, the applications 0kgN/ha and 37kgN/ha were significantly lower yielding and less profitable (Table 3).

The highest yielding treatment was 221kgN/ha, however it was less profitable than the GAI treatment (147kgN/ha, in three applications). Even though the treatments did not reach the dry matter target of 5t/ha at the start of flowering, the favourable seasonal conditions at flowering meant that high yields were still achieved on the GAI and nitrogen rich treatments.

This paddock has been monitored in 2022, to ascertain if the additional nitrogen applied in 2021 will have an impact on the wheat crop in 2022.

Table 3. Nitrogen treatments Raptor Canola

TREATMENT	UREA AT SOWING) KG/HA	UREA MID JUL KG/HA	UREA 9 AUG KG/HA	TOTAL N TO DATE KG/HA	DRY MATTER START OF FLOWERING T/HA	YIELD T/HA		ADDITIONAL GROSS MARGIN COMPARED TO CONTROL * $/HA
Paddock Control	80	100	100	129	3.0	3.41	c	
ON	0	0	0	0	0.4	1.78	d	-916
37 N	80	0	0	37	0.8	2.30	d	-617
GAI 147 N	80	150	90	147	3.0	3.79	b	235
N Rich 221 N	80	200	200	221	3.1	3.96	a	225

*Based on 2021 Urea price of $800/t and canola price of $700/t

** Yields were analysed using a paired T test. Yields with a different letter are statistically different (p=0.05) from each other.

CONCLUSION

The *Hyper yielding crops project* demonstrates the yield possibilities in wheat, canola and barley paddocks. This on-farm demonstration shows that nitrogen is a key driver of high yielding crops. However there is a point where the cost of applying additional inputs becomes uneconomical. In this demonstration, that point was reached with the application of 221kgN/ha, based on 2021 prices and inputs. This paddock was monitored in 2022 to identify if any of the nitrogen applied in 2021 carried over to benefit the wheat crop in 2022 (results not available at time of printing).

ACKNOWLEDGEMENTS

The *Hyper yielding crops project* is a GRDC investment, led by FAR Australia. *The Cool Soil Initiative* is a partnership between Mars Petcare, Kellogg's, Manildra Group, Allied Pinnacle, Corson, Charles Sturt University (CSU), and the Food Agility Cooperative Research Centre (CRC), with support from the Sustainable Food Laboratory, Vermont USA.

The authors wish to thank farmer co-operators: The Moll family, the Russell family and the Severin family.

Authors: Kate Coffey, Riverine Plains; Jane McInnes, Riverine Plains; Jon Midwood, TechCrop; Nick Poole, FAR Australia; Cassandra Schefe, AgriSci Pty Ltd.

SOUTHERN NEW SOUTH WALES DROUGHT RESILIENCE ADOPTION AND INNOVATION HUB (SNSW HUB)

KEY POINTS

- **The sNSW Hub enables regional communities to have a voice in drought resilience activities and gain access to resources. The sNSW Hub provides tools and programs to assist adoption.**
- **Riverine Plains farming systems group has appointed a Knowledge Broker for the sNSW Hub to represent our region and contribute to developing projects and resources that address identified priorities.**
- **The work to date has revealed that while much can be learned and applied from past droughts, there are still knowledge gaps that could be filled by helping farmers to manage current situations and be better prepared for future climate variability.**

BACKGROUND

The partners in the sNSW Hub are the Australian National University, Farming Systems Groups Alliance (which includes Riverine Plains), the First Nations Governance Circle, Local Land Services, the NSW Department of Primary Industries, Rural Aid, the University of Canberra and the University of Wollongong. The hub encompasses most of the Macquarie River catchment and lower reaches of the Darling River, the Illawarra and South Coast, the Riverina, the Australian alps and Western New South Wales. The sNSW Hub's coverage includes Canberra, Dubbo, Orange and Bathurst and their surrounding regions.

Since the engagement process for the sNSW Hub was completed in November 2021, Rhiannan McPhee has been appointed to represent the Riverine Plains region as a Knowledge Broker for the sNSW Hub. Rhiannan works with the team at Riverine Plains, our members, and individuals across the region to provide information to the sNSW Hub on the key drought preparedness and innovation priorities our region has identified. The sNSW Hub works with the Knowledge Broker network and universities to provide relevant resources and support the development and delivery of projects that help address these priorities across southern New South Wales.

Australian Government Department of Agriculture, Fisheries and Forestry | Future Drought Fund | SOUTHERN NSW Innovation Hub

This project received funding from the Australian Government's Future Drought Fund

PROJECTS

A major project that has resulted from sNSW Hub collaboration is the *Improved drought resilience through optimal management of soil and water* project. (See page 57 for a detailed update) Partners involved in this large-scale project are CSIRO, NSW Department of Primary Industries, Southern Growers, Central West Farming Systems, FarmLink and Charles Sturt University. This project showcases the work of John Kirkegaard's previous small-scale field trials looking at increased water use efficiency, soil organic carbon and nitrogen utilisation.

Other successful cross-hub projects with the Farming Systems Group Alliance (FSGA) include:

- Preparing Australia, an audit of existing weather stations to provide support to standardise and validate data with the Bureau of Meteorology
- Creating landscape-scale change through drought resilient pasture systems, led by Holbrook Landcare Network
- Saving our Soils during drought, led by Murray LLS

SUMMARY

The SNSW Hub has played a key role in enabling Riverine Plains' involvement in these large, multi-agency projects. The first year of the sNSW Hub has resulted in many new projects, increased community engagement and confirmation that for the sNSW Hub to be a success, it must provide accessible resources and support to community members. Riverine Plains has committed to providing resources through our communication channels, including social media, emails, blog posts and our Trial Books, as well as incorporating key information across our events throughout the year. Most of our audience is time-poor, so we are working to streamline information and provide timely, relevant and reputable information and support, not only for our members but for the wider region in which we operate.

ACKNOWLEDGEMENTS

This program is supported by Riverine Plains through funding from the Australian Government's Future Drought Fund

Author: Rhiannan McPhee, Riverine Plains

VICTORIA DROUGHT RESILIENCE ADOPTION AND INNOVATION HUB (VIC HUB)

KEY POINTS

- **The Vic Hub is giving farmers and regional communities tools to address climate variability, enhance drought preparedness and adopt relevant, innovative practices.**
- **Riverine Plains have appointed an Adoption Officer for the Vic Hub to represent our region through contributing to project development and sharing resources that address identified priorities.**
- **The work to date has demonstrated that while there is a large amount known about drought and climatic cycles, there are still many knowledge gaps that need filling to help our region be prepared for climate variability through continued, local support and adoption.**

BACKGROUND

The Vic Hub is led by the University of Melbourne's Dookie Campus, in association with five regional nodes, led by highly respected farming and industry groups Birchip Cropping Group (NW Node); Riverine Plains (NE Node); Food & Fibre Gippsland (Gippsland Node); Southern Farming Systems (SW Node), and Mallee Regional Innovation Centre (NW Irrigated Horticulture Node). It is further supported by Deakin University, La Trobe University, Federation University Australia and Agriculture Victoria. The Vic Hub represents a comprehensive approach to enhancing economic, environmental and social resilience to drought in order to create innovative and profitable sectors, sustainable and functioning landscapes, and resourceful and adaptable communities.

Lynn Macaulay has been appointed as an Adoption Officer with the Vic Hub's northeast regional node. Lynn works with the team at Riverine Plains, our members, and individuals across the region to provide information to the Hub on key priorities around drought preparedness and innovation.

PROJECTS

The development of an investment prospectus for the use of stock containment practices commenced in November 2021 with the employment of a livestock officer for Riverine Plains. We ran multiple farmer focus groups across the region to gain insight on current stock containment systems and investigate where greater investment could lead to wider spread adoption of the practise. The business case has been finalised and we are in consultation with other farming systems groups and large-scale organisations on further funding work in this space.

Other projects we are working on in collaboration with the Vic Hub partners are *the Drought resilience practices* in mixed farming systems project. Riverine Plains has increased its project portfolio as a result of Vic Hub support; such projects include *Agriculture Innovation Program – Digital agriculture, building capacity for community-led drought resilience action, Silicon fertiliser for drought resilience in broadacre cropping, and the Accelerating the adoption of agri-tech solutions by female farmers* project. New projects recently commenced, also facilitated through involvement with the Hub, include a feasibility study on renewable energy on farms and assessing the suitability of small-farm dams.

SUMMARY

Key priorities for action identified through initial and ongoing consultation through the Vic Hub have enabled the rapid development of project, extension and capacity building opportunities. These opportunities will be essential in assisting the communities in northeast Victoria prepare for climate variability and to be innovative. Riverine Plains, in the capacity as the northeast Node, is committed to providing resources through our well-established communication channels, including social media, emails, and blog posts, and at events held throughout the year.

ACKNOWLEDGEMENTS

The Vic Hub is funded by the Future Drought Fund, through the Australian Government Department of Agriculture, Fisheries and Forestry.

Author: Rhiannan McPhee, Riverine Plains

This project received funding from the Australian Government's Future Drought Fund

SILICON FERTILISER FOR DROUGHT RESILIENCE IN BROADACRE CROPPING

KEY POINTS

- **When applied in drought-stress trials, silicon (Si) has demonstrated increased photosynthetic activity of the plant and improved water relations, leading to improved crop yield.**
- **Silicon fertiliser application has not shown any significant differences in biomass and grain yield of the evaluated crops this season. The season's climate must be considered when interpreting this result, as it was not a typical season where crops can face periods of moisture or heat stress.**
- **Visual effects of stay-green phenotype (prolonged green foliage) were observed in wheat plots later in the season, indicating Si's beneficial effects.**

BACKGROUND

In Australia, drought and heat events have challenged the resilience and profitability of farming businesses. Climate change requires a more resilient farming approach to sustain farm productivity. Diversified farming options can make existing farms more resilient and profitable in changing climate scenarios. On-farm diversification can be a promising strategy for farming communities to cope with and recover from stresses like drought.

This project is supported by Riverine Plains, through funding from the Australian Government's Future Drought Fund.

Northern Victoria is one of four regions in Australia with the highest level of drought risk (ABARES, 2020). Because of the propensity to drought, broadacre farming systems across southeastern Australia require sustainable approach to remain productive and profitable when exposed to increasing risks from more frequent droughts.

The parent project, 'Whole-system redesign of broadacre farming of southeast Australia', aims to help the agricultural industry to cope with, and recover from drought. One of the main drought mitigation strategies being trialled is the use of Si fertiliser in broadacre systems. The project also demonstrates overall farm diversity enhancement with the inclusion of native vegetation cover on non-farming areas of the farm.

AIM

To provide evidence-based, innovative research for diversified farms in south-eastern Australia. The projects aims are:

1. to demonstrate the potential role of legumes incorporation in the wheat/canola monocropping system
2. further consider the option of dual-purpose wheat (grain and graze option) cultivars in the Riverine Plains region
3. to showcase cost effective drought mitigation strategy to the farming community, i.e., foliar application of Si
4. to consider the health of cropping ecosystem, integration of native vegetation on the farmland to diversify farms income.

Table 1. Site details

Sowing date	15 June 2022
Varieties	Spring wheat: Scepter Dual-purpose wheat: Annapurna Faba bean: Samira Canola: Roundup Ready
Starter fertiliser	80kg/ha MAP
In season fertiliser	150kg/ha Urea (not on faba beans)
Soil mineral N	38.5kg/ha
Average annual rainfall	542mm
Actual annual rainfall	679MM

METHOD

Eight plots were sown to each crop type, in a paddock within the Riverine Plains region. Crop types included faba beans, spring wheat, dual-purpose winter wheat, and canola. The treatments were control (no Si) and foliar Si application, with four replications per treatment. Before sowing, 12 soil cores were taken across site, segmented into 0-10cm and 10-20cm (pre-sowing soil chemical analysis is presented in Table 2). A demonstration site for faba beans was also included as a part of this project. This site was managed within a farmer's paddock and Si fertiliser spray was applied to half of the selected area. The commercially available Si fertiliser was applied at the rate of 300ml/ha, with a water rate of 400L/ha, five times throughout the season. The first application was in mid-August, GS30 in wheat, with the consecutive sprays being applied 10-14 days after the previous.

A native corridor assessment by expert Meredith Mitchell and FDF project staff identified plants and marked them for continuous monitoring.

Three different types of native grasses were identified in the Riverine Plains native corridor. To understand the impact of these native grasses on the soil microbial community composition, diversity and their role in shaping the soil health for sustainable crop production, soil samples will be taken throughout the length of the project.

Grazing wheat plots had half the plot area mown (to represent grazing) at GS25. The biomass cuts were taken for all plots at GS33 (wheat) and again at GS65 (wheat). Approximately 2.7m2 of the grazed area of the plot was sprayed with Si fertiliser and 1L/ha of micronutrient formulation in mid-October to enhance crop re-growth after a grazing period. Final biomass cuts and harvest index calculations were taken on this portion of the plot to compare with the unsprayed control grazed area.

Harvest index was calculated at crop maturity. Plots were harvested for grain yield and sub-samples were taken to test protein and nutrient content. The dual-purpose wheat plots were harvested separately, the grazed and non-grazed areas.

Table 2. Pre-sowing soil chemical properties

SOIL CHEMICAL PROPERTIES	PRE-SOWING 0-10CM	PRE-SOWING 10-20CM
pH (CaCl2)	4.8	4.9
EC (dS/m)	0.06	0.07
Nitrate N (mg/kg)	12	13
Ammonium N (mg/kg)	6.9	3.1
Colwell P (mg/kg)	12	27
PBI	91	90
Organic carbon %	0.3	1.3

RESULTS AND DISCUSSION

Site details and soil data are shown in Tables 1 and 2. Post-harvest soil test data are at analysis stage, and not included in this report. Due to excessive rainfall, all canola replicates were not taken through to harvest at the Uncle Tobys site. Faba bean replicated plots were maintained near our demonstration site, in Bundalong South, due to poor establishment at the Uncle Tobys site. The faba bean replicated trial did not receive all anticipated Si sprays due to unexpected rains and a road closure due to flooding, therefore the results are not included in this report.

Tables 3 to 5 show biomass, harvest index, plot yield and grain traits, averaged across all replicates. Across all crop types at this site, no significant difference was observed between the treatment of Si and control. Visual differences were observed with Si-treated plots showing slightly higher growth and extended green foliage compared to their non-treated counterparts.

Table 3. Biomass results

CROP TYPE	1ST BIOMASS T/HA – CONTROL (EARLY-MID OCT)	1ST BIOMASS T/HA – SI TREATED	2ND BIOMASS WHEN?? T/HA - CONTROL	2ND BIOMASS T/HA – SI TREATED
	(Early-mid October)		(Mid-December)	
Canola	3.93	4.46	N/A	N/A
Wheat	6.71	8.12	8.71	10.55
Grazed Dual-purpose Wheat	4.22	4.12	3.17	4.31
Grazed Dual-purpose Wheat + Micronutrient Treatment	N/A	N/A	5.24	5.03
Non- Grazed Dual-purpose Wheat	8.35	4.12	7.81	8.9

Table 4. Harvest traits

CROP TYPE	HARVEST INDEX - CONTROL	HARVEST INDEX - SI TREATED	YIELD T/HA - CONTROL	YIELD T/HA - SI TREATED
Wheat	44.34	41.40	2.65	3.02
Grazed Dual-purpose Wheat	47.19	48.86	3.4	3.44
Grazed Dual-purpose Wheat + Micronutrient Treatment	49.75	48.86	2.6	2.48
Non- Grazed Dual-purpose Wheat	35.46	40.24	1.88	2.07

Table 5. Grain traits

CROP TYPE	GRAIN PROTEIN % - CONTROL	GRAIN PROTEIN % - SI TREATED	MOISTURE % - CONTROL	MOISTURE % - SI TREATED
Wheat	9.9	9.6	6.3	5.45
Non- Grazed Dual-purpose Wheat	8.72	8.28	8.1	6.03

The native corridor area will be analysed throughout the duration of the project to understand the effect native vegetation on the soil biodiversity and nearby cropping systems. These results will be included in future Trial Book articles.

Silicon is a micronutrient that has been used in previous drought-stress trials under controlled and field conditions at The University of Melbourne. Silicon induced tolerance to abiotic stresses, such as drought, promotes enzymatic activities, and therefore improves photosynthetic efficiency. Results from previously published research trials showed that Si applications have improved water relations through higher water uptake by roots, reduced water loss from leaves, and improved antioxidant defense mechanisms. Silicon application may have potential to improve grain quality by increasing antioxidant compounds in the grain. Silicon application can potentially increase the soil microbial biodiversity and nitrogen fixing capacity in legumes.

CONCLUSION

Previous research trials have confirmed that the effects of Si on plants are primarily seen in times of stress (such as drought and heat). It can be inferred that no significant differences were seen between the treatment of Si and control (no Si) across all crop types, due to the extremely wet seasonal conditions, including flooding, across the sites. Extended stay-green phenotypes were observed in spring wheat, providing a reasonable indication of the positive effect of foliar Si application regardless of waterlogged conditions.

ACKNOWLEDGEMENTS

This project is supported by Riverine Plains, through funding from the Australian Government's Future Drought Fund. This project is led by The University of Melbourne (project lead - Associate Professor Dorin Gupta), with partners Riverine Plains Inc, Birchip Cropping Group, Gap Flat Native Foods, Goulburn Broken Catchment Management Authority and Black Duck Foods. Riverine Plains would like to thank its farmer hosts, Ian and Kaye Wood, and Adam and Ingrid Inchbold for the use of their land and support throughout this trial.

Author: Rhiannan McPhee, Riverine Plains

IMPROVED DROUGHT RESILIENCE THROUGH OPTIMAL MANAGEMENT OF SOIL AND WATER

KEY POINTS

- **Diverse legume rotations may help build soil organic carbon.**
- **Early sowing of slower-maturing crops may lead to higher crop water use efficiency; this demonstration will commence in the region in 2023.**
- **Measuring residual mineral nitrogen will aid in preventing excess application, increase profitability, and decrease environmental losses.**
- **It is recommended to split deep nitrogen samples (for example 0-30cm and 30-60cm) to ascertain location of nitrogen in the soil profile.**

BACKGROUND

The project *Improved drought resilience through optimal management of soil and water* covers central and southern New South Wales regions with 12 demonstration sites.

The project is supported by Riverine Plains, through funding from the Australian Government's Future Drought Fund and the Grains Research and Development Corporation (GRDC).

The purpose of the project is to improve the management of natural capital through increased water use efficiency, soil organic carbon, and nitrogen utilisation, which, in-turn, is crucial to environmental and economic resilience in drought. These sites will focus on three strategies that have been proven previously, through the work of John Kirkegaard, in small scale field trials in New South Wales.

There were two sites in the Riverine Plains in 2022, with an additional site being added in 2023. Throughout the project, case studies and marketing collateral will be produced to ensure information is dispersed to encourage wider adoption across Australia. These will be promoted through the Vic Hub and the sNSW Hub and their farming systems groups.

FOCUS PADDOCK 1: DIVERSE ROTATIONS

AIM

To demonstrate how diverse legume rotations can fit into the modern farming system and potentially help build soil organic carbon.

METHOD

A host farmer from Howlong had two paddocks side-by-side to compare a non-legume and a legume rotation. In 2022, a paddock was sown half to wheat and half to faba beans. In 2023, the entire paddock will be sown to canola. Previously the paddock was in a wheat/canola rotation. The paddock can be irrigated by an overhead irrigator, but was not irrigated in 2022, due to the very high rainfall.

The following measurements were taking to identify the value of a diverse rotation:

- soil tests 0-30cm and 30-60cm, gravimetric soil water analysis, nitrogen content and organic carbon pre-sowing and post-harvest, GPS located on the same spot
- plant counts
- biomass counts at mid-pod fill
- nitrogen[15] (N15) analysis on faba beans and reference plants

Table 1. Mid-west paddock site details

	FABA BEANS	WHEAT
Variety	Amberley	Coota
Sowing date (beans)	22/04/2022	28/04/2022
Plant density (beans)	26 PLANTS/M2	NOT RECORDED
Starter Fertiliser	70KG/HA MAP	70KG/HA MAP
pH CaCl2 (0-30cm)	6.0	5.7
pH CaCl2 (30-60cm)	6.4	6.6
Colwell P mg/kg (0-30cm)	24	18
Colwell P mg/kg (30-60cm)	<5	<5
Rainfall (mm) Jan-March	258	258
Rainfall (mm) April - October	498	498

RESULTS AND DISCUSSION

Dry matter cuts, taken from the faba beans at mid-pod fill in October 2022 weighed 10.36tDM/ha. Subsamples from the faba bean dry matter cuts and a weed reference plant were also sent for N^{15} sampling to determine the amount of nitrogen fixation by the faba beans (data not available at time of publishing). The faba bean paddock yield of 0.98t/ha was dramatically down on expectations, due to severe waterlogging and disease. The wheat in the paddock was also affected by waterlogging yielded 2.5t/ha.

Soil properties taken before sowing and post-harvest at GPS locations indicated small increases in organic carbon (Table 3) However, the difference was potentially due to the different timing of the sampling. Carbon levels can fluctuate during the season and may not always be a legacy of the crop. Changes in soil organic carbon generally occur slowly over many seasons, and therefore can be difficult to detect in the short term. The soil moisture levels were converted from gravimetric to crop Plant Available Water (PAW) using bulk densities and soil lower limits for canola (pers. comm, Dunn M, 2023). Soil samples taken at 60cm depth in faba bean trials showed a decrease of PAW of 60.9mm, between sowing in May 2022 and post-harvest in January 2023. In contrast the wheat profile over the same depth and time period showed a decrease in PAW of 13.1mm. The higher stubble cover in the wheat may have reduced evaporative soil water loss between harvest and sampling.

Table 3. Soil properties faba beans, pre and post-sowing

	PRE-SOWING (17 MAY 2022)	POST-HARVEST (27/01/2023)
Organic carbon (% 0-30cm)	0.7	1.0
Organic carbon (% 30-60cm)	0.3	0.5
Soil moisture (PAWmm 0-30cm)*	36.1	1.9
Soil moisture (PAW mm 30-60cm)*	42.4	15.8
Total soil moisture (PAW mm 0-60cm)	78.5	17.6
Nitrogen (kgN/ha 0-30cm)	101.6	155.3
Nitrogen (kgN/ha 30-60cm)	20.6	77.4

*Note the pre-sowing soil moisture % is an air-dried soil moisture, while the post-harvest soil moisture was an oven dried soil moisture. The oven dried soil moisture may result in significantly drier soil, and the two cannot be compared.

Table 4. Soil properties wheat, pre and post-sowing

	PRE-SOWING (17 MAY 2022)	POST-HARVEST (27 JANUARY 2023)
Organic carbon (% 0-30cm)	0.9	1.1
Organic carbon (% 30-60cm)	0.4	0.5
Soil moisture (PAW mm 0-30cm)*	41.6	42.5
Soil moisture (PAW mm 30-60cm)*	61.8	47.8
Soil moisture (PAW mm 0-60cm)*	103.4	90.3
Nitrogen (kgN/ha 0-30cm)	94.1	152.6
Nitrogen (kgN/ha 30-60cm)	18.5	12.2

*Note the pre-sowing soil moisture % is an air-dried soil moisture, while the post-harvest soil moisture was an oven dried soil moisture. The oven dried soil moisture may result in significantly drier soil, and the two cannot be compared.

The deep nitrogen sampling pre-sowing showed the paddock had between 102 and 94kgN per hectare in the 0-30cm layer prior to sowing. The paddock was then sown to wheat on the west side and beans on the east side. After harvest, the nitrogen levels in the 0-30cm increased for both the beans (155kgN/ha) and the wheat (153kgN/ha).

The deep nitrogen sampling in the 30-60cm layer showed different trends for wheat and faba bean post-harvest. Prior to sowing, both sites had between 21kgN/ha and 18kgN/ha. Post-harvest, the nitrogen in the 30-60cm layer increased to 77kgN/ha in the faba beans and decreased to 12kgN/ha in the wheat.

The results show there is a total of 233kgN/ha following the bean crop and 165kgN/ha in the wheat crop, with most of the additional nitrogen in the beans being in the 30-60cm layer (Figure 1). Based on the rule of thumb of 80kgN/tonne to grow a canola crop, there is currently enough soil nitrogen following the wheat to grow a 2.1t/ha canola crop and enough nitrogen following faba bean crop to grow a 2.9t/ha canola crop.

The faba bean crop yielded poorly, so potentially the high levels of residual nitrogen are due to the failure of the crop and the residual is a combination of unused mineralised nitrogen and potential break down and mineralisation of the nitrogen rich crop root and shoot residue. The wheat crop also yielded below expectations, which may explain the high level of residual nitrogen in the top 30cm.

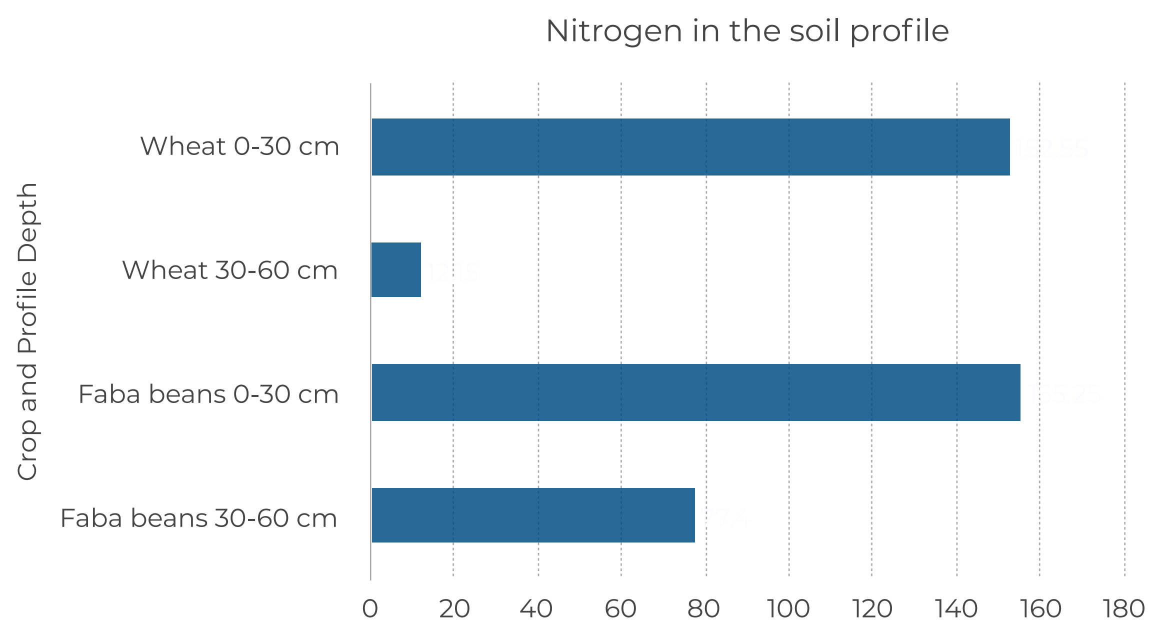


Figure 1. Kilograms of nitrogen per hectare remaining in the soil post-harvest (paddock sampled 27 January 2023.

CONCLUSION

Introducing diversity through a faba bean crop can increase the amount of nitrogen available to the following crop. In this year's demonstration, both the beans and the wheat succumbed to water logging and disease, which reduced the profitability of both crops. The higher levels of soil nitrogen measured after the failed faba bean crop is likely a result of unused mineral nitrogen and the breakdown and mineralisation of the crop residue. It is expected that the extra nitrogen in the faba bean crop will be available to the following crop later in the season, once the roots have penetrated below 30cm. The results suggest less soil water is available following the faba bean crop, which may limit the yield of the following canola crop, depending on the season.

FOCUS PADDOCK 2: NITROGEN BANKING

Table 5. Baragoola paddock site details

SOWING DATE	15 JUNE 2022		
Sowing rate and variety	Calibre/Rockstar Wheat @ 80kg/ha		
Starter fertiliser	70KG/HA MAP		
Total soil N to 70cm	166 KG/HA		
Average annual rainfall	571MM		
Actual annual rainfall	746MM		
Soil property	**0-10cm**	**10-40cm**	**40-70cm**
pH (CaCl2)	5.1	5.5	6.4
EC (dS/m)	0.11	0.07	0.04
Colwell P (mg/kg)	16	6	<5
PBI	39	47	83

AIM

To understand strategies of nitrogen banking versus application based on nitrogen demand, preventing excess application, increase profitability and decrease environmental losses.

METHOD

A farmer was identified who had sown wheat for the 2022 season. Pre-season soil samples were taken on 17 May 2022 to understand starting nitrogen, organic carbon and soil moisture. See Table 5 for pre-sowing soil test results and site details.

To gain understanding of crop establishment in each treatment, plant emergence counts, or tiller counts were taken early in the season.

Nitrogen was applied in the form of urea via a spreader in mid-September. The three treatments of nitrogen were calculated by Mathew Dunn from NSW Department of Primary Industries. Based on starting profile N of 166kg N/ha and additional 7kg N/ha (from MAP), the first two rates were calculated on decile 2 predicted yield and decile 7 predicted yield and final rate was an additional 120kg Urea/ha to understand how excess nitrogen can affect soil nitrogen stores, yield and profitability. See Table 6 for decile 2 and 7 calculations and Table 7 for applied fertiliser rates. The predicted yields have been determined from site modelling and the additional nitrogen required considers 40kg of nitrogen needed to grow 1t of wheat per ha.

Table 6. Nitrogen treatment calculations

TOTAL STARTING N KG N/HA (INCLUDING MONOAMMONIUM PHOSPHATE (MAP))	DECILE 2 PREDICTED YIELD T/HA	ADDITIONAL N REQUIRED FOR DECILE 2 KG N/HA	DECILE DECILE 7 PREDICTED YIELD T/HA 7 PREDICTED YIELD T/HA	ADDITIONAL N REQUIRED FOR DECILE 7 KG N/HA
173	5.2	35	6.5	87

Table 7. Urea rates

TREATMENTS	RECOMMENDED UREA RATE	APPLIED UREA RATE
Standard Rate	80kg/ha	75kg/ha
High Rate	180KG/HA	192KG/HA
Very High Rate	300KG/HA	319KG/HA

Biomass cuts were taken just prior to harvest on 15 December. The crop still had relatively high moisture and was harvested on 28 December once it had dried down. The biomass cuts were sent to NSW Department of Primary Industries in Wagga to have harvest index, yield estimates and seed protein estimates calculated. As mentioned above, post-harvest soil tests for total nitrogen, organic carbon and soil water content were taken in January 2023.

RESULTS AND DISCUSSION

A comparison of pre-sowing and post-harvest soil test results; organic carbon and soil moisture, are listed in Table 8. The comparison of total nitrogen values can be seen in Figure 3.

Table 8 Soil properties

PROPERTIES	PRE-SOWING 17 MAY 2022	POST-HARVEST – 75KG/HA UREA	POST-HARVEST – 192KG/HA UREA	POST-HARVEST – 319KG/HA UREA
Organic carbon % (0-10cm)	1.1	1.8	1.5	1.1
Organic carbon % (10-40cm)	0.3	0.5	0.3	0.3
Organic carbon % (40-70cm)	<0.2	0.2	0.2	<0.2
Soil moisture % (0-10cm)*	17.63	9.5	8.5	9.67
Soil moisture % (10-40cm)*	15.02	6.44	6.6	7.51
Soil moisture % (40-70cm)*	12.54	6.71	12.89	8.89
Soil moisture (PAW mm 0-10cm)*	14.5	1.7	0.2	2
Soil moisture (PAW mm 10-40cm)*	31.3	0	0	0
Soil moisture (PAW mm 40-70cm)*	12.7	0	14.2	0

*Note the pre-sowing soil moisture % is an air-dried soil moisture, while the post-harvest soil moisture was an oven dried soil moisture. The oven dried soil moisture results in significantly drier soil, and the two cannot be compared.

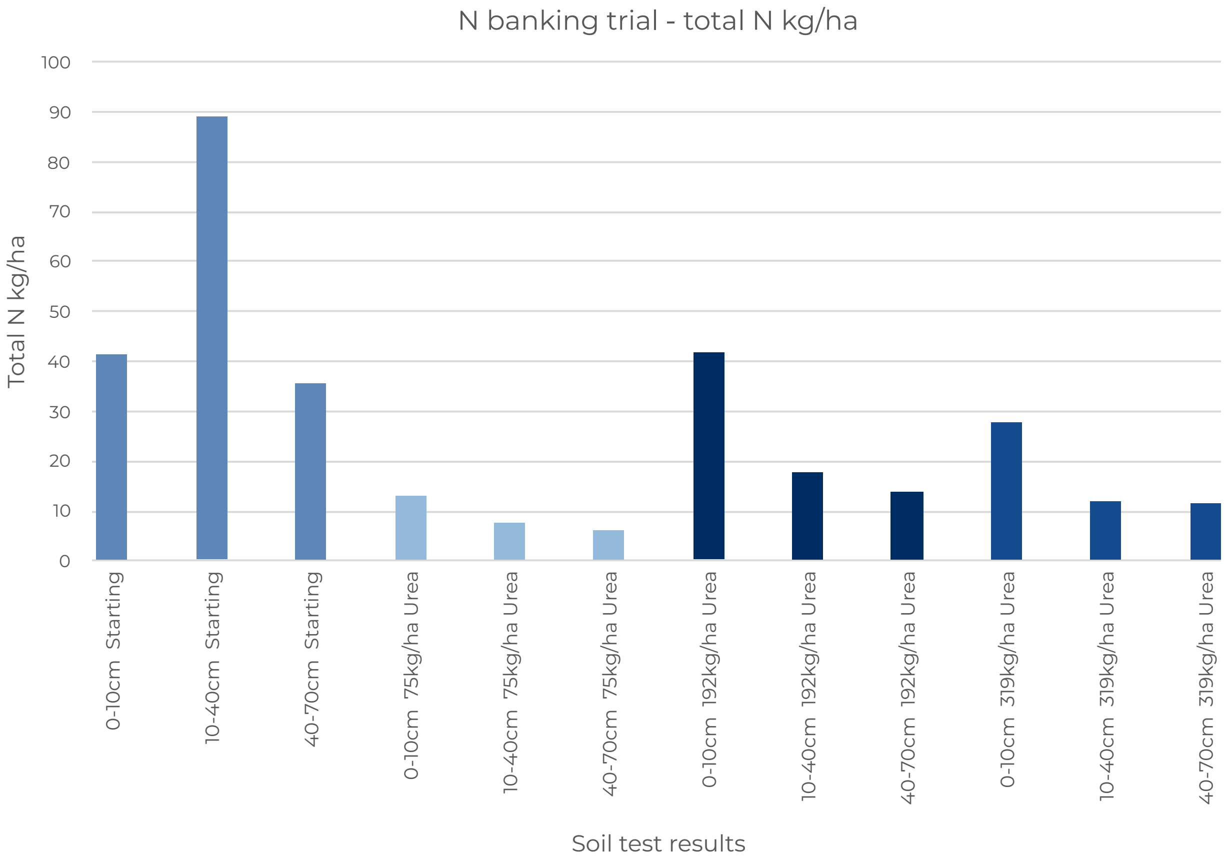


Figure 3. Nitrogen banking trial – total N kg/ha

The starting soil nitrogen results were taken in May 2022, with the paddock coming out of a canola crop in 2021. When comparing the soil tests of pre and post-harvest, we can see a large portion of soil nitrogen has been used up in the deeper parts of the soil profile, with the biggest change in the 10-40cm depth.

Organic carbon levels (Table 8) have remained the same or shown a very slight increase. This is likely due to fluctuation of carbon levels depending on timing of sampling as well as variation seen with post-harvest samples compared to the entire paddock sample pre-sowing. Changes in soil organic carbon generally occur slowly over many seasons and therefore can be difficult to detect in the short term.

The soil water sample for urea applied at 192kg/ha at 40-70cm looks to be an outlier. Across the majority of samples, soil-water content has decreased across all depths of the profile from pre-sowing to post-harvest. The samples do indicate that both the 192kg/ha and 319kg/ha urea treatments have increased soil water content across the profile compared to the 75kg/ha. However, it is very challenging to statistically prove this due to variability across the paddock. Plant available water (PAW) calculations were also completed across the samples, using information on soil type and crop type to assist with accuracy. PAW shows that the profile is extremely dry post-harvest for all three treatments, due to the above average rainfall at this site it is assumed that water was not necessarily a limiting factor in this crop, but has since been removed from the profile.

Harvest index cuts were taken prior to the machine harvest, demonstrating a relationship between nitrogen application with yield and protein content. These results are not statistical as the trial is not replicated. See comparison of dry matter, harvest index, grain yield and seed protein content in Table 9 and Figure 4.

Table 9. Harvest cuts results

UREA RATE	TOTAL DRY MATTER (T/HA)	HARVEST INDEX	GRAIN YIELD (T/HA AT 11% MOISTURE)	SEED PROTEIN (% AT 11% MOISTURE)
75kg/ha	8.1	0.41	3.76	12.5
190kg/ha	8.7	0.48	4.64	12.4
320kg/ha	9.2	0.45	4.68	13.4

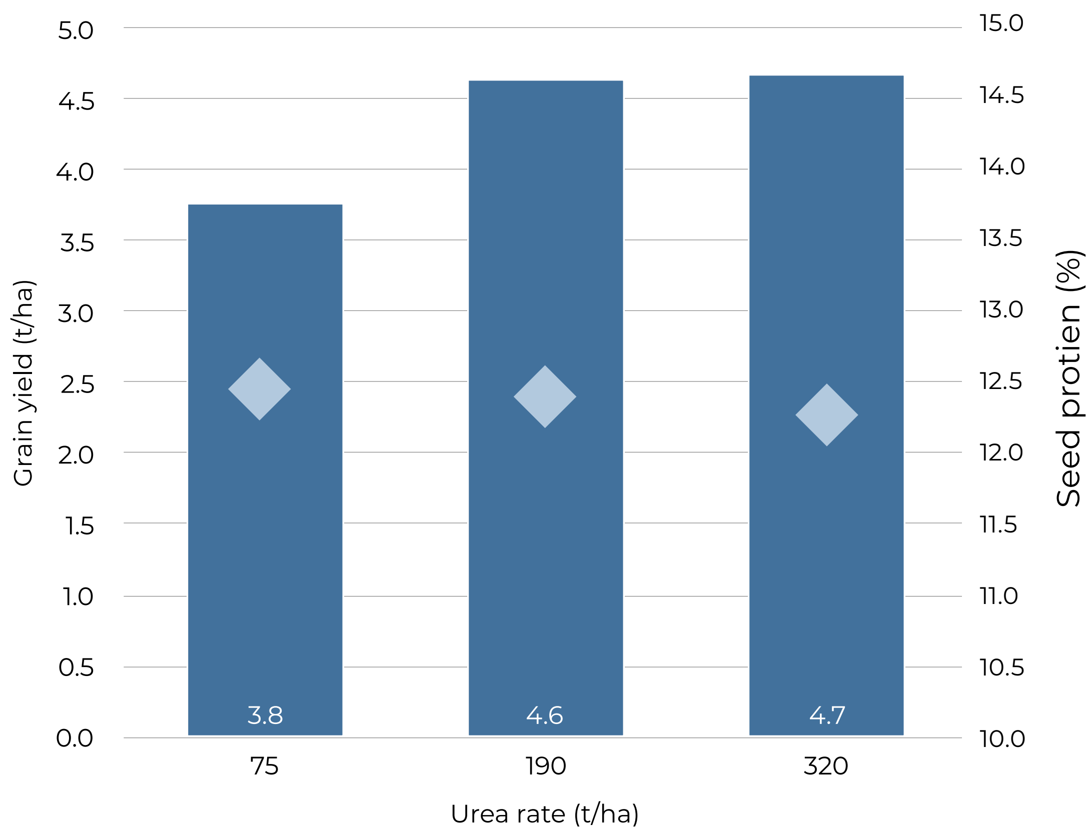


Figure 4. Harvest index cuts – yield and protein %

The yield for each treatment was below the predicted yield, as estimated prior to nitrogen application with modelling from data collected at the site, climate history and season predictions. The paddock suffered a high disease load of Rust, with Septoria coming in late and unfortunately the fungicides used were not able to control the severity and therefore a yield impact was seen. Increased nitrogen resulted in increased yield, with yield capped at the 190kg/ha urea treatment and only protein % increasing in the 320kg/ha urea treatment.

Normalised Difference Vegetation Index (NDVI) images and yield maps for the trial can be seen in Figures 5-7. These images indicate that the 320kg/ha urea treatment had increased the green area in September, compared to the other treatments, however by November it was equal to the 192kg/ha treatment. Yield for both of these was not different, however the images do indicate a lower yield for the 75kg/ha treatment. The images, particularly the yield map, shows a line within the paddock of low compared to high yield. This line coincides with the split of the two wheat varieties, Calibre and Rockstar and potentially highlights disease tolerance between the two.

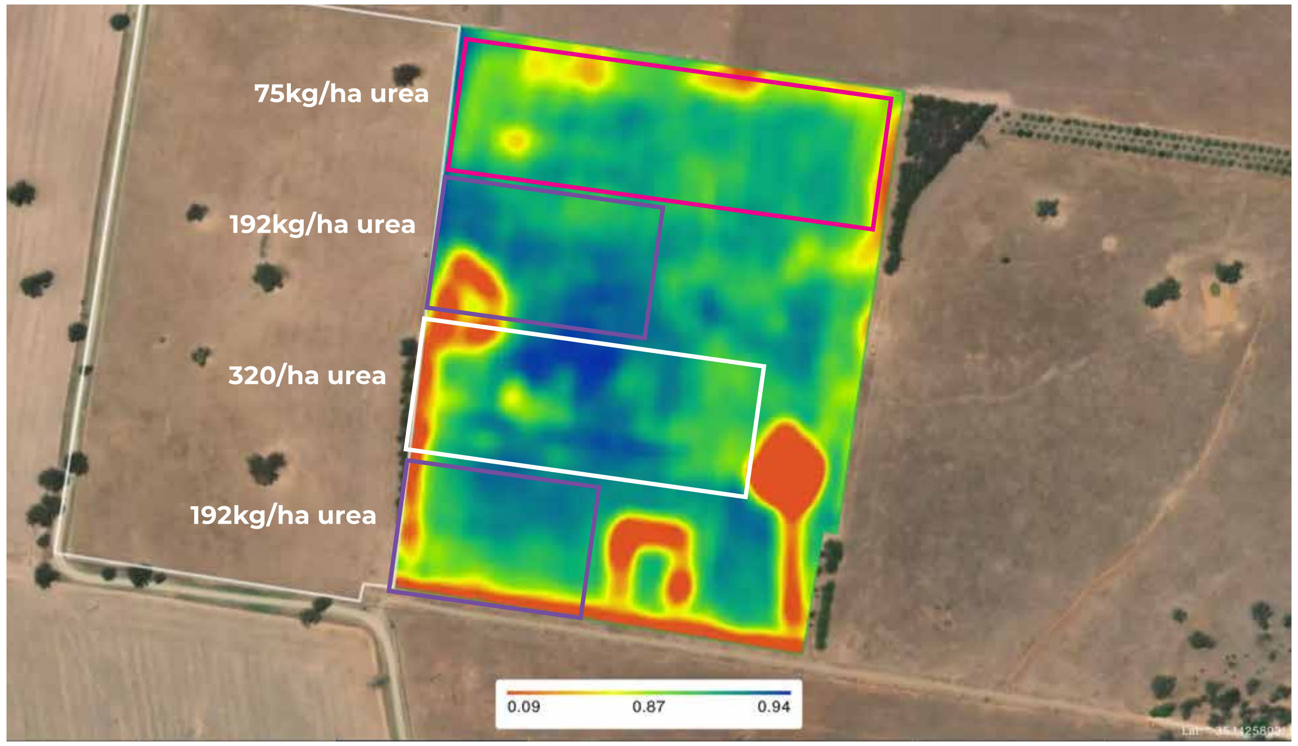


Figure 5. NDVI image 29 September 2022

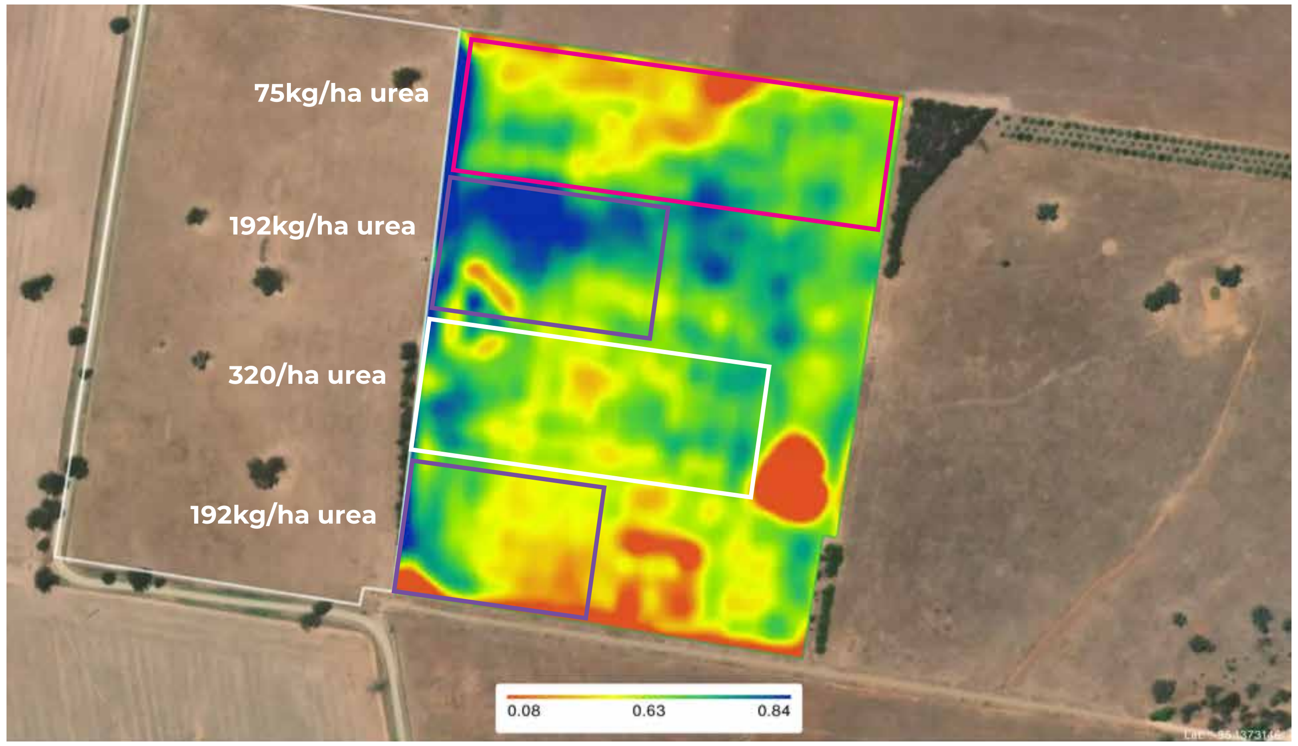


Figure 6. NDVI image 18 November 2022

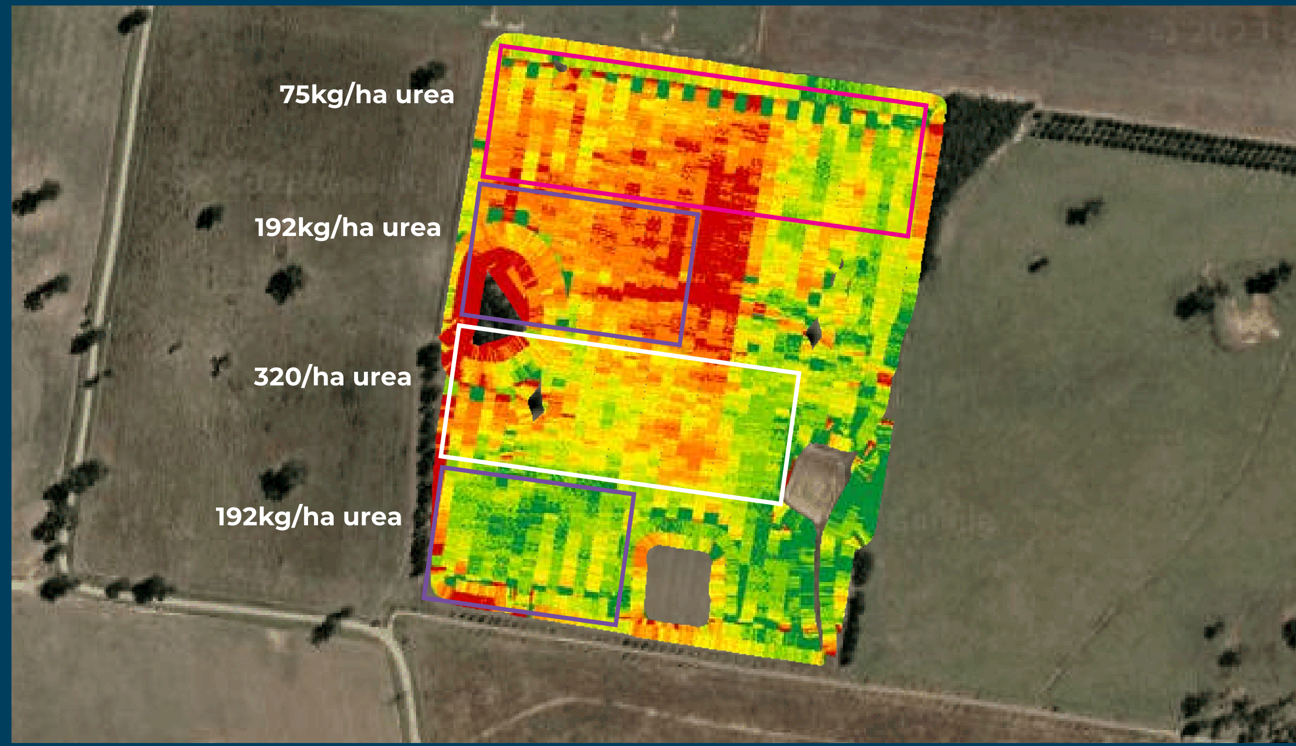


Figure 7. Yield map wheat paddock

For the economic analysis we assume there is a statistical difference between protein content (not proven) and the 190kg/ha urea rate is equivalent to H2 quality, and the 320kg/ha urea rate is equivalent to APH2 quality.

Sales at the GrainCorp Temora sub-station show that Hard Wheat grade 2 (H2) sales are at $390/t and APH2 are at $436/t. Urea prices fluctuated in 2022 depending on time of purchase, a price of $1,200/t is used for the below calculation.

Urea @ 190kg/ha: 4.6t/ha x $390 = $1794

Urea @ 320kg/ha: 4.7t/ha x $435 = $2045

An extra 130kg/ha of urea required to increase the rate, @ $1,200/t is an additional $156/ha

$2045 - $1794 - $156 = $95/ha profit for additional urea applied.

CONCLUSION

Increasing the supply of nutrients, including nitrogen, to the soil system will allow for microbial activity to continue to function. Over time it may allow for the maintenance or a slight increase in organic carbon content. It is not expected to see any real change in the system at this early stage. Increased soil water content is also a factor that can be impacted by the addition of nitrogen to the soil system. In this demonstration, yield was limited due to disease and did not reach predicted rates set in June. Water was not considered a limiting factor, however PAW is very low post-harvest. The highest nitrogen rate provided the highest yield and protein percentage, as expected, however post-harvest nitrogen stores were lower in the 320kg/ha urea treatment compared to the 190kg/ha urea treatment. This is likely due to a portion of nitrogen contributing to the increased protein content of 320kg/ha urea treatment yield and variation when testing in the paddock.

GLOSSARY

Bulk density: the volume of soil particles and pores among the particles, calculated as dry weight of soil divided by its volume.

Deciles: Rainfall deciles take the historic rainfall records at a location and sort into ten equal parts. Decile 1 are the years with lowest rainfall on record and decile 10 are the highest.

N15 plant analysis: A technique used to study the nitrogen cycle, providing more information on the conversions of one nitrogen compound to another.

pH in CaCl2: pH measured in 0.01M CaCl1 solution instead of water is often preferred as it is less affected by soil electrolyte concentration and results in a more consistent measurement.

Plant available water: the maximum amount of water stored in the soil profile that is available for plant use.

Wilting point: the amount of water that is held so tightly by the soil that roots cannot absorb and therefore the plant will wilt.

Field capacity: the amount of soil water content held in soil after excess water has drained away, through gravity not through plants or evaporation.

ACKNOWLEDGEMENTS

This project is supported by Riverine Plains, through funding from the Australian Government's Future Drought Fund and the Grains Research and Development Corporation.

It is delivered by a collaboration between Riverine Plains Inc, CSIRO, NSW Department of Primary Industries, FarmLink, Central West Farming Systems, Southern Growers and the Southern NSW Drought Resilience Adoption and Innovation Hub. Riverine Plains would like to thank its farmer hosts, Emily and Phil Thompson, Tim and Ian Trevethan for the use of their land and support throughout this trial.

Authors: Kate Coffey, Riverine Plains and Rhiannan McPhee, Riverine Plains.

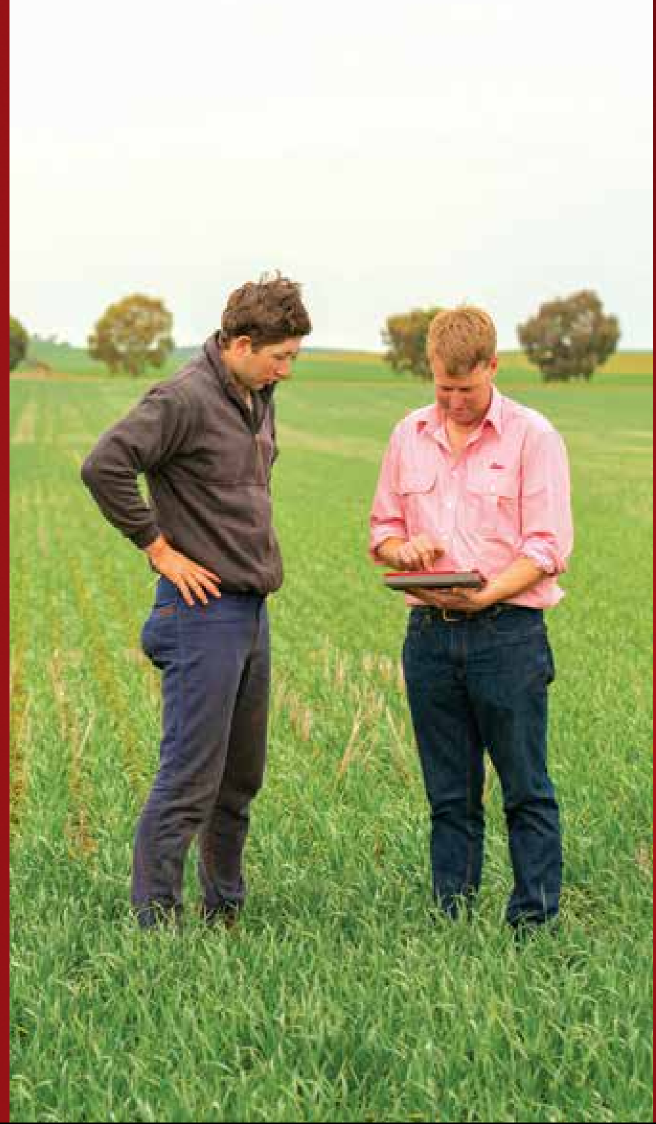
GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Australian Government Department of Agriculture, Fisheries and Forestry

Future Drought Fund

SOUTHERN NSW Innovation Hub SUSTAINABLE AGRICULTURE, LANDSCAPES AND COMMUNITIES

This project received funding from the Australian Government's Future Drought Fund



BEST PRACTICE LIMING TO ADDRESS SUB-SOIL ACIDITY

KEY POINTS

- **Paddocks with a history of no-till management (cropping and pasture) may have highly stratified pH values in the top 20cm. This means accurate testing for soil acidity may require sampling at 5cm increments, rather than the traditional 10cm increments.**
- **Not all lime has the same Calcium Carbonate Equivalence (CCE) value and therefore they have different capacity to neutralise acidic soils, get yours tested.**

BACKGROUND

Acidity levels in topsoil and sub-surface layers are increasing across the southern region of Australia and are rapidly becoming a key constraint to productivity. Increasing soil acidity and the associated declining production is a gradual process. Applying lime to address increasing acidity is often the first input to be dropped when cash flow is limited due to its high cost. Additionally, the development of acidity can be masked where an acid throttle (a layer of low pH that restricts movement of nutrients and roots past it) exists in a stratified layer. This is often overlooked in lab analysis of 0-10cm mixed soil samples. Often growers do not recognise the gradual decline in fertility and do not apply lime until the problem is already established.

With the low solubility of lime and its relative immobility, top-dressed lime can take ten or more years to significantly increase subsoil pH below 10 cm. Soils that have not been adequately maintained with lime applications to counter the increasing rate of acidification, need a management solution to increase subsoil pH, as well as having a faster return on investment and increase in crop productivity.

The placement of the lime in the soil plays a significant role in the lime's ability to neutralise acidity when it exists at depth due to the need to establish contact for the acid base reaction to occur. The quality of the lime is another factor contributing to its effectiveness in neutralising soil acidity, specifically its neutralising value. Effective Neutralising Value or ENV describes a chemical property of the lime based on its Calcium Carbonate Equivalence (CCE) to neutralise acid and can vary greatly between lime sources. In addition, the lime's fineness also has a significant impact on its ability to neutralise acid where finer products have higher surface area and therefore greater contact with soil particles to improve its efficacy. A higher Effective Neutralising Value (ENV) lime is generally more expensive, so ensuring maximum value from higher ENV lime through effective placement in the soils is of great significance to farmers.

AIM

To demonstrate best practice liming strategies and a field demonstration of the impacts of lime quality.

OBJECTIVES

The objective of this project is to establish one replicated field trial to demonstrate best practice liming strategies and a field demonstration to show the impacts of lime quality per annum, over two years. It will demonstrate different incorporation methods, evaluate the impact of different lime types/sources, as well as extend findings including comparisons of the economic and agronomic returns using the Acid Soils SA calculator tools.

Extension efforts are focussed on raising grower awareness on the speed of acidification and stratification of soils in this region. This is while providing resources and tools available to assist management decisions such as the aforementioned calculators.

It is pertinent for growers to evaluate the most practical and economical methods for managing soil pH and paddock variability in soil types. This will form part of the demonstration whereby achieving the best overall benefit on variable soil types will be examined. 'Nil' treatments, where no lime is applied, are designed to showcase the cost of complacency toward addressing pH in the short and long term.

Is it hoped that by the end of the project in December 2023, growers and advisers in northeast Victoria will have improved understanding of the state of topsoil and subsoil acidity, the limitations to crop profitability it causes, and finally, an improved knowledge of the agronomic and economic benefits of different lime sources, lime quality and incorporation methods.

Table 1. Final treatments for the trial

TREATMENT#	DETAILS
1	Control – nil lime: nil incorporation
2	Nil lime, with incorporation
3	Lime to target pH 5.2, incorporated by sowing
4	High rate of lime (to pH 5.8), incorporated by sowing (0-10cm value)
5	High rate of lime (to pH 5.8), incorporation by shallow discs (0-10 value)
6	High rate of lime (to pH 5.8), deep incorporation to 10-15cm, follow up with speedtiller
7	High rate of lime (to pH 5.8), to deep incorporation to 10-15cm, follow up with speedtiller (rate calculated for 5.8 at depth) DELUX option

METHOD

After consultation with a steering committee, made up of growers and researchers, a number of treatments were agreed and are provided in Table 1 below.

An intense soil sampling regime was completed in February 2022 across every replicate, to baseline and characterise the whole site, understand current pH levels, and ensure the proposed incorporation methods were appropriate. It was calculated that the rates of lime used would be:

Lime to target pH 5.2 – 1.2 tonnes/ha

High rate to 5.8 – 5.0 tonnes/ha

High rate to depth – 8.5 tonnes/ha

Figure 1 illustrates the trial plan whereby the replicated trial sites have a buffer in between the treatments. The buffer was sown to canola. At the end of the replicated trial, strip trails were established to assess the impacts of two types of lime quality, granular and fine and were both spread at 3t/ha and incorporated with sowing. The lime used from Galong was very fine with bulk density of 1.4, while the Mt Gambier lime was much coarser with a bulk density of 1.1.

DEMO 1 - MOUNT GAMBIER LIME 3T/HA - INCORPORATE WITH SOWING					13m
DEMO 2 - NIL LIME 3T/HA - INCORPORATE WITH SOWING					13m
DEMO 3 - GALONG LIME 3T/HA - INCORPORATE WITH SOWING					13m
1	Lime =5.0t/ha incorporate with TIGER		28	Lime =5.0t/ha incorporate by sowing	13m
2	Lime =5.0t/ha incorporate by shallow discs		27	No lime, with Incorporation	13m
3	Control - Nil Lime: Nil Incorporation		26	Lime = 1.2t/ha, Incorporate with sowing	13m
4	Lime = 1.2t/ha, Incorporate with sowing		25	Lime =5.0t/ha incorporate by shallow discs	13m
5	No lime, with Incorporation		24	Lime =8.5t/ha incorporate with TIGER	13m
6	Lime =8.5t/ha incorporate with TIGER		23	Lime =5.0t/ha incorporate with TIGER	13m
7	Lime =5.0t/ha incorporate by sowing		22	Control - Nil Lime: Nil Incorporation	13m
8	Control - Nil Lime: Nil Incorporation		21	Lime =8.5t/ha incorporate with TIGER	13m
9	Lime =5.0t/ha incorporate by sowing		20	Lime =5.0t/ha incorporate by shallow discs	13m
10	Lime =5.0t/ha incorporate by shallow discs		19	Lime =5.0t/ha incorporate by sowing	13m
11	No lime, with Incorporation		18	Lime = 1.2t/ha, Incorporate with sowing	13m
12	Lime =5.0t/ha incorporate with TIGER		17	No lime, with Incorporation	13m
13	Lime =8.5t/ha incorporate with TIGER		16	Control - Nil Lime: Nil Incorporation	13m
14	Lime =1.2t/ha incorporate with TIGER		15	Lime =5.0t/ha incorporate with TIGER	13m
40m		30m	40m		221m

N →

Figure 1. Trial design for the liming demonstration

Lime was applied on 16 February 2022 with the incorporation completed on 17 February 2022. A Horche Tiger was used for the deep incorporation, with calibration to ensure that the depth of the lime was kept above 20cm. The speed tiller was run over both incorporated treatments to ensure a smooth surface for ease of sowing. Once the treatments were completed the host sowed and managed the trial site in line with management practices of the remainder of the paddock.

The site was sown to canola on 14 April 2022 with 70kg/ha of MAP. There was 250kg/ha of Urea applied and 100kg of GranAm® (ammonium sulphate fertliser) during the season.

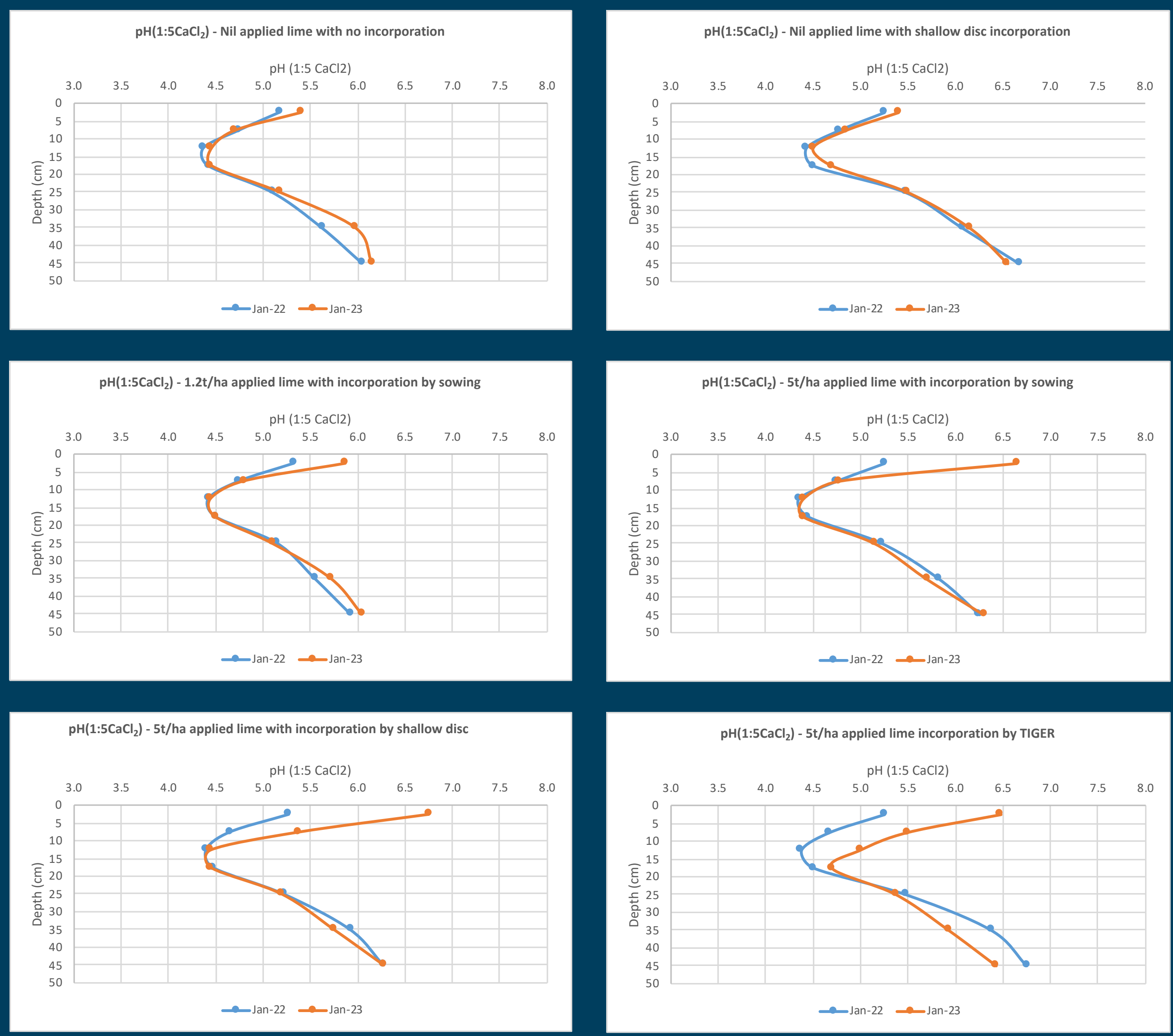
Green seeker measurements were taken on 21 July and on 2 August to assess differences in growth between plots. Photos were also taken during the season as a record of plot growth.

Harvest was not carried out by a plot header for the trial site due to inundation of the site by water, which prevented collection of yield data. Despite significant waterlogging, the host farmer harvested the site with the remainder of the paddock.

RESULTS

Soil test results for the January 2023 sampling (Year 1) have not yet been statistically analysed. However, early data suggests high rates of lime with incorporation is an effective tool to improve lime placement and ameliorate subsurface acidity. pH results are presented in Figure 2 below. Aluminium and CEC were also measured but are not displayed in Figure 2.

pH



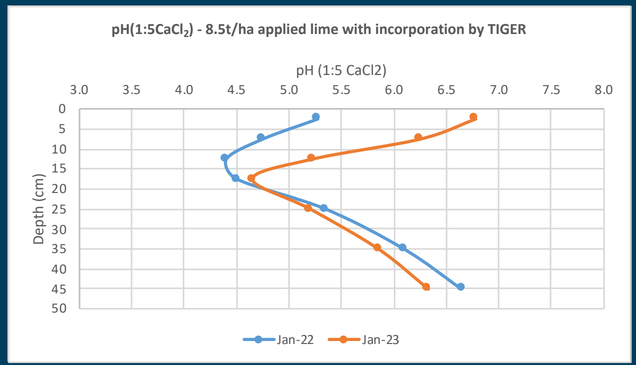


Figure 2 Impact of lime treatments and incorporation methods on pH at depth over a 12-month period

Slugs caused significant damage to the whole paddock in 2022, despite the site being baited twice. It appeared anecdotally that plots that had incorporation and lime treatments were less affected by slug damage, and where lime wasn't incorporated, damage was higher. This however this was not able to be quantified. Figure 3 shows the poor and patchy emergence of one of the plots following slug attack.

The region experienced a large rainfall event in January, with the site having around 150mm.

There was a total of 1150mm for the year and 538mm GSR (growing season rainfall, May – Oct). October had a large rainfall event after the image displayed in Figure 3. This caused the canola to 'lie down' in patches or had been 'washed out'.

Harvest was not able to be carried out by a plot header for the trial site, which disappointingly, resulted in no trial yield data. Despite the crop being black and on the ground the host farmer harvested the site with the remainder of the paddock.

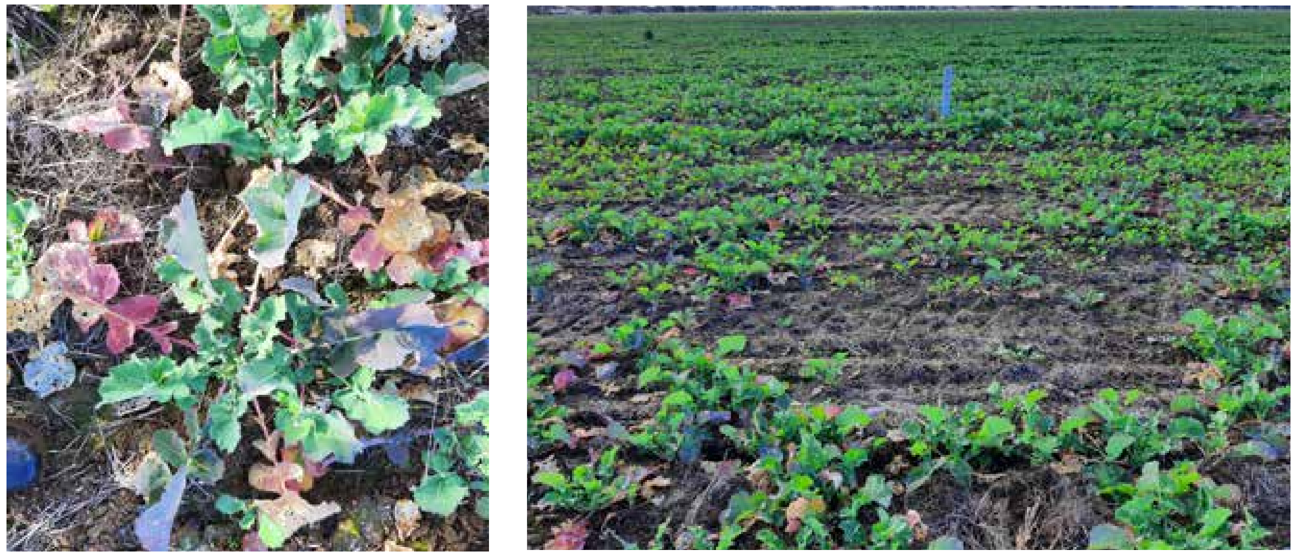


Figure 3. a) waterlogging effects b) slug effect. Photo taken 12 July 2022.

Figure 4 Drone image taken 17 October 2022. Canola had finished flowering and was either lodged, rotted or had not established.

DISCUSSION

Riverine Plains hosted a paddock walk shortly after soil amelioration had been completed. A dig stick and visual observation were used to confirm that the incorporated lime had moved to the required depths.

The areas eaten by slugs were re-sown in an attempt to improve crop cover and trial uniformity, mimicking local grower practice for patchy establishment/ slug damage. Re-sown sections were able to compensate for the poor establishment later in the season.

Due to the site experiencing extensive waterlogging there were concerns waterlogging effects would confound trial results such that significant effects from amelioration treatments may not be able to be inferred from yield and soil test results. Preliminary analysis of the soil test results in 2023, fortunately indicate treatment effects are present despite waterlogging of the site.

ACKNOWLEDGEMENTS

This research trial is funded by Grains Research and Development Corporation (GRDC). The authors would like to thank the Spence family for hosting the site. We would like to thank AgriSci Pty Ltd for assisting in the data collection and maintenance of the site.

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IMPROVING SOIL TO OPTIMISE WATER USE ON-FARM

KEY POINTS

- **The economic analysis showed there were a number of low and high-cost options for stubble retention which provide alternatives to burning.**
- **A high liming rate of 6.7t/ha was applied across the demonstration to address the acidity in the 5-15cm layer of soil.**
- **The liming increased the 0-10cm pH across all treatments increased to pH 5.8 or higher, which is the target level of pH to address subsurface acidity.**
- **The 10-20cm pH results for the unincorporated lime treatments were not consistent with current research and require further investigation.**

AIM

To demonstrate different methods to retain stubble for soil moisture retention.

METHOD

The demonstration treatments were decided in collaboration with local farmers and agronomists in the Murchison district of northern Victoria (Table 1). The cost of each treatment was measured using contract rates.

Table 1. Cost of stubble treatments in addition to farmers normal harvest costs (cost does not include liming).

TREATMENT	CALCULATION	DATE	COST $/HA^
1. Harvest cut high# bale 1.7t/ha straw	Income from straw $25 less cost of nutrient removal $62 (see Appendix 2)	20/1/2021	$37
2. Harvest cut low#	Additional cost of cutting low	17/12/2021	$123
3. Harvest cut high, deep incorporation* of stubble		17/02/2022	$125
4. Harvest cut low, deep incorporation of stubble	Additional cost of cutting low $123 deep incorporation $125	17/02/2022	$248
5. Harvest cut high, flail mulch stubble		24/01/2022	$45
6. Harvest cut high, shallow incorporation** of stubble		24/02/2022	$45
7. Harvest cut low, shallow incorporation** of stubble	Additional cost of cutting low $123 shallow Incorporation $45	24/02/2022	$168
8. Burn	Cost of nutrient removal $20 (see Appendix 3), estimated cost of labour for burning $35	06/04/2022	$55

#Harvest cut high: stubble is cut at 40cm, harvest rate is 2.2ha/hr; harvest cut low 15-20cm, harvest rate is 4.89ha/hr

*Deep incorporation was done using a Performer, which cuts, chops and incorporates stubble to a depth of about 15cm. All cultivated treatments required an additional pre-sowing weed spray compared to uncultivated and burned.

^Header contract rate $550/hr, header fuel rate 60L/hr, fuel cost $1.50/l

**Shallow incorporation was done using a multidisc, which chops and incorporates stubble just below the surface. All cultivated treatments required an additional pre sowing weed spray compared to uncultivated and burned.

^In addition to standard farmer practice of harvesting high.

The stubble treatments were done at or after harvest of a wheat paddock in 2021, which was then sown to a second wheat in 2022. A wheat-on-wheat rotation was chosen at Murchison East (Table 2), as traditionally, stubble is burned after the first wheat crop, in preparation for the second. Some of the treatments in the demonstration were based on a four-year research trial in the Riverine Plains which showed that stubble management play a significant role in overall crop production (Riverine Plains Inc, 2019).

Table 2. Site description

LOCATION	MURCHISON EAST
Rainfall (mm): Jan – March Rainfall (mm): April -October Rainfall (mm): Jan-December	88 490 679.5
Sowing date	**8 May 2021**
Row spacing	300 mm
Soil type	Clay
Organic carbon (% 0-10cm)	1.5
Colwell P (mg/kg 0-10cm)	60
Sulphur (KCL 40 0-10cm)	10

A previous project in the region shows that high producing cropping soils may have a layer of acidity below 10cm. Hence, part of the methodology of this project included taking segmented sampling in 5cm increments down to 20cm on the 19 January 2022. This was to identify acid layers and lime requirements. Deep nitrogen and soil moisture samples were also taken on 21 May 2022. Soil sampling for soil moisture, acidity and nitrogen was repeated in January 2023 to allow measurement of changes to the system.

Stubble treatments were applied at different dates between harvest of the wheat crop on 20 December 2021 and sowing of the 2022 Scepter wheat crop on 8 May 2022. Yields were collected using yield monitor data and two samples from each treatment were tested for grain quality and grain nutrient analysis. Grain samples and yield data in December 2022 were taken from the northern area of the paddock that was less affected by waterlogging.

RESULTS

Cost of stubble management treatments

The cost of stubble management treatments from the different stubble management options ranged from $37/ha to $245/ha (Table 2). The lower cost options were burning; baling straw after harvest; shallow incorporation of stubble (using a speed tiller) and flail mulching.

The medium cost options were harvest cut low; harvest cut high/deep incorporation and harvest cut low/shallow incorporation. The most expensive stubble management treatment was harvest cut low/deep incorporation.

The cost of the lime ($60/t) and surface application ($11/t) of 6.7t/ha was $475/ha. The best management practices to incorporate the lime into a wheat stubble is to cut it low and then mechanically incorporate to the required depth, which in this demonstration cost $248/ha.

Soil and water test results 2022

The soil test results showed that acidity was higher in the 10-20cm layer compared to the 0-10cm layer (Table 3). More intensive sampling at 5cm increments (data not shown) showed elevated aluminium levels at 5-10cm, 10-15cm and 15-20cm. Results from the sampling were used to determine a lime application rate of 6.7t/ha, which was applied across the whole demonstration site in May 2022.

Deep nitrogen sampling showed that the quantity of nitrogen after the stubble treatments were applied was varied in the top 20cm, with Treatment 4, deep incorporation with the highest amount of nitrogen (Table 3). There were also differences in Plant Available Water (PAW) between treatments. The 'cut short' treatment had the highest plant available water, followed by burning. The deep incorporation dried the profile out, especially below 20cm.

Table 3. pH (sampled 19 January 2022), Nitrogen and PAW measurements (sampled 8 May 2022).

TREATMENT	pHCaCl2 (0-10cm)	pHCaCl2 (10-20cm)	DEEP N KGN/HA 0-20CM	DEEP N KGN/HA 20-60CM	PAW (MM) 0-20CM	PAW (MM) 20-60CM	PAW (MM) 0-60CM	PAW (MM) 0-60CM
2. Harvest cut short	4.8	4.5	28.3	13.2	22.8	33.7	56.5	
3. Harvest cut long, deep incorporation of stubble	4.8	4.4						
4. Harvest cut low, deep incorporation of stubble			39.3	12.6	19.3	6.5	25.8	
7. Harvest cut low, shallow incorporation of stubble.	Additional cost of cutting low $123 deep incorporation $125	5.1	4.7					
8. Burn		5.9	4.6	34.1	9.5	12.5	32.7	45.2

Plant density, tiller counts dry matter and yield results

Plant densities and tiller counts varied between treatments (Table 4). By the time dry matter samples were taken on 5 September, most treatments had a similar amount of dry matter (between 5.4 and 6.1t/ha). One exception was Treatment 3, harvest cut high, deep incorporation, which had the highest dry matter of 6.8t/ha. The other outlier was the harvest cut low which had the lowest dry matter of 5.2t/ha.

The paddock yield and quality was extremely variable across the paddocks (ranging between 0.1t/ha and 8.6t/ha) and appeared to be more of a result of water logging rather than stubble treatment (Figure 1). There did not seem to be a correlation between dry matter production (at tillering) and final yield (yields presented in Table 4). In general the proteins were good across treatments and the reason some samples were downgraded to AGP 1 was mainly due to low test weights, which reflects that the plants were stressed and waterlogged at the critical times of flowering and grainfill. Grain nutrient testing showed varied nutrient removal levels depending on crop yield (Appendix 1).

Table 4. Plant counts, dry matter counts, head counts, final yield, protein, test weight and screenings.

TREATMENT	PLANT DENSITY (PLANTS/ M2)	TILLER COUNTS (TILLERS/ M2)	DRY MATTER (T/HA)	HEAD COUNT (HEADS/ M2)	YIELD* (T/HA)	PROTEIN %	GRADE
1. Harvest cut high# bale straw	110	343	6.0	315	5.1	11.2	AGP 1
2. Harvest cut low#	109	318	5.2	289	4.7	11.6	AUH 2 & AGP1
3. Harvest cut high, deep incorporation* of stubble	113	425	6.8	372	4.7	13.3	AGP1
4. Harvest cut low, deep incorporation of stubble	107	356	5.4	319	5.1	12.6	AUH2 & AGP1
5. Harvest cut high, flail mulch stubble	127	364	6.1	343	5.3	11.7	H2 & APW1
6. Harvest cut high, shallow incorporation** of stubble	106	334	5.7	300	5.4	13	AGP1
7. Harvest cut low, shallow incorporation** of stubble	122	357	5.8	334	5.8	11.5	APW1 & H2
8. Burn	109	292	5.5	294	6.0	11.6	AGP1 &H2

*Yields were calculated by Precision Ag using Whiteboxgeo to process yield data to remove high level of noise.

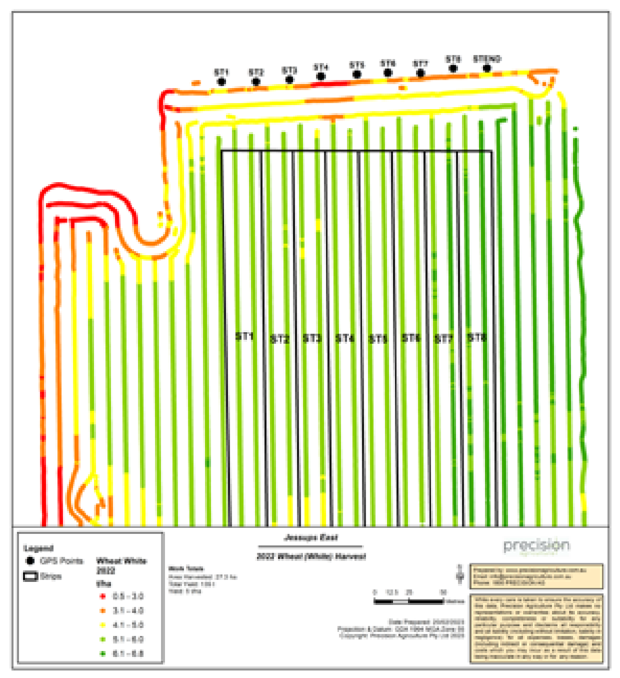


Figure 1. Yield map for stubble management demonstration

2023 pH results compared to 2022

Sampling of soil pH in January 2023 showed that the high rates of lime (6.7t/ha) applied in 2022 increased all the pH levels of treatments tested by between 0.8 and 1.5 units in the 0-10cm layer (Figure 3). The pHCaCl of these treatments after liming was 5.8 or higher, which is the optimum level to treat subsurface acidity.

The weak calcium chloride solution pH test (pHCaCl) increased by a small amount in the 10-20cm layer with all treatments tested increasing by between 0.1 and 0.5 units. The 10-20cm soil test results are not consistent with current research and require further testing to determine the effect of treatments on soil pH in the 10-20cm layer.

Post-harvest residual soil nitrogen and water results

Of the three treatments tested, post residual nitrogen levels were the highest in Treatment 4, deep incorporation, followed by Treatment 2 cut short (Figure 2). The higher levels of nitrogen and soil water in these treatments relate to lower grain yields in these treatments, causing less water and nutrient to be removed. The lowest residual nitrogen and soil water levels were in treatment 8 burn, which correlates to the higher grain yield in this treatment removing more water and nutrient (for grain nutrient removal figures per treatment, see Appendix 1).

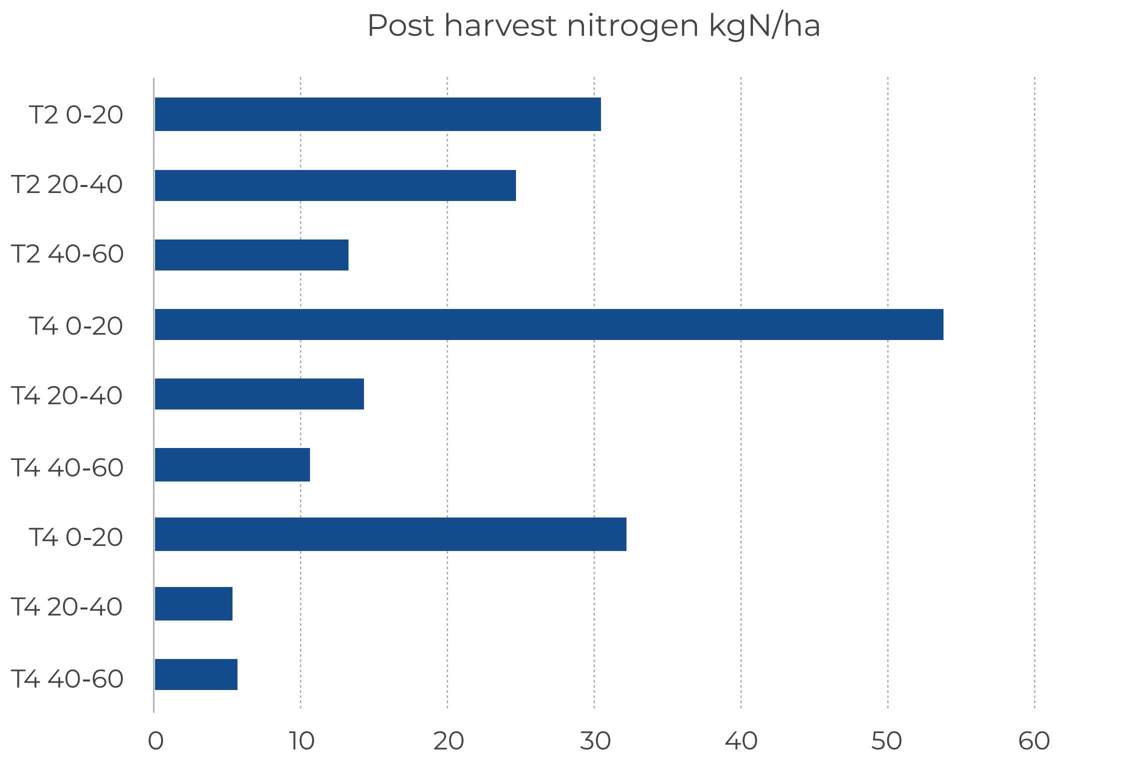


Figure 2 Post-harvest residual nitrogen levels (kg/ha) in T2 Cut low, T4 cut low deep incorporation, T8 Burn

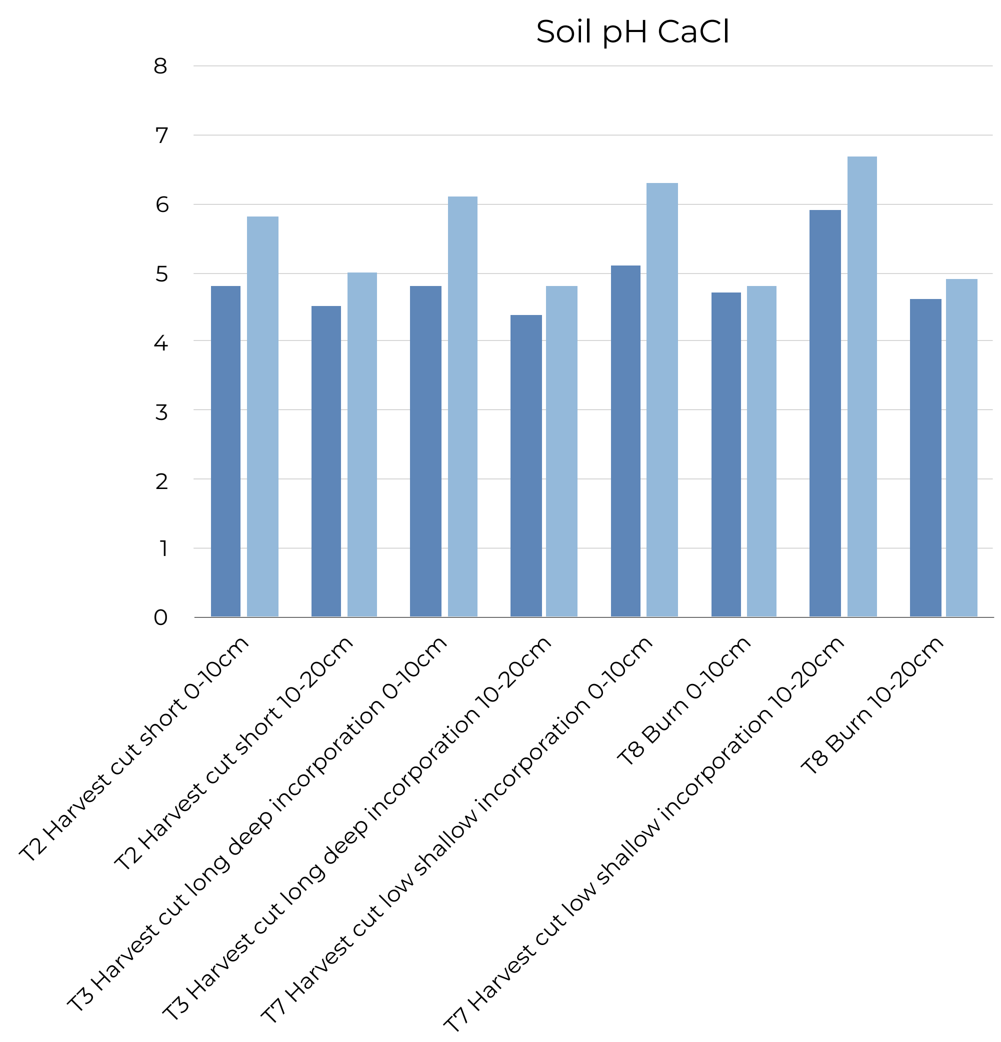


Figure 3 Soil pH levels before and after 6.7t/ha lime with different stubble treatments

OBSERVATIONS AND COMMENTS

The yields and quality across the treatments were extremely variable, due to the very high rainfall received, which caused water logging stress for the crop at the critical time of flowering and grain fill. The difference between treatments was more due to the level of waterlogging within the geography of the paddock, rather than a treatment effect.

Of the seven different options that were tested for stubble retention, three options were lower in cost compared to the burning treatment, which was estimated to cost $55/ha (based on labour costs for burning and nutrient losses by burning). These treatments were post-harvest treatments, including flail mulching, shallow incorporation using a speed tiller and baling straw and cost in the order of $37 - $45/ha. More expensive options were cutting low at harvest with and without deep or shallow incorporation of the stubble, which cost $160- $285/ha.

The deep incorporation of stubble and lime treatment (T3 and T4) was to investigate the practice of deep incorporation of stubbles to mix the lime and wheat residue evenly throughout the 0-15cm layer. This cannot be achieved through surface application or shallow incorporation with a speed tiller. Over the past two to three years, soil testing in the region has shown that surface applied lime is sitting in the top 2-5cm and not moving down the profile due to dry seasons.

A deep incorporation of lime would be used in a situation where a high rate of lime is required to address a subsurface acidity issue (below 10cm) and would be considered as a one in twenty-five-year treatment depending on crop removal of alkalinity. Given the high cost of this treatment, it is recommended that farmers seek advice to ensure the best possible outcome for the investment. In the demonstration, deep incorporation of lime was tested with either cutting the crop at normal height or cutting the crop low, to allow better incorporation. More testing is required on these two treatments to ascertain which treatment gave the best mixing of lime in the soil.

Even though the year turned out to be extremely wet, measurements taken after stubble treatments in the summer of 2021-2022 showed different soil moisture retention between treatments. The harvest cut short had the highest soil moisture retained, followed by the burning. The deep incorporation treatment had the lowest retained soil moisture. This demonstration showed that stubble retention had little effect on yield in 2022 when soil moisture was not limiting, however in drier years an extra 11mm in the soil at sowing (as seen in the stubble cut short treatment compared to the burn treatment), can make a difference of 220kg/ha of wheat, based on a water use efficiency of 20kg/ha/mm. With wheat valued at $350/t, this would represent an income of $77/ha.

Table 5. Grain nutrient removal by treatment, major nutrients
Appendix 1. Nutrient removal (major nutrients kg/ha and minor nutrients g/ha) from the treatments

GRAIN NUTRIENT REMOVAL KG/HA							
Treatment	Nitrogen	Phosphorus	Potassium	Sulphur	Calcium	Magnesium	Sodium
1	107	16.3	21.9	6.1	2	5.1	0.51
2	103	15.5	20.6	5.6	1.8	5.1	0.47
3	113	16.9	22.5	6.1	1.8	5.6	0.47
4	117	16.8	21.4	6.1	2	5.6	0.51
5	116	18	24.3	6.8	2.1	5.8	0.53
6	130	18.9	22.6	7	2.1	6.4	0.54
7	122	19.7	24.3	7.5	2.3	6.3	0.58
8	126	18.6	23.4	7.2	2.4	6	0.6

Table 6. Grain nutrient removal by treatment, minor nutrients

GRAIN NUTRIENT REMOVAL GRAMS/HA					
Treatment	Manganese	Iron	Copper	Zinc	Boron
1	347	383	13.2	96.9	5.1
2	334	348	11.3	94	8.5
3	306	306	16.9	103	4.7
4	316	260	17.3	102	10.7
5	382	355	21.2	111	5.3
6	389	335	19.4	113	7.6
7	406	354	16.8	116	14.5
8	360	348	17.4	114	12.6

Appendix 2. Cost of nutrient removal from baling straw

	NITROGEN	PHOSPHORUS	POTASSIUM	SULPHUR	TOTAL COST $/HA
*Nutrient removal straw kg/t	6.1	0.36	11.7	1.17	
Straw removed t/ha	1.7	1.7	1.7	1.7	
Kg removed /ha	10.4	0.6	19.9	2.0	
Nutrient cost $/kg	1.75	4.2	2	0.8	
Cost of nutrient removal $/ha	18.15	2.57	39.78	1.59	62.09

Appendix 3. Cost of nutrient removal from burning

	NITROGEN	PHOSPHORUS	POTASSIUM	SULPHUR	TOTAL COST $/HA
*Nutrient removal straw kg/t	6.1	0.36	11.7	1.17	
Straw removed t/ha	2	2	2	2	
Burning removal %^	88	0	0	75	
Kg removed /ha	10.7	0.0	0.0	1.8	
Nutrient cost $/kg	1.75	4.2	2	0.8	
Cost of Nutrient removal $/ha	18.79	0.00	0.00	1.40	20.19

*Source: Lee Menhenett, Incitec Pivot
^Source: Stubble retention in Southern Aust. BJ Scott

ACKNOWLEDGEMENTS

This project is jointly funded through the Australian Government's Future Drought Fund and Riverine Plains Inc. Riverine Plains wishes to thank farmer host the Brown family, and contributions of soil and grain testing Incitec Pivot and machinery and labour contributions by Graeme Donaldson, Scott Perry, the Brown family.

Authors: Kate Coffey, Riverine Plains; Lee Menhenett, Incitec Pivot.

ORGANIC FERTILISERS FOR CROP NUTRITION

KEY POINTS

- The use of biosolids, manures and other forms of organic fertilisers was raised as a priority area of interest at a Riverine Plains Research Advisory Committee, Grains Research and Development Corporation's (GRDC) Corowa National Grower Network Forum (NGN) and through conversations with FAR Australia.
- The GRDC National Grower Network (NGN) supported the development of a two-year project to investigate the issue.
- The project coincides with a steep rise in global fertiliser prices, which has prompted grain growers to consider alternatives for improving soil fertility.

BACKGROUND

An abundance of organic amendment options exist in northeast Victoria, due to the proximity of feedlots and other intensive livestock operations. Therefore, there is local interest in using these by-products to supply nutrients for grain production systems and improve soil conditions that may normally constrain yield (creating a circular economy).

Nitrogen fixation provides most of the nitrogen demand of grain legume crops (assuming adequate rhizobial function) at high yields. A large part of this fixed nitrogen is exported in grain, which can affect the pulse crop's ability to restore fertility to the soil. With the said nitrogen leaving with the grain, remaining nitrogen in the soil may not be enough to sustain higher-yielding wheat crops the following season.

This project is evaluating whether benefits of nitrogen fixation by legume crops can be amplified with added organic amendments or manure. It is also investigating whether this strategic use of organic amendments can help buffer the farm business from high synthetic fertiliser inputs. The project is assessing the impact of two different application timings of nitrogen on faba bean yield, and wheat yield in the following year. The outcome of these trials will be communicated via a workshop, field days and communication material.

METHOD

Wheat trials were established in Bundalong, Victoria in autumn 2022 on 7t/ha (grain yield) faba bean stubble from 2021 crop. Trials were designed using a split-plot design with manure applied as shown below in Table 1. to faba bean stubble as the main plot, and in-season nitrogen fertiliser in wheat as a sub-plot superimposed on manure.

Manure rates for treatments 3-8 were spread by hand in early April and then incorporated with an offset disc cultivator. Wheat was sown at the end of April and nutrient treatments 9-12 were applied shortly after. Soil samples were taken pre-sowing and again prior to GS30. In-season fertiliser applications (75kg N/ha) were applied after GS30, for the specified treatments. Fallow and green manure plots have been established in the 2022 faba bean paddock, ready for the 2023 trial.

The treatments can be seen in the following table.

Table 1.

TREATMENT	DESCRIPTION
1	Control; farm standard
2	Control; Plus 75kg N/ha
3	2.5t/ha manure; farm standard
4	2.5t/ha manure; Plus 75kg N/ha
5	5t/ha manure; farm standard
6	5t/ha manure; Plus 75kg N/ha
7	10t/ha manure; farm standard
8	10t/ha manure; Plus 75kg N/ha
9	Nutrient Value of 5t/ha manure (N only fertiliser); farm standard
10	Nutrient Value of 5t/ha manure (N only fertiliser); Plus 75kg N/ha
11	Nutrient Value of 5t/ha manure (NPKS fertiliser); farm standard
12	Nutrient Value of 5t/ha manure (NPKS fertiliser); Plus 75kg N/ha

RESULTS

Early results of the trial show that application of manure at any level, with the addition of 75Kg/N per hectare were the only significant treatments that lead to a significant increase in yield from the control treatment. The quantity of manure added did not have an impact on yields.

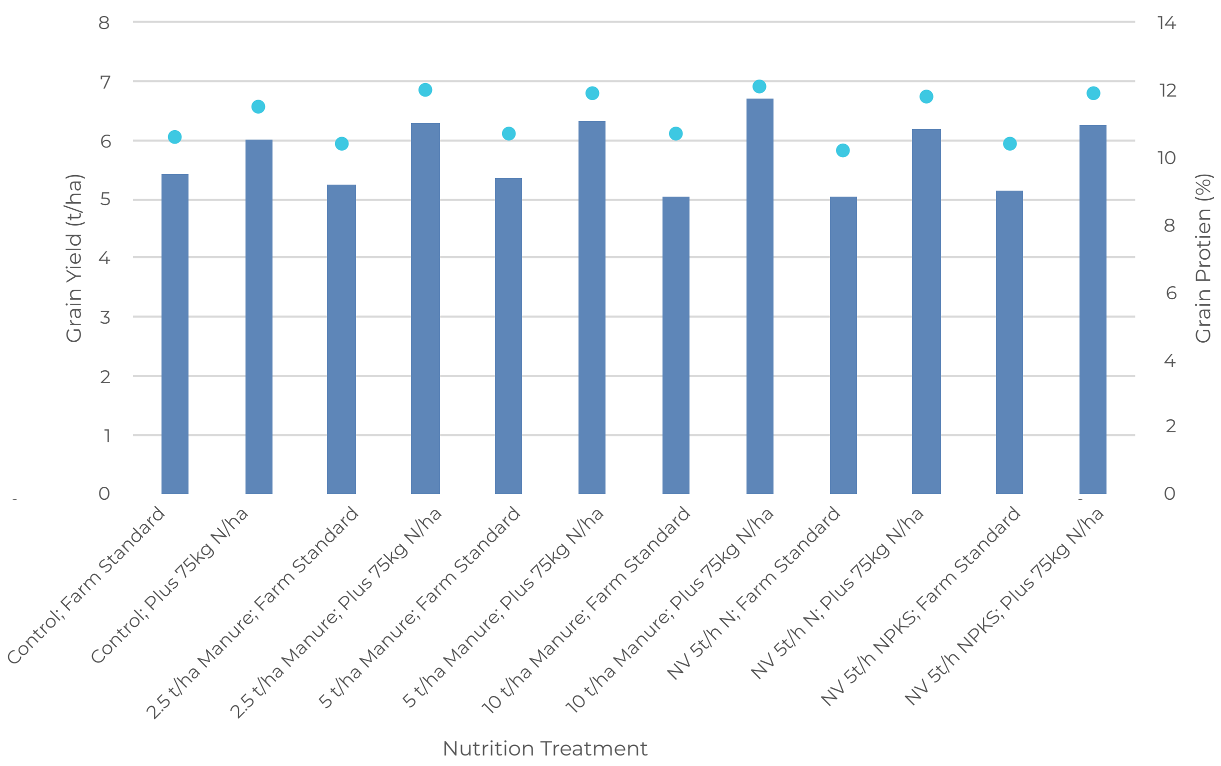


Figure 1. The 12 treatment combinations of nitrogen with or without manure applied compared to control plots consisting of either the farm standard nitrogen applied and 75kg N/ha applied. Aqua dots represent the protein levels of each treatment.

CONCLUSION

At this stage, the reasons for results seen in the first season of the trial are unclear. However, possible causes could be that background fertility of the soil was high, or that the wet season did not create water limitation, and with good control of disease, the crop was essentially at yield potential. A further season of data is required to confirm the causes of these early results.

ACKNOWLEDGEMENTS

This project is supported by GDRC and our collaborators on the project, FAR Australia. Thanks also goes to the Inchbold family as co-collaborators on the project.

Authors: Dr Sara Hely, Riverine Plains; Ben Morris, FAR Australia.

Credit: Beatrix Clarke

BUILDING DROUGHT RESILIENCE THROUGH STOCK CONTAINMENT INITIATIVES

KEY POINTS

The main barriers to adoption were:

- **A belief that farmers did not need containment facilities to survive drought.**
- **A fear of making large capital investments that would be rarely used or not work as expected.**
- **The risks associated with operating containment facilities, especially feed rations, animal health, animal welfare and labour.**

BACKGROUND

Stock containment or containment feeding is considered an important practice for farmers wanting to manage retained livestock during drought, while avoiding degradation to the pasture, land and water resources. Yet surprisingly few farmers have dedicated containment facilities, despite the success of those who have established them. If it is assumed that containment feeding is a practice to build farm resilience, then it is important to understand the current barriers to adopting containment practices and make investment decisions to mitigate those barriers.

METHOD

A literature review, workshops and interviews was conducted with more than 170 farmers across Victoria, Tasmania and South Australia. An analysis was then completed on the outcomes of these engagements and resulted in providing a set of recommendation for investment in projects that would accelerate adoption.

RESULTS

The literature review conducted by Riverine Plains in collaboration with Melbourne University's Paul Cheng, examined how stock containment areas were used for emergency feeding and managing seasonal challenges in southeastern Australia. The review found there was limited scientific studies conducted on the topic, particularly on the cost benefit, social and biophysical analysis. The review highlighted that most literature was previously focused on sheep and there are many biotic and abiotic factors that contribute to decision making around the implementation and use of stock containment areas.

Following the literature review, consultations were conducted to understand why some farmers had established a stock containment area and others had not.

Of the farms investigated, 30% have stock containment areas and 45% use sacrifice paddocks when faced with drought.

Five areas of investment were identified to address the barriers to adoption of containment feeding. These were:

- enhancing decision making
- establishing a team of local experts to provide advice
- providing information on options
- design and operations
- identifying priority areas for containment feeding through research
- implementing a communications strategy

SUMMARY

By identifying the main barriers to adoption of stock containment areas, a list of investment activities were proposed that, if adopted, would lead to a fourfold increase in adoption after 10 years. Riverine Plains plans to deliver projects that will increase farmer adoption of stock containment areas and consequently increase livestock farmers' productivity, profitability and adaptability as well as protecting grazing land during periods of drought.

This would result in an additional 9,650 farms having containment facilities across Victoria, South Australia and Tasmania. If these facilities were used during drought, they would contribute to the protection of 4.23 million hectares of improved grazing land across these states.

ACKNOWLEDGEMENTS

The Future Drought Fund with support from the Victorian Drought Hub, through the Australian Government Department of Agriculture, Forestry and Fisheries funded this project.

Author: Sophie Hanna, Riverine Plains.

CASE STUDIES

SMART FARMS SMALL GRANTS: SOIL EXTENSION ACTIVITIES

BACKGROUND

Soil issues in the Riverine Plains region are complex and can be segmented through the soil profile i.e., acidity may not be present at the surface but can be quite profound at 15cm depth. This means soil testing needs to be comprehensive and better targeted to understand where problems lie. Traditional soil testing at 0-10cm depth does not pick up deeper soil issues, however comprehensive soil mapping, ground truthing of soils and amelioration is expensive, which has been a disincentive for farmers.

This project will support land managers by promoting the benefits of more frequent, comprehensive and targeted soil sampling and testing to inform better soil management decisions that improve soil health outcomes.

AIM

This project aims to give farmers a better understanding of their soils and how soils can be better managed to improve production, water retention and water use.

TRIAL UPDATE

In early 2022 our farmer hosts identified paddocks with problem soils, determined through electromagnetic surveys. These sites were soil tested at 5cm increments, to understand the key constraints contributing to the issues seen above ground. The results were analysed by soil scientists and presented at our 2022 workshops alongside further discussion on acidic and sodic soils.

After these events we asked local farmers and agronomists to join our discussion group for the project. This group allows farmers to follow what is happening in the trial more closely and be involved with decision making.

Our first discussion group worked through soil tests taken across the host farms in Rand, Buraja and Daysdale, sharing ideas on a treatment plan for the 2023 amelioration demonstration trial. From the two paddocks selected to continue, one paddock has acidic soil, with high aluminum saturation and the other sodic soil (high percentage of sodium ions).

The result of the discussion was to focus the trials on different machinery options to incorporate various lime rates at the acidic site, and lime with various gypsum rates at the sodic site. The numerous machine options, Speedtiller, Deep offset discs, Lemken Rubion 10 and Horsch Tiger, will help provide further understanding and comparisons for product incorporation and depth, seed bed preparation and overall plant establishment. The final treatment plan has been reviewed by soil scientists and shared with the discussion group. The next step is for the paddocks to be grid sampled for pH to assist with determining lime rates for the trial. A field walk will be held at both sites in August 2023 to see the effects of the various treatments. Yield maps and post-harvest soil tests will be used to measure results at the end of the trial and presented at our final workshop in early 2024.

ACKNOWLEDGEMENTS

This project is supported through funding from the Department of Agriculture, Fisheries and Forestry through the Smart Farms Small Grants program and is co-funded by the Grains Research and Development Corporation. It is delivered by Riverine Plains with partners AgriSci, Precision Agriculture and NSW Department of Primary Industries. Riverine Plains would like to thank its farmer hosts, Roy and Michael Hamilton, Denis and Rebecca Tomlinson and Beau and Rebecca Longmire, for the use of their land and support throughout this trial.

Author: Rhiannan McPhee, Riverine Plains

STUBBLE RETENTION CASE STUDIES

INTRODUCTION

Stubble retention in the cropping systems of Riverine Plains was made possible with funding from Grains Research and Development Centre (GRDC) and thanks to the Sustainable Agriculture Victoria – Fast Tracking Innovation Initiative. In addition, we are thankful to the Foundation for Rural and Regional Renewal (FRRR), and the William Buckland Foundation, for providing the opportunity to better understand key drivers in stubble retention systems through the publication of the research and farmer case studies to showcase the outcomes from the project.

The Stubble project was a five-year program initiated in 2013. GRDC commissioned 10 projects involving Riverine Plains and 15 other farming systems groups/research organisations. It was dubbed 'The Stubble Initiative'. Each of the 10 projects focused on a locally relevant issue that impacted on the profitability of retained-stubble systems across a range of environments in southern Australia. The project's aim was to develop regional guidelines and recommendations to assist local growers.

KEY LEARNINGS

- Stubble management is not a key driver of yield – stubble management approaches should be considered strategic and flexible not a fixed element that has to be managed around. It is recommended to retain stubble where possible but use tools such as mulching or incorporation to optimise the efficiency of the farming system. Only use burning as a strategic tool when necessary.
- Long stubble shades the emerging crop, resulting in a delay in flowering and maturity. Growers can use this to their advantage by sowing crops earlier into a longer stubble and still have them flower in the correct window, allowing the spread of sowing operations.
- Long stubble did not significantly increase the risk of frost damage in the Riverine Plains region. The likelihood of frost damage is directly connected to the date of flowering and is dependent on whether the date of the frost event coincides with flowering. Managing risk of frost damage by employing a range of sowing dates or stubble heights across a variety/paddock helps spread the risk.
- If full stubble retention is not feasible due to machinery, weeds or disease constraints, there are other options such as shallow incorporation, slashing straw or cutting short at harvest which can reduce the frequency of burning and address timeliness issues.

SUMMARY

- Strategic burning is a useful tool to have, especially when stubble loads are high.
- Accurate GPS systems are vital for inter-row sowing operations which allow the farmers to sow through their stubbles from the previous year.
- Different methods of sowing/seeder bars result in different thresholds for change in terms of maximum stubble load that can be retained.
- There are some drawbacks associated with stubble retention that may be the reason why some farmers are slow to adopt.
- Poor weed control from pre-emergent herbicide application.
- Still the perception that retaining stubble increases your risk of frost damage.
- Higher risk of pests e.g. slugs, slaters, mice, earwigs.
- Nitrogen tie-up – it is expensive to apply extra fertiliser required and payback is slow.
- Poor establishment due to early shading, particularly for canola sown into cereal stubble.
- It is much easier to retain stubbles in lower rainfall years and the major benefits of doing this are to conserve moisture and prevent soil erosion.
- Stubble management practices to help with high stubble loads include harvesting cereal crops at a lower height or slashing straw post-harvest.

KNOWLEDGE OPPORTUNITIES

- To what extent does stubble retention help improve soil carbon levels?
- Wet summers lead to higher pest populations on retained stubbles – how can we manage these higher pest populations efficiently to ensure productivity levels can be maintained?

STEVE LUDEMAN

BACKGROUND

With the help of funding through FRRR we are updating the outcomes from the Stubble Initiative. Back in 2018 we did a case study with Steve Ludeman, who farms at Dookie with his brothers Tony and Chris. Their farm has variable soil types, ranging from light sandy loams to clays to self mulching clays and red volcanic soils. In this case study we reviewed how Steve's stubble management practices have changed in his farming system over the past five years.

Location:

Dookie, Victoria

Describe your farming enterprise?

100% cropping.

What is your usual cropping sequence/ rotation? Is there a pasture phase?

Four-year rotation: faba beans and/or vetch, wheat, canola, wheat. Adding pulses in our rotation has helped us to increase nitrogen in our soils as well as providing a good chemical and disease break. The vetch seems to be the standout performer for fixing nitrogen from our deep nitrogen test results.

What value do you place on retaining stubbles in your cropping system?

We place a high value on stubble retention in our system. The main reasons include improving soil structure, raising the moisture holding capacity of the soil and from a management perspective it means less hours in the paddock either on the tractor or burning.

What percentage of cereal stubble do you retain?

We aim to retain 100% of our stubbles. Strategically we may choose one or two paddocks a year to burn to help with pre-emergent chemical application. However, last year due to the high stubble loads we had to burn a few more paddocks. This also helped the soil profile in a few of our paddocks dry out and we have more nitrogen freely available.

How do you manage your stubbles within your cropping system?

Our main issue when planting canola into a cereal stubble five years ago, was the lack of nitrogen available to the plants. To mitigate the nitrogen tie-up, we are now applying 100kg/ha of urea on crops early post-emergence to help break down cereal stubbles.

How do you change your management style based on the weather conditions?

If we have a good year with big stubbles we will burn a few more paddocks, this also helps the paddock dry out faster if we have had high summer rainfall like last year. This is vital to allow us to sow the following season's crops on time.

What is your threshold for any change in management?

We haven't got one at the moment. If we did have one, last year's wheat crops averaging 8t/ha, would have exceeded it. I would say 6.5-7t/ha would be where we would have to look at changing our management. Last year we slashed the stubbles but ended up burning the trash in more paddocks than we would have if we didn't have so much summer rainfall.

What height do you harvest your cereals at?

We harvest at a maximum height of 300mm in our cereal crops. If we need to lift up due to high stubble loads, we harvest at 500mm and then slash down to 250mm later, before sowing.

How do you manage your stubbles over summer and before sowing?

Slash, burn if required, or they are sown straight into.

What is your set up for sowing?

We have a positive parallelogram system which has depth gauge wheels and coulters at the front, followed by a fertiliser tyne and a seed placement closing tool, then coil press wheels at the back.

The seeder has 330mm spacings. We also have a steerable John Deere hitch. In the past we sowed inter-row however we found this was only 75% successful when sowing through stubble and led to a few establishment issues. We now sow wheat on a 7-degree angle to alleviate these issues.

Have you had to invest in new equipment to help manage your stubble or are you planning to in the future?

Currently we are hiring a slasher to mulch our stubbles down after harvest. If we decide that it is the right direction for our farming system, we will purchase one.

Has your approach to stubble management changed over the past 10 years?

Yes, we now retain much more stubble than we did 10 years ago.

If you have moved to no-till full stubble retention, what benefits have you seen?

Soil structure on most soil types has improved. Another benefit is the higher soil moisture conservation under the retained stubbles, which provide cover over the soil in the normally, hot, and dry summer months.

What are the drawbacks to stubble retention?

Spending more on fertiliser to break down the stubbles, we find it takes a few years before we get the payback from this. We still have major concerns about frost events.

Pests were a major issue last year, exacerbated by the wetter summer months. We had slugs, slaters, earwigs and mice to a lesser degree. Slugs did the most damage in canola following wheat however we also had damage in wheat following faba beans.

In some paddocks we had to bait up to three times which is an expensive exercise. We find weeds manageable as we are starting from a low weed threshold.

Have you observed any changes in infiltration, soil structure or soil carbon levels as a result of retaining stubbles over time?

Soil structure has improved through retaining our stubbles. With regards to soil carbon, it is, in my opinion, too early to say. There is a lot of work that needs to be done and the goal posts seem to be shifted regularly.

What do you feel has been one of the greatest learnings to come out of the Stubble project work for the Riverine Plains region?

The greatest learnings that we have taken from the stubble project is the improvement of soil structure through the addition of organic matter from stubble retention. This helps improve the water holding capacity of the soil, allowing greater establishment and plant available water if there is very little rainfall over summer prior to sowing.

Authors: Lynn Macaulay and Kate Coffey, Riverine Plains.

FRRR
Foundation for Rural Regional Renewal

DENIS TOMLINSON

BACKGROUND

With the help of funding through FRRR we are updating the outcomes from the Stubble Initiative. Back in 2018 we did a case study with Denis Tomlinson (Riverine Plains Inc, Stubble retention in cropping systems of the Riverine Plains 2018), who farms at Coreen on variable soil types, ranging from heavy clays to clay loam to loams over clay. In this case study we reviewed how Denis' stubble management practices have changed in his farming system over the past five years.

Location: Coreen, NSW

Describe your farming enterprise?

We are dryland continuous cropping enterprise growing wheat, barley, and canola. All our land that can be cropped is. We also run a couple of hundred first cross ewes on areas that cannot be cropped.

What is your usual cropping sequence / rotation? Is there a pasture phase?

We have a four-year rotation of canola, wheat, wheat, barley but an increasing area of vetch and sub-clover. This helps to reset our paddocks, put some nitrogen back into the soil and clean up some annual ryegrass problem areas.

What value do you place on retaining stubbles in your cropping system?

We place a high value on stubble retention. We prefer to retain stubbles where we can where the positives of stubble retention are not outweighed by the negative impacts. We are pragmatic with our approach.

What percentage of cereal stubble do you retain? Does this vary from year to year with stubble load, or do you have a standard approach across years?

The percentage of stubble that we retain varies year to year, mainly depending on seasonal conditions. In a dry year, low-yielding year we will retain as much as possible, up to 100% of cereal stubble, because it helps keep moisture in the soil. In a year where the stubble load is high, retention may be as low as 30%.

How do you manage your stubbles within your cropping system?

We manage stubble height at harvest time by cutting at around 200mm. In addition, since the project ended, we have upgraded our header to a New Holland CR990 which provides us with a much more even spread of chaff and straw, preventing block ups when sowing.

How do you change your management style based on the weather conditions?

If the conditions in summer are wet then summer weed control is vital to ensure weeds are controlled before they get too large, as then they become a problem at sowing time. If there is a wet autumn forecast, we will have to burn the paddocks early in preparation. Paddocks with retained stubble take longer to dry out compared to paddocks that have had the straw baled or burnt.

What is your threshold for any change in stubble management?

There are a number a factors that we consider but I would say a wheat crop that has yielded over 4t/ha is a paddock that we will have to look at and assess the stubble load.

What height do you harvest your cereals at?

200mm.

How do you manage your stubbles over summer and before sowing?

Our system is no-till. We do lightly graze the stubbles to clean up any grain left over after harvest, and this helps reduce the likelihood of any major mice or slug problems.

What is your set up for sowing?

We have a DBS bar with knife points and press wheels on 300mm spacings. The RTK guidance system on our John Deere 8370RT tractor is vital to interrow sow accurately, allowing us to sow through our retained stubbles.

What are the drawbacks to stubble retention?

Drawbacks include the reduction in effectiveness of pre-emergent herbicides, the potential for seeder blockages, nitrogen tie-up and reduced crop establishment, particularly due to early shading of canola in a cereal stubble. Other issues may include the buildup of mice and slugs. These potential drawbacks can be alleviated using legumes in the crop rotation, and with strategic burning of heavy stubbles.

As a host farmer for the Riverine Plains GRDC stubble project since 2014, have you changed your farming practice based on the results obtained?

From the project we have realised that we needed more nitrogen in our cropping system. We are doing this by using higher rates of urea and incorporating legumes in our crop rotation.

At the moment, we are incorporating lime at high rates with the aim of increasing our soil pH at a depth of 125- 150mm.

Hopefully correcting our soil acidity problems will open up a greater potential to grow more pulses in the future.

What do you feel has been one of the greatest learnings to come out of the Stubble project work for the Riverine Plains region?

The project looked at different stubble management strategies and we now understand what effect each strategy has on our farming system. If a strategy has a negative effect, we can apply practices that ameliorates that effect.

Authors: Lynn Macaulay and Kate Coffey, Riverine Plains

FRRR
Foundation for Rural Regional Renewal

INNOVATION UPTAKE CASE STUDY: ADDRESSING SUBSURFACE SOIL ACIDITY

INTRODUCTION

AgriFutures Innovation Uptake Program demonstrates how a farmer, Curt Severin from Brocklesby, used technology to apply lime using variable rates on his farm. Curt identified an issue with soil acidity and by partaking in two Riverine Plains projects, the *Cool Soil Initiative** and the GRDC's Hyper Yielding Crops project**, he used various forms of technology and advice to quantify the problem and then implement and evaluate a solution. Curt has been able to compare two different treatments for application of lime on the paddock and measure the performance of each treatment.

What issues/problems did you have prior to using the technology?

We were trying to get better value out of the lime, so back in 2015 we started pH mapping. Through our own experience and talking to others we found it better to apply the lime at different rates based on the pH mapping in the paddock, rather than doing blanket rates across the whole paddock. We are targeting a pH of 5.8 across the paddock, making blanket application across the paddock an inefficient way of applying the lime.

Another issue was some of the soil testing was not making sense, for example in one test there was a pH of 4.2, but the paddock still produced a 3 t/ha canola crop. However, we then realized that the transect sample included cores from a small patch of the paddock that was quite acidic and wasn't representative of the paddock. We could see some variation in the paddock but didn't really understand the extreme nature of the pH, which can differ by a whole pH point, for example pH 4.2 to pH 5.2. In the first year when we did the mapping, we had the contractor apply 1.3t/ha to half of an unmapped paddock and 2t/ha to the other half based on separate transect samples. It had a massive effect on the paddock itself and the soil test results the following year showed the benefits of applying the two different rates of lime.

After we started doing the variable rate lime application, there were still some problems with production on some paddocks and we wanted to find out more. Targeted sampling with Precision Agriculture focused on areas that had been performing poorly for about three or four years running, especially in the dry years of 2018 and 2019. These segmented soil tests showed subsurface acidity levels of pH 3.8 at 10 – 15cm depth in the poor yielding area compared to pH 4.2 in the better yielding area. Ryegrass also grew well in the poor performing area due to lack of crop competition, which was another indicator of a greater problem in these areas. We were applying the lime to the surface and we thought that the air seeder was incorporating the lime, but it was not.

By using some basic soil test kits, we could see that previously applied lime was just staying in the top 2cm and not moving into the root zone. The tests and yield results both showed that where we had been applying variable rate lime, we were getting a result but we questioned whether it could be better. We were applying the lime at the rate required where it was needed however, in some cases the lime was still at the surface and it was taking far too long to get to where it was needed, so we decided we needed to physically get the lime down deeper in the soil. The original pH mapping was far too shallow, as we only sampled 0-10cm. So next time we map we will do 0-20cm as well as segmented sampling to get more accuracy on where the lime is sitting.

To incorporate the lime, we looked at a number of machines to get the lime to where it was needed. With the help of soil science company AgriSci Pty Ltd, we identified that at 20cm there was slaking clay that we would not want to disturb with cultivation. We settled on the Lemken Rubin 12 which is full disc and no tynes. The limit of cultivation depth for the Lemken is 20cm compared to the Horsch Tiger which goes deeper but did not suit our purpose. The Lemken was able to mix the lime into the soil at 150 -170mm and it was well mixed. It got the lime down into the worst area and 90% of the time fully incorporated the wheat stubble at the same time. It's something I thought I would never say, but I bought a plough. It seems so wrong because it is something I have rarely done and it's not common practice. We have gone an extra step this year and bought a grader board to smooth out and firm the surface afterwards to make it better for seeding. The Lemken is not too expensive to run because it is not going as deep as some of the other machines.

What were the key lessons?

1. Find the right people to help you investigate your issues and potential solutions. For example, if you have a soil problem, consult with a soil scientist.
2. Look at the data available to you, such as NDVIs and yield maps to identify poor areas in a paddock over a number of years. Talk to someone who is experienced in interpreting the information.
3. Find out why a paddock is not performing by looking into possibilities such as disease, pests, soil types or soil issue.
4. If it is a soil issue, try and do some segmented samples to depth in the poor areas (0-5cm, 5-10cm, 10-15cm, 15-20cm) and compare them to the good areas.
5. Based on the results of the segmented soil tests, determine how to do the soil mapping (such as 0-10cm, or 10-20cm). Use the soil mapping, with the help of advisors, to work out a strategy to fix the problem.
6. Once you have implemented the strategy, follow up with relevant data to measure how well it worked.
7. Follow up with long term monitoring of the site.

What is the outcome provided by technology?

The outcomes are more targeted application of lime to try and fix soil issues where they are causing yield loss, which provides an economic return from the applied lime. We are applying more lime than in the past. We realised we weren't applying enough lime because we were testing the pH at 0-10cm, however the pH was declining in the 10-20cm zone. As a result of our investigations, we know where the problem is, and can address it.

What benefits are you seeing by using technology?

It's a bit tricky to tell as we have made other improvements such as new airseeder with liquid system. Any paddocks tested with the pH indicator have shown that the pH has improved to depth. We have been able to address the acidity issue deeper in the soil profile by using cultivation to incorporate the lime. We need to be aware that if it gets wet, it can be hard to sow cultivated paddocks as they risk being too wet compared to uncultivated soil. Also cultivation stirs up weeds such as dormant radish in the winter and heliotrope in summer. With the use of advisors, and by being part of Riverine Plains projects we now understand how the technology can be used and interpreted to manage our soils and maintain production on our farm.

What is Normalised Difference Vegetation Index?

It determines the amount of greenery in an area of land. An image of the paddock is generated where the darkest green represents large amounts of greenery and red shows little to no amount of greenery. For example NDVIs can be used to show poor growing areas in a paddock throughout the year.

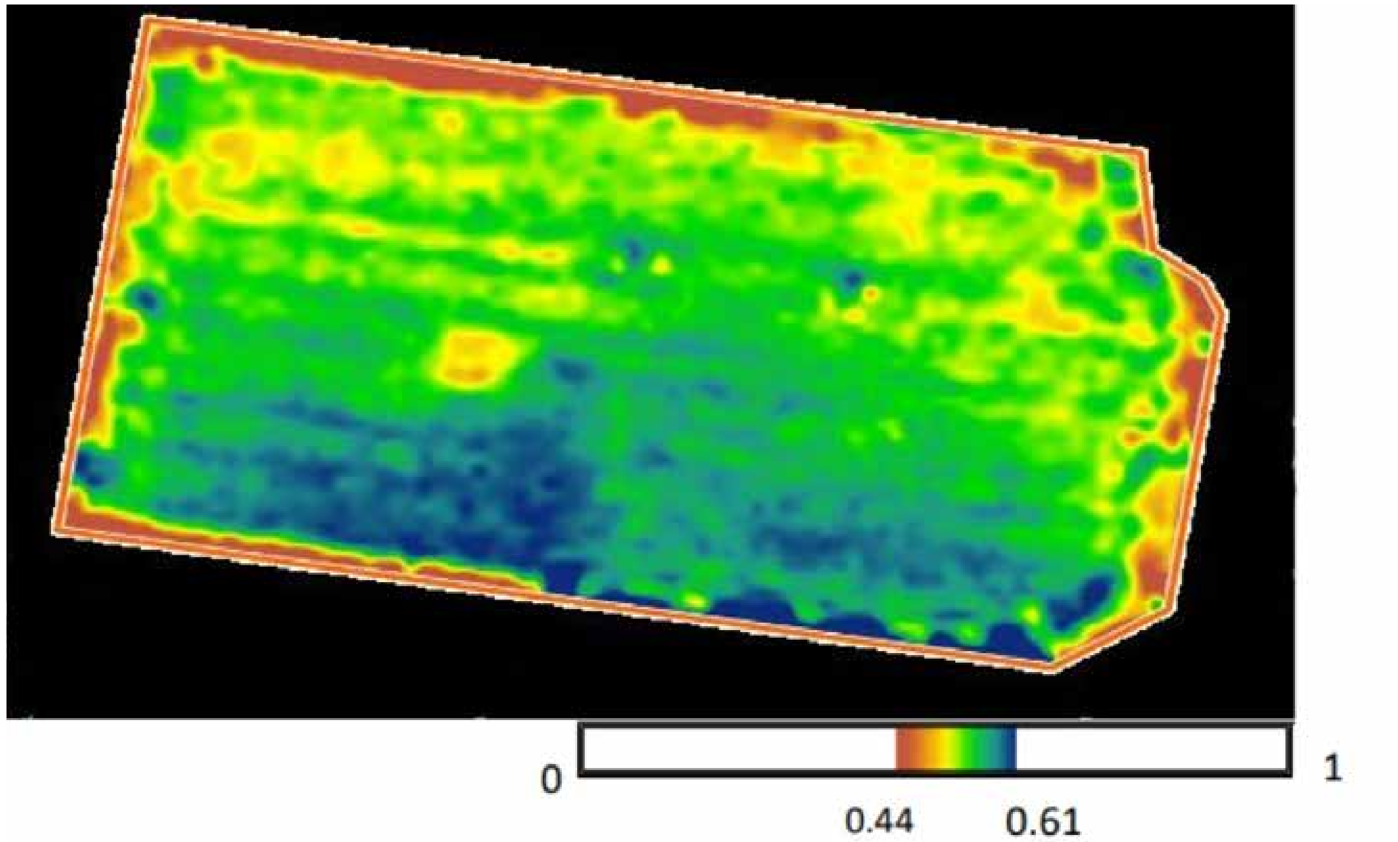
*Cool Soil Initiative see update on page 104

**Hyper Yielding Crops see update on page 42

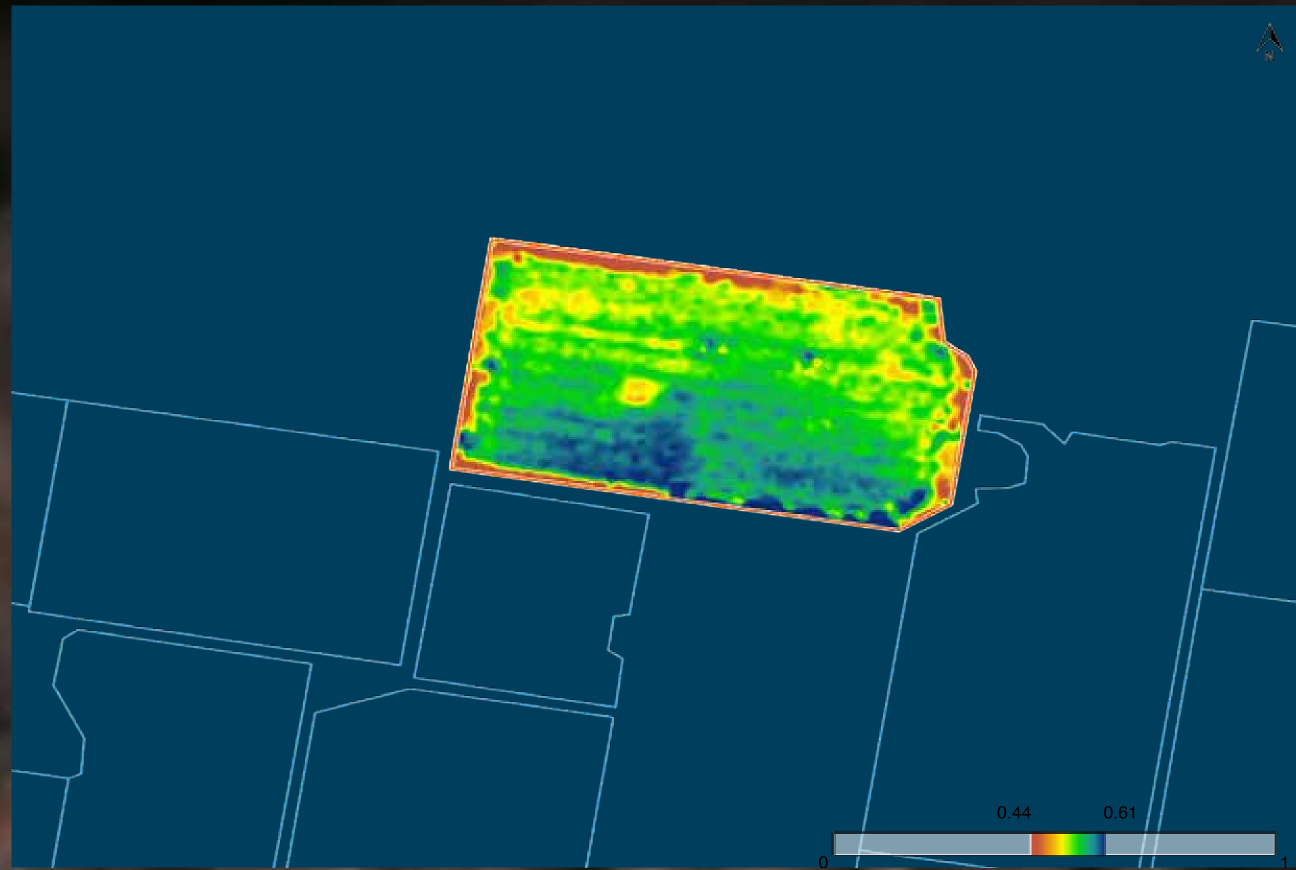
Thanks to farmer co-operator Curt Severin who shared his experience with addressing sub-surface acidity for this project.

Author: Kate Coffey, Riverine Plains.

Farmers inspected the emergence of canola in a paddock that Curt incorporated lime at the Riverine Plains Hyperyielding and Cool Soils Initative Crop Walk. Curt left 3 squares in the paddock that were not incorporated for comparison (see foreground).



NDVI map (taken of wheat 21 July 2022) showing poorer performing areas where the lime was not incorporated in 2021. It is particularly obvious with the yellow and red square in middle of the image.



Drone shot of Curts paddocks taken in July 2021. The areas that were not mechanically incorporated are the squares shown in the photo. The diagonal lines show the angle that the paddock was cultivated to incorporate the lime. Photo courtesy: Jon Midwood.

COOL SOIL INITIATIVE CASE STUDY - PETER CAMPBELL

KEY LEARNINGS

- During the first few years of application, post-harvest application of fertiliser does not have a statistically measurable impact on soil organic carbon (SOC). There may be a positive result after 5-10 years but the monetary value of that stored carbon would have to be significant to recoup the costs of applying fertiliser over this time.
- There are benefits in continuing to focus on maintaining soil cover and soil organic matter, even if SOC levels do not increase. Maintaining high microbial activity will have many physical, chemical, and biological benefits that go beyond the actual SOC value.

BACKGROUND

With the help of funding through FRRR we are updating the outcomes from the Soil Carbon project. In 2018 we conducted a case study with Peter Campbell, who farms at Henty on a mixture of red brown earths and yellow podzolic soil types. In this case study we reviewed how Peter's soil carbon management practices have changed in his farming system over the past five years.

What is your farming enterprise?

We run a mixed farm with sheep and cropping over 1200ha. We currently have around 2800 breeding merino ewes and 2000 lambs.

Describe your cropping sequence or rotation?

Our cropping rotation is flexible. Generally, we start with a pasture phase, followed by canola followed by wheat, then barley, oats, triticale, narrow leaf lupins or arrowleaf clover. We rarely have two consecutive wheat crops and try to put a pulse in the middle of the five-year cropping rotation.

How do you manage your stubbles?

We try to retain our stubbles 100% across the farm. This year was the first year in 20 years that we had to burn paddocks because of the large stubble load and high moisture in the soil. If we didn't burn, then we would have had yield penalties and possibly would not have been able to sow in some paddocks due to how wet they were. Although we try to keep our stubbles and sow through them you must be flexible in your approach.

What pulse do you sow and what are your perceived and real benefits from including a pulse?

I have sown faba beans and albus lupins but found the grain yield to be unreliable so now we stick to narrow leaf lupins. The benefits of growing a pulse include providing a disease break and lower costs through not having to apply nitrogen and sometimes phosphorous.

We use an aerial seeded clover such as arrowleaf in the middle of the cropping phase for a disease break and nitrogen input.

Do you use pastures, and what is the composition of the pasture, and how long does your pasture phase go for?

We have a pasture phase of 7-10 years in paddocks. Generally, the paddocks with poor draining soil types stay in pasture longer than those that drain more freely.

We use a lucerne sub-clover mix on the free draining soils and either phalaris or tall fescue and sub-clover on the poorly drained soils.

What range in soil carbon values do you have across your property (0-10cm) and how have these changed in recent years?

Our aim is to have 2 to 2.5% carbon in our soils. Some paddocks have over 3% carbon.

There seems to be variation, again based on soil types. The poorly drained soil average around 2.2% carbon in the top 10cm, possibly due to a longer pasture phase, with the better soil types struggling to reach 2%, again possibly because of more intensive cropping regime.

When testing it is important to sample at the same GPS point each time and at the same time of year to allow a fair comparison.

What value do you place on maintaining or improving soil carbon in your cropping system? How do you do this?

Maintaining and improving our soil carbon levels is very valuable to us. It is important as high carbon levels are linked with good soil fertility and allows us to reduce our nitrogen fertiliser use.

We preserve and increase our soil carbon through stubble retention, through having a zero-tillage system and using pastures in our rotation.

Healthy pastures need healthy soils and lime is a critical component to correct acidity.

Are you likely to change your management practices to attempt to improve soil carbon (if not unprofitable?)

We could currently put fertiliser on cereal stubbles to prevent the tie-up of nitrogen while the stubbles are being broken down, however for us I don't feel like it is a financially viable option.

What benefit do you see the Cool Soil Initiative project has to your enterprise?

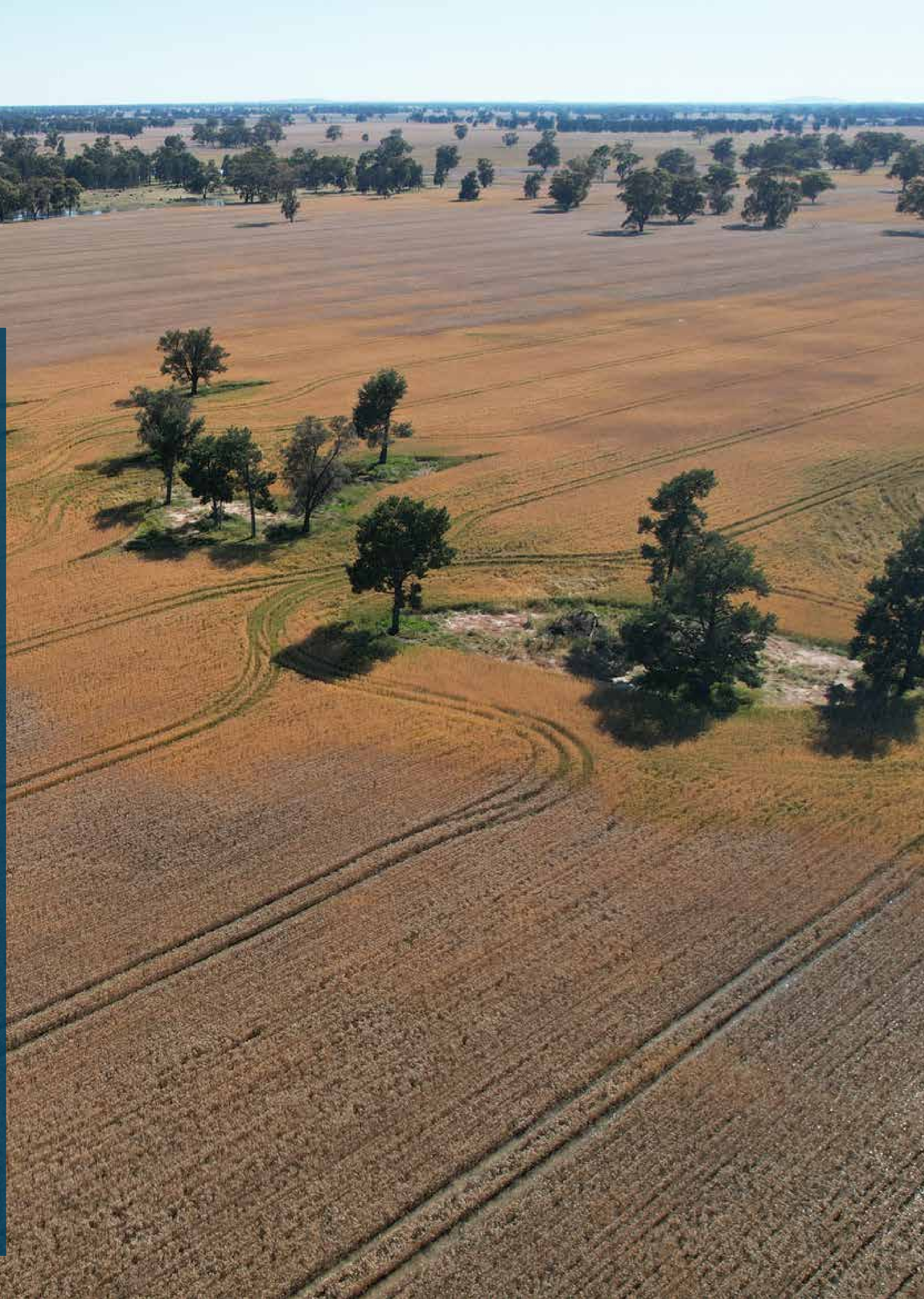
I was a bit disappointed with our soil test results as we were only around the mid-range of values. It will be interesting to see if they are different when we test again as there are some anomalies compared to our regular soil testing program.

From the project, I would like to see a methodology developed for Australian farmers around how we can market and sell our carbon.

Have you trialed any new ideas or approaches regarding plant systems, rotations, novel species, cover* or companion crops*?

We have tried companion cropping forage radish with winter cereals for grazing. We didn't identify any real benefit for soil health however radish provides good nutritional value for the sheep when combined with a cereal.

I am interested in cover crops however sceptical about the benefits to the soil compared to simply retaining stubbles, which provides biota habitat and protection from erosion.



Have you changed any practices to try to reduce your greenhouse gas emissions?

No, not specifically. We have planted thousands of trees on our farm which I believe helps reduce the GHG emissions. Not burning stubbles will help too. It is hard to reduce livestock emissions especially when they are out in a paddock and not in a feedlot as you can't control their diet.

Do you change your carbon management practices based on the weather conditions?

Yes, we are flexible in our approach depending on how the season is going. 2022 is the first year over a 20-year period we have had to burn a number of stubbles.

To prevent nitrogen volatilisation, we avoid spreading urea onto waterlogged soils and we don't apply it in the summer months. Like most growers we tend to wait until there is a strong forecast for rain before we apply any fertiliser.

SUMMARY

- The inclusion a pasture phase and pulses/legumes in the cropping rotation is important to maintain soil organic matter and soil cover which promotes high microbial activity which has benefits that exceed the actual soil organic carbon value.
- Applying fertiliser after harvest is a long-term investment, it will take at least 5-10 years to see an increase in soil carbon levels and even then, it may not provide return on investment if the monetary value of soil carbon is insufficient.
- Soil carbon levels may vary based on soil type.

EXTENSION AND PRACTICAL KNOWLEDGE OPPORTUNITIES

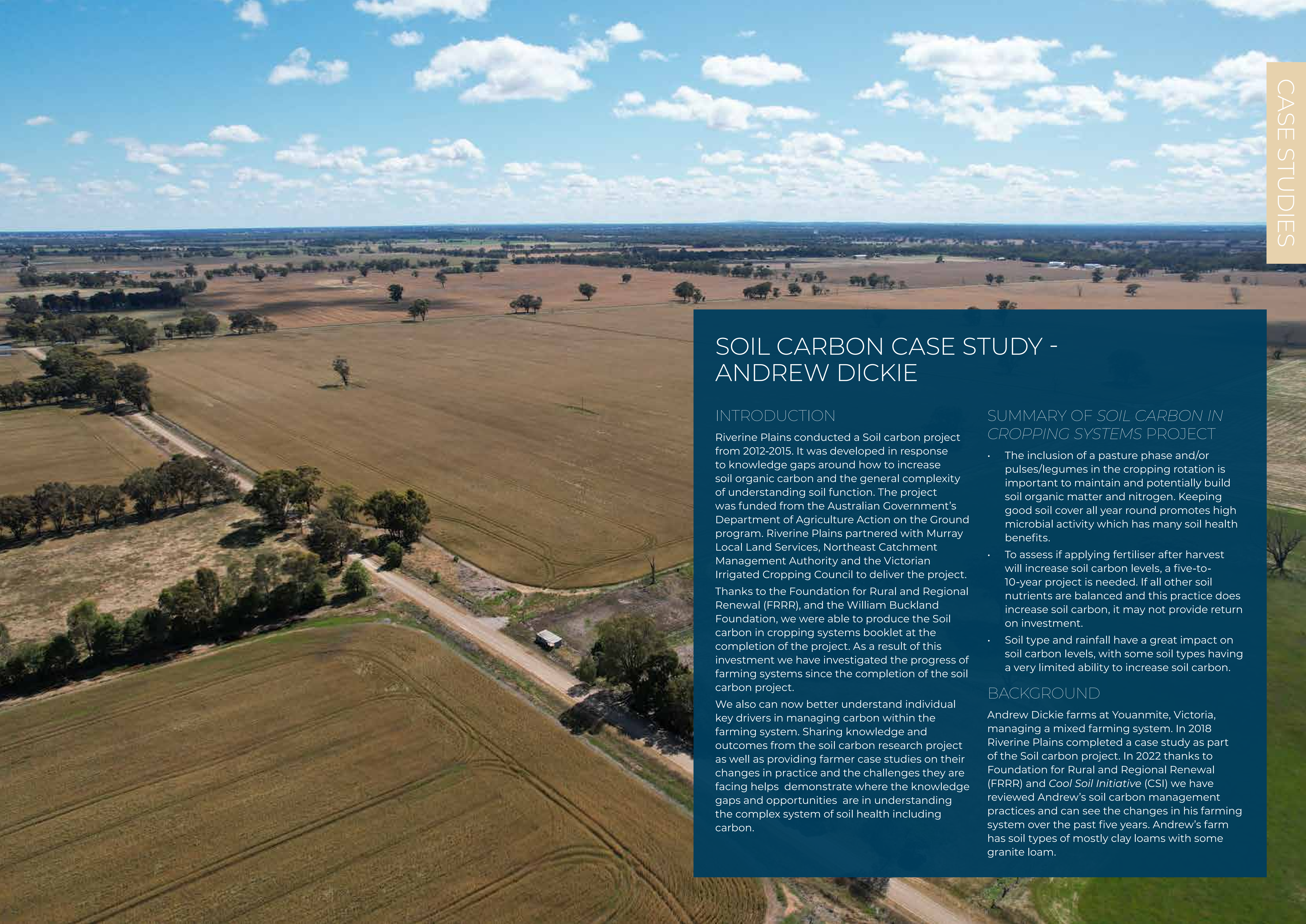
- How do soil types affect soil carbon levels?
- Is there a limit to how high soil carbon levels can go in a continuous cropping system – is a target of 3% carbon realistic?
- Is there a significant connection between soil organic carbon and soil nitrogen levels?
- What will soil carbon levels need to be at for us to claim carbon neutrality in the future?
- Research on cover crops and if they increase soil carbon
- More research on the benefits of companion cropping in Australian farming systems
- Method for measuring soil carbon for Australian farmers

***Companion cropping** is planting and growing two or more crops together in the same paddock, at the same time.

***Cover cropping** is any non-cash crop grown in addition to the primary cash crop, but not at the same time.

The **Soil Carbon** project was developed in response to knowledge gaps and ran from 2012-2015, with funding from the Australian Government's Department of Agriculture Action on the Ground program. Our projects partners were Murray Local Land Services, North East Catch Management Authority and the Victorian Irrigated Cropping Council. In addition, we are thankful to the Foundation for Rural and Regional Renewal (FRRR), and the William Buckland Foundation, for providing the opportunity to better understand key drivers in managing carbon in farming systems through the publication of the research and farmers case studies to showcase the outcomes from the project.

Authors: Lynn Macauley and Kate Coffey, Riverine Plains



SOIL CARBON CASE STUDY - ANDREW DICKIE

INTRODUCTION

Riverine Plains conducted a Soil carbon project from 2012-2015. It was developed in response to knowledge gaps around how to increase soil organic carbon and the general complexity of understanding soil function. The project was funded from the Australian Government's Department of Agriculture Action on the Ground program. Riverine Plains partnered with Murray Local Land Services, Northeast Catchment Management Authority and the Victorian Irrigated Cropping Council to deliver the project.

Thanks to the Foundation for Rural and Regional Renewal (FRRR), and the William Buckland Foundation, we were able to produce the Soil carbon in cropping systems booklet at the completion of the project. As a result of this investment we have investigated the progress of farming systems since the completion of the soil carbon project.

We also can now better understand individual key drivers in managing carbon within the farming system. Sharing knowledge and outcomes from the soil carbon research project as well as providing farmer case studies on their changes in practice and the challenges they are facing helps demonstrate where the knowledge gaps and opportunities are in understanding the complex system of soil health including carbon.

SUMMARY OF *SOIL CARBON IN CROPPING SYSTEMS* PROJECT

- The inclusion of a pasture phase and/or pulses/legumes in the cropping rotation is important to maintain and potentially build soil organic matter and nitrogen. Keeping good soil cover all year round promotes high microbial activity which has many soil health benefits.
- To assess if applying fertiliser after harvest will increase soil carbon levels, a five-to-10-year project is needed. If all other soil nutrients are balanced and this practice does increase soil carbon, it may not provide return on investment.
- Soil type and rainfall have a great impact on soil carbon levels, with some soil types having a very limited ability to increase soil carbon.

BACKGROUND

Andrew Dickie farms at Youanmite, Victoria, managing a mixed farming system. In 2018 Riverine Plains completed a case study as part of the Soil carbon project. In 2022 thanks to Foundation for Rural and Regional Renewal (FRRR) and *Cool Soil Initiative* (CSI) we have reviewed Andrew's soil carbon management practices and can see the changes in his farming system over the past five years. Andrew's farm has soil types of mostly clay loams with some granite loam.

Farmer: Andrew Dickie

Location: Youanmite, Victoria

Describe your farming entrerprise

In the past five years we have increased our cropping area from 1300ha to 2000ha and removed the sheep enterprise from our business.

Describe your cropping sequence/rotation?

Our continuous cropping runs on a four-year rotation. Wheat, canola, wheat, and then either vetch or faba beans. Generally, we crop 50% of our area in wheat, 25% in canola and 25% in vetch/faba beans.

If there are any pulses or legumes, what are they and what are your perceived and real benefits from including a pulse or legume?

Nitrogen fixation is the main benefit for us, you can't beat natural nitrogen, especially with the high costs of fertiliser the past couple of years. We had a deep nitrogen soil test last year show us that after brown manure vetch we would have enough nitrogen in the soil to grow a 6.5t/ha wheat crop with 11.5% protein.

In my opinion, a wheat-canola-wheat rotation that relies on urea as the only source of nitrogen may not be sustainable in the longer term. Legumes/pulses also offer us different weed control options and there is the opportunity to bale vetch for another source of income if the faba bean market is poor.

If there are any pastures used, what is the composition of the pasture, and how long does your pasture phase go for?

We don't currently have any pastures. In the future I have thought of the possibility of tightening the rotation to wheat-vetch or wheat-canola-vetch and if the costs of inputs keep rising this may be something that we consider. However, the wheat-vetch rotation would only be financially viable for a business with low levels of debt, and we would have to run some sheep on the vetch for an extra income source. Having said that, it may significantly reduce chemical and fertiliser input costs.

What range in soil carbon values do you have across your property (0-10cm) and how have these changes in recent years?

Our soil carbon is sitting at around 0.9 - 1.3%. These values have remained stable over the last 15 years.

What value do you place on maintaining/ improving soil carbon in your cropping system? And how do you do this?

We place a high value on maintaining our soil carbon. Soil carbon and fertility is the engine room of our farming system. I was hoping our values would have been above 2% across the farm, in the recent soil tests completed. I am not sure what more we can do to try and increase our carbon levels but 2- 3% soil carbon in a r harvest.

Are you likely to change your management practices to attempt to improve soil carbon (if profitable)?

Not at this stage. I believe that what we are doing currently is as good as we can do without completely changing our farming system. For now, we are going to continue what we are doing, and we are happy that our soil carbon levels are being maintained.

What benefit do you see the Cool Soils Initiative project has on your enterprise?

It will be a valuable benchmarking tool for us to have soil samples taken and analysed from the same spot over a period of time.

Hopefully having evidence of our soil carbon levels and understanding how on-farm practices affect these levels, will build a sustainable farming system will give us a bit of insurance in the future if the government decide to bring in policies for carbon in farming systems.

Have you trialled any new ideas or approaches regarding plant systems, rotations, novel species, cover* or companion crops?**

We haven't tried anything in the past five years. Companion cropping is an interesting avenue, and we are watching some other farmers in the area closely to see how successful their on-farm trials are. One farmer has sown 15kg of wheat with 40kg of vetch and sprayed the vetch out in late August to allow the wheat to finish for harvest. I don't think we get enough reliable summer rainfall in a normal year to grow cover crops.

Have you changed any practices to try to reduce your greenhouse gas emissions?

No. It is too hard for us to measure. I am more concerned about building a sustainable system overall than specifically reducing our emissions. We don't burn stubbles which would help us have lower emissions overall as well as placing a high value on soil carbon in our system.

Do you change your carbon management practices based on the weather conditions?

The only issue that we get is on the retained stubbles where we are planting faba beans, if we have a wet autumn then trafficability becomes difficult.

KNOWLEDGE OPPORTUNITIES

Research into soil carbon has progressed in the last 10 years, what effects it, how it behaves in cropping systems and how it interacts with other nutrients for overall soil health. However, there is a need to put all this into practical on-farm terms for growers for them to be able to implement changes.

Some extension opportunities and practical knowledge gaps for farmers in the region are:

- How do soil types affect soil carbon levels?
- Is there a limit to how high soil carbon levels can go in a continuous cropping system – is a target of 3% carbon realistic?
- Is there a significant connection between soil organic carbon and soil nitrogen levels?
- What is the effect of cover crops on soil carbon?
- Companion cropping in Australian farming systems.
- What does carbon neutral in an Australian farming system look like?
- Impact of carbon markets for Australian farmers.

*Cover cropping is any non-cash crop grown in addition to the primary cash crop, but not at the same time.

**Companion cropping is planting and growing two or more crops together in the same paddock, at the same time.

Authors: Lynn Macauley and Kate Coffey, Riverine Plains.

FRRR Foundation for Rural Regional Renewal

Cool Soil INITIATIVE

PARTNER ARTICLES

Above: Oat Noodles & Oat “Rice” from AEGIC

Above: Presentation on Conservation Agriculture: Chris Maughan (Quaker) & John Pitcher (Uncle Tobys)

INTERNATIONAL OAT CONFERENCE

Every four years (global pandemics allowing) the world’s leading oat breeders and scientists share developments and research in oats at the International Oat Conference (IOC). The last time this event was held in Australia was 1992 in Adelaide, so it was wonderful that the first face to face meeting once Covid eased, was held in Perth last October.

As a proud Riverine Plains partner and the IOC’s platinum sponsor, John Pitcher and Kaye Wood represented Uncle Tobys at the event and shared their key highlights below.

The conference attracted a stellar line up of oat enthusiasts from around the world. This included Government bodies (GRDC, AEGIC, CSIRO, GIWA, AgriFutures, Grains Australia), oat breeders (Intergrain, General Mills, Quaker as well as others from Canada, Sweden, Argentina and the UK), health researchers (Coeliac Society / Walter & Eliza Hall Inst, Lund University [Sweden], Agriculture & Agrifoods Canada), plant genetics and disease experts, grain quality and measurement researchers, global oat market experts, agronomists, growers, agents (Including Croker), and millers (UNCLE TOBYS, Quaker, CBH [Blue Lake], Unigrain, Morning Foods [UK], Seamild [China]).

As part of the conference agenda, delegates visited a professional matrix of field trials that demonstrated heritage, emerging and imported varieties, showcasing:

- different disease resistance, yields, grain and hay quality and nutritional characteristics
- over 200 known varieties helping to develop the genomic map of oats
- technology (drones, robots, machine learning etc.) and intense empirical measurement to map phenology (plant characteristics)
- different sowing and ripening times and management practices

Health researchers presented data on the antioxidants unique to oats (avenanthramides), the special fibre (beta glucan) which reduces cholesterol, and how some people with Coeliac’s Disease can become desensitised to the protein in oats (Avenin).

Others presented on various oat pests and diseases such as Septoria, Fusarium and Rust. It seems like the rust organism in the USA has mutated to overcome the defences bred into current oat varieties. “Conservation/ Regenerative” agricultural practices was also a hot topic across the supply chain.

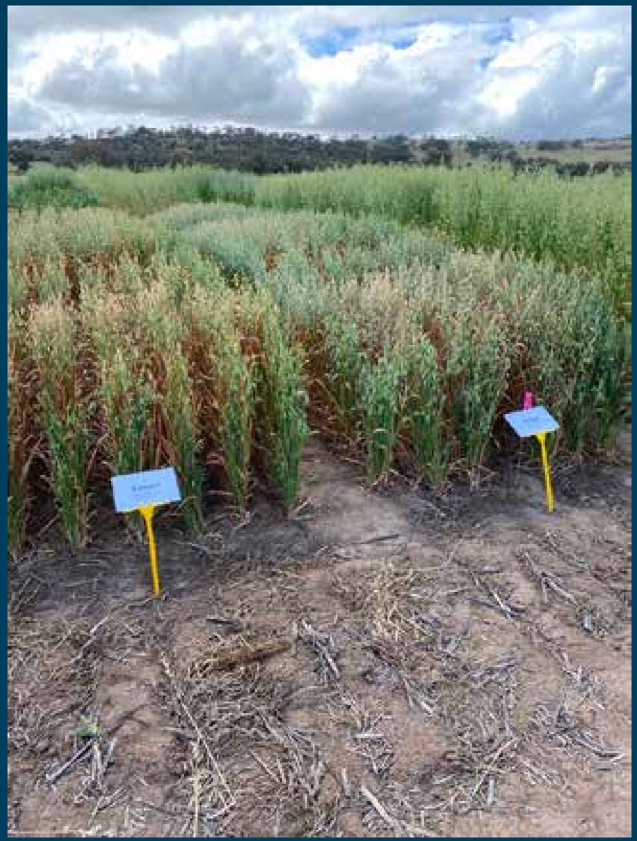
Oat breeding cycles in the future are likely to be much faster using technology for “fast phenotyping”, greenhouses to accelerate seasons, and genomic selection, not to mention the prospect in the not-too-distant future of gene editing (not GMO as no new genes are introduced).

Conference attendees also had a chance to taste innovations in oat processing which included Oat Beer, Oat “Rice” and Oat Noodles.

Globally, approximately 23 million tonnes of oats are grown per year, with 1.38 million tonnes in Australia (over half of this comes from WA). Only about 4% of Australian grain acres are devoted to oats. This has decreased over the last 3 years, with farmers turning to canola, wheat and barley. However, both locally (Australia & Asia) and globally, consumer demand for oats is growing.

The local and international focus – both agronomically and scientifically - is a reflection of the importance of oats as a nutritious, plant-based ingredient with all presentations showing the great advances in oat growing and processing for the global market.

Signature Partner contribution from Uncle Tobys



Above: Three varieties Mitika, Kowari (a Mitika cross) and Bilby (all semi-dwarf). Note they ripen earlier than tall hay varieties in the background.

AGT INTRODUCES WORLD FIRST COAXIUM® BARLEY VARIETY

- Tolerant to Aggressor® (Group 1) herbicide
- Derived from popular variety Compass
- Mid-season maturity, slightly later than Compass, similar to RGT Planet

Titan AX is the first barley variety to be released by Australian Grain Technologies (AGT) as part of the CoAXium® Barley Production System, offering tolerance to Aggressor® (a Group 1, Quizalofop-P-Ethyl) herbicide.

Opportunistically discovered by Eyre Peninsula farmer Shannan Larwood in 2010, and further developed by the University of Adelaide, this novel herbicide tolerance trait has been bred into a range of widely adapted, high yielding backgrounds by the University of Adelaide and Australian Grains Technologies (AGT); with Titan AX being the first variety to be released.

In May 2022, AGT announced a partnership with Albaugh LLC and Sipcam Australia to launch the CoAXium® Barley Production System, involving Aggressor® herbicide and tolerant barley varieties. The system offers growers a new tool for control of tough annual grass weeds including brome grass, barley grass, wild oats, susceptible ryegrass, and Acetolatate synthase (ALS Group 2) resistant weeds.

The system provides more crop rotation freedom due to lack of soil residue, offering an alternative to Clearfield® technology. Importantly, Aggressor® herbicide applied according to the label does not result in residues in barley grain, thus no market access issues have been identified.

AGT testing of this technology has demonstrated excellent crop safety and performance across a range of environments. To support this new technology, a new website has been launched: www.coaxium.com.au, where more details can be found, including the CoAXium® Barley Stewardship Guideline that all users of this technology will need to be aware of.

Titan AX is agronomically similar to popular variety Compass. It's a plant type that particularly lends itself to low-medium or Mallee style environments where early vigour and longer straw is preferred, and where lodging is less of an issue. However, AGT data suggests that Titan AX performs consistently well across a range of growing conditions and therefore should be a suitable option for all growers that see value in tolerance to Aggressor® herbicide.

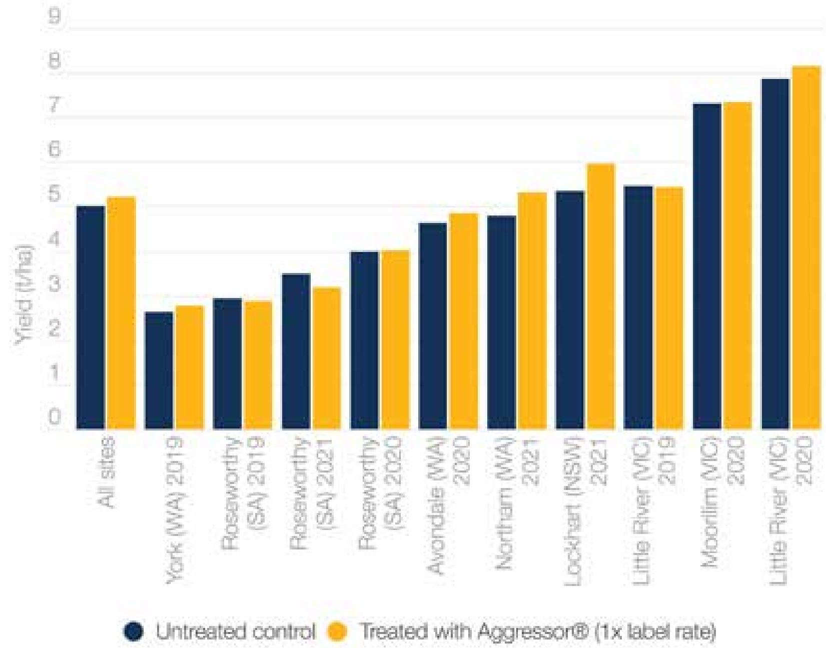


Figure 1 Yield of CoAXium® barley treated with 1x label rate of Aggressor®

AGT

Signature Partner contribution from AGT.

EFFECT ON BIOMASS

Trials carried out by AGT at Roseworthy South Australia (SA) in 2021 showed that Aggressor® applied at both 1x and 2x label rate did not negatively impact biomass production of CoAXium® barley at all, whilst causing gradual biomass reduction and ultimately death of a conventional barley variety at both rates (Figure 2).

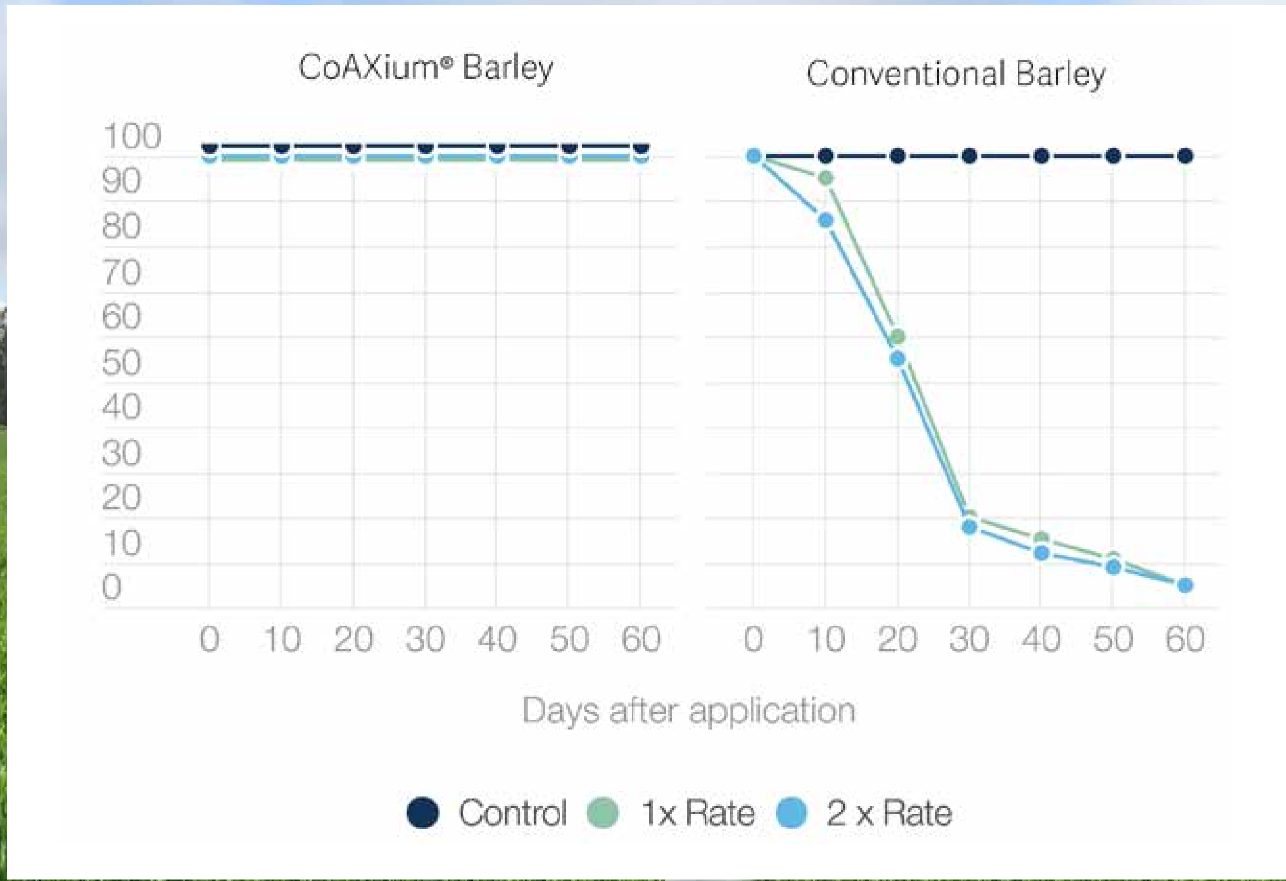


Figure 2 Biomass reduction of CoAXium® barley & conventional barley, treated with 1x label rate & 2x label rate of Aggressor ®

Aggressor® tolerance at work

Trial site: Roseworthy, SA

Sown: 18th May 2020

Aggressor® application date: 17th June 2020

Aggressor® application rate: 1x label rate

Crop growth stage at time of application: 4 leaf

	Untreated control	Treated with Aggressor® herbicide	Treated with Aggressor® herbicide
Days after application	CoAXium® barley	CoAXium® barley	Conventional barley
14			
28			
35			
48			
96			

Titan AX has been initially released as a Barley/Feed grade variety, however AGT expect to nominate Titan AX as a malt quality candidate with Barley Australia in 2023.

Titan AX is now available through AGT Affiliates and local retailers.

CORTEVA LAUNCHES COLEX-D HERBICIDE

Corteva has long recognised the benefits and strengths of 2,4-D as a herbicide. With its robust broad spectrum activity on some of the most important, hard to kill weeds in fallow, it is well justified as a vital tool for weed management. However, for many farmers, the use of current 2,4-D products is becoming increasingly difficult to maintain due to the proximity of 2,4-D sensitive crops and restricted use areas.

Colex-D is a next generation, patented technology that offers all the performance and efficacy of normal 2,4-D products, but has field proven Drift Reduction Technology (DRT), near-zero volatility and ultralow odour built in.

Colex-D will provide a superior offering which will allow farmers to comply with APVMA label requirements and use 2,4-D with more confidence.

WHAT IS COLEX-D TECHNOLOGY?

Colex-D herbicide contains a combination of novel technologies.

Colex-D formulation contains proprietary materials that reduce the production of driftable fine droplets. This has been confirmed with wind tunnel tests for specific mix partners and nozzles types which are detailed on the label.

1. Colex-D contains a new patented form of 2,4-D (choline) that is essentially non-volatile reducing the potential for vapour loss to a fraction of the risk from either 2,4-D amine (DMA) or 2,4-D ester.
2. Colex-D has been designed with improved characteristics for practical use including ultralow odour and good compatibility.

HOW DOES COLEX-D TECHNOLOGY WORK?

1. **Drift Reduction Technology.** Colex-D has been optimised through wind tunnel and field testing to reduce the formation of extremely fine, very fine and fine droplets produced by a spray boom. When applied according to label directions there is a significant alteration of the 'driftable' droplet spectrum produced without significantly altering the numbers of larger droplets. Figure 1 shows that even when applied with glyphosate, there is a significant reduction of driftable fines when compared to a market leading 2,4-D amine formulation.
2. **Near-Zero Volatility.** The near-zero volatility of the 2,4-D choline salt has been demonstrated in both laboratory and field studies. Field research has confirmed that 2,4-D choline salt significantly reduces the potential for off-target movement of herbicide vapour from the treated area. In Australia, volatility trials using in-field plastic wind tunnels (shown in the picture above) has shown the difference in volatility between Colex-D, 2,4-D DMA and 2,4-D ester. Three separate studies conducted in 2021/22 showed a similar trend, with significant injury observed on cotton from 2,4-D ester volatility, minor injury to cotton from 2,4-D DMA and no observable injury from Colex-D under the conditions of the trials.

   Figure 2 shows the results a contract trial at "Tosari", Pampas, Queensland with a graph of the percent visual leaf damage (% severity) to cotton 0-4 m either side of a tray treated with 2,4-D, when it was placed between two cotton rows and the tunnels were installed for 48 hours. Photos of the injury caused to cotton, near where the tray was placed between the rows, are shown.
3. **Ultralow 2,4-D odour.** Colex-D has ultra-low odour compared to other 2,4-D products. This is due to two factors:
   a. lower levels of impurities in the technical material used to make Colex-D, and
   b. quality manufacturing

Phenol impurities in 2,4-D formulation are the cause of the odour and Colex-D has very low levels of these impurities. The ultra-low odour still allows users to detect use, but Colex-D is far less noticeable than any of the presently available 2,4-D products. Quality manufacturing also further limits the Colex-D odour.

Simple olfactory testing at the Breeza Research Station in 2021 showed that Colex-D had a very low odour in comparison to commonly available amine or ester formulations of 2,4-D.

4. **Proven Compatibility.** The Colex-D herbicide label will contain a specific list of approved products for use as mixing partners. These have been tested and shown to be compatible with Colex-D and they have no detrimental impact on the drift reduction performance of the formulation.

Signature Partner contribution from Corteva Agriscience.

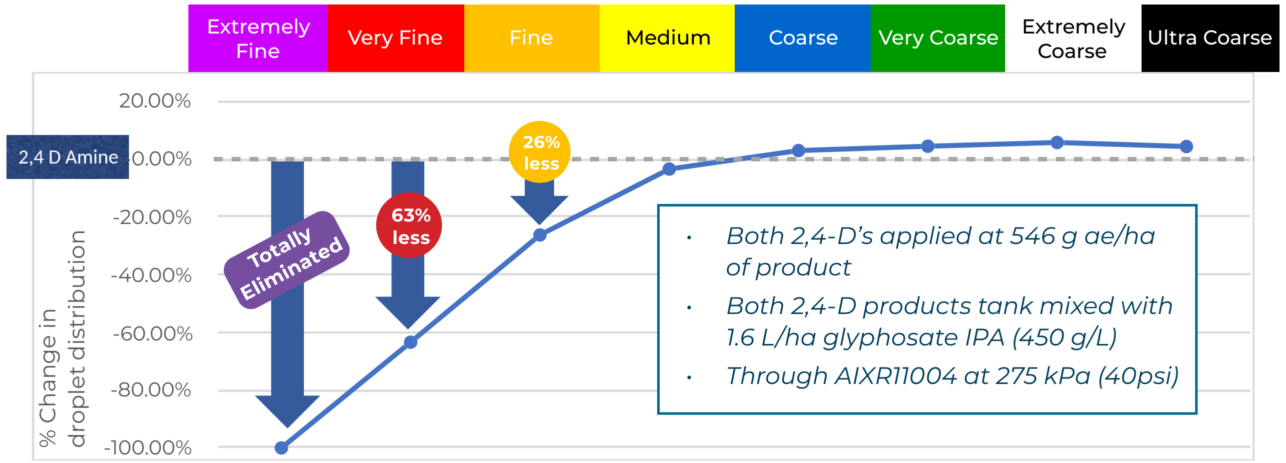
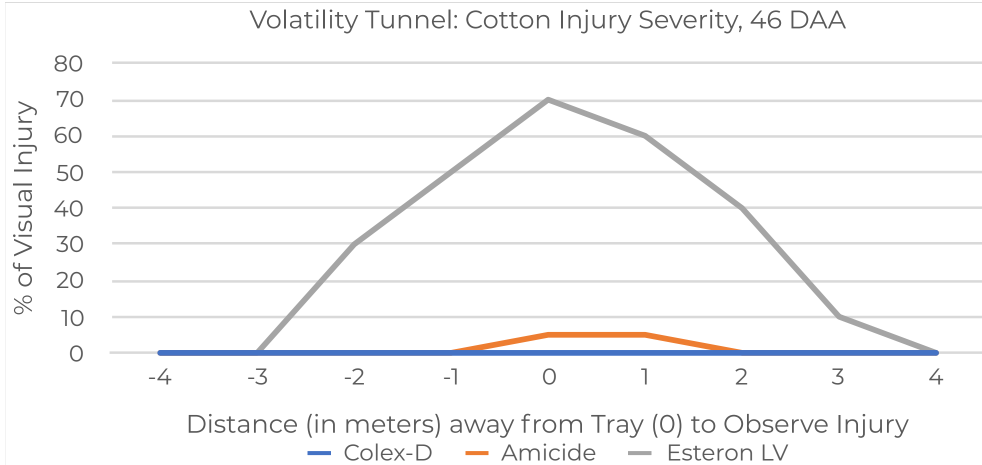


Figure 1 2021 Wind tunnel testing for Drift Reduction Technology.
% Change in droplet spectrum by class for Colex-D vs 2,4-D Amine

Figure 2



Colex-D

Amicide

Esteron LV

Above: Comparison of efficacy of Colex- D with other commonly used herbicides at 42 days after applications at "Tosari", Pampas, Queensland.

In conclusion Colex-D has been formulated to reduce off target movement. It has proven field use following seven years commercial experience in the US corn belt. When used in accordance with the label and best 2,4-D spray management practices, Colex-D gives Australian growers confidence they can target their problem weeds and not neighboring crops.

HISTORIC DATA PROVIDES REGIONAL INSIGHTS, HIGHLIGHTING SOIL VARIABILITY

KEY POINTS

- Soil pH and exchangeable sodium percentage (ESP) are highly variable across the study area.
- There were no strong spatial trends across the catchment with soil acidity and areas of sodicity observed across the region.

AIM

To provide regional insights on soil conditions drawn from a large database of real soil data collated between 2017 and 2022.

METHOD

Soils data from the Australian Bureau of Statistical Area 2 (ABS SA@) regions that best align with Riverine Plains membership area (Wagga Wagga surrounds, Nagambie, Tocumwal Finley Jerilderie, Corowa surrounds, Albury surrounds, Moira, Shepparton surrounds – East, Rushworth, and Numurkah) was used.

Five years of soil data was analysed. This represented around 75,000 soil samples (0-10cm) collected using a methodology consistent with industry best practice and analysed at a National Association of Testing Authorities (NATA) accredited laboratory.

The data was restricted to paddocks with five or more soil samples, to provide information addressing both between and within paddock variability.

RESULTS

pH (CaCl2)

The relevant pH (CaCl2) dataset consisted of 2,344 paddocks, and 77,821 individual soil samples. Over this dataset, the average pH for an entire paddock was 5.05, but ranged from 4.16 to a high of 7.48.

The spatial distribution of the paddock average pH is shown in Figure 1. Within any individual paddock, pH varied on average by 1.12 pH units but by as much as 3.6 units. This is reflected by the coefficient of variation (CoV), a measure of variability, which ranged from 1-8% with a mean of 4%. The actual distribution of individual paddock minimum, average and maximum pH is shown in Figure 2.

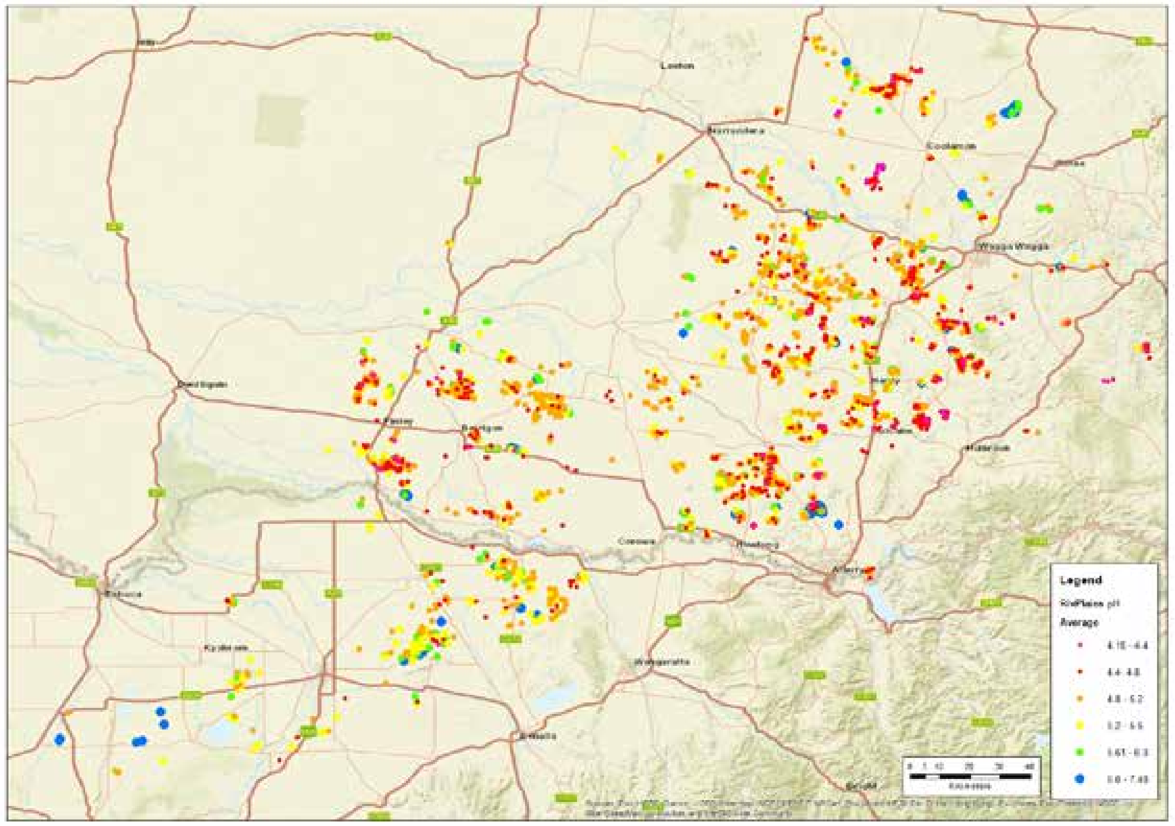


Figure 1. Shows the spatial distribution of the paddock average soil pH used in the study, ranging from 4.16 to 7.48.

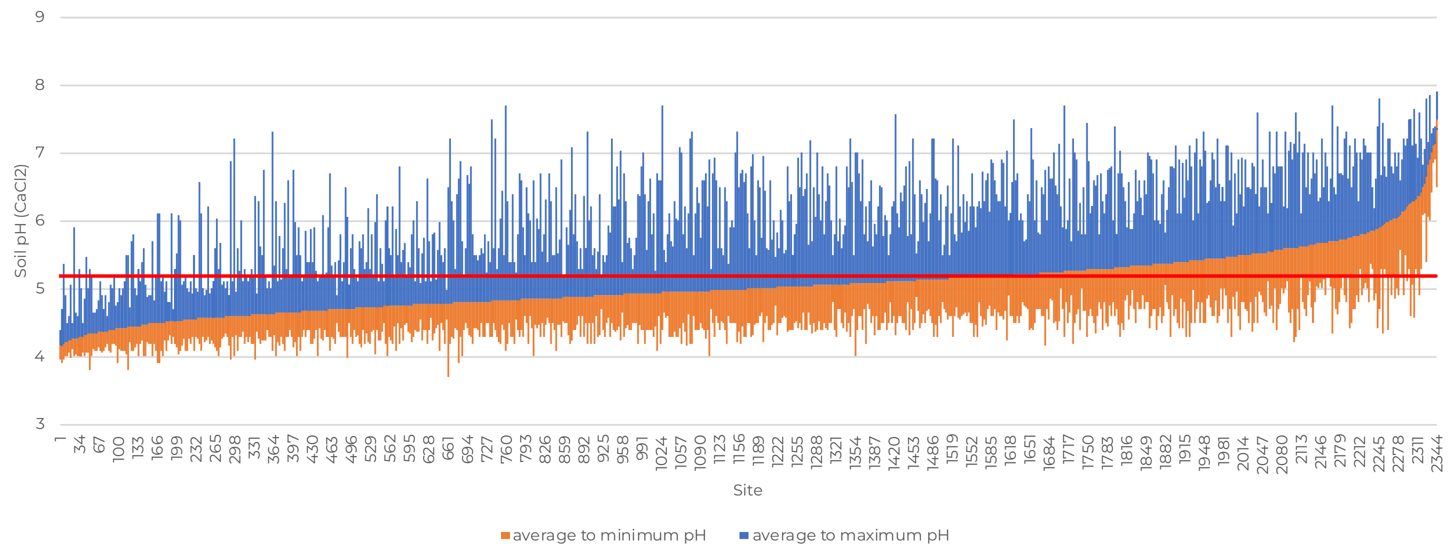


Figure 2 Soil pH for individual paddocks sorted by paddock average, lowest to highest. The orange line is the minimum to average pH and the blue line is the average to maximum pH in individual paddocks. The red line shows the critical pH value of 5.2, which is commonly used to target acidic soils.

Exchangeable Sodium Percentage (ESP)

The relevant pH (CaCl2) dataset consisted The relevant ESP dataset consisted of 847 paddocks and 25,056 individual soil samples. Over this dataset, the average ESP for an entire paddock was 3.2%, but ranged from 0.3% to a high of 22.8%. The spatial distribution of the paddock average ESP is shown in Figure 3. Within any individual paddock, ESP varied on average by 4.5% but by as much as 27.2%. This is reflected by the CoV, which ranged from 3-206% with a mean of 41% as highlighted in Figure 4.

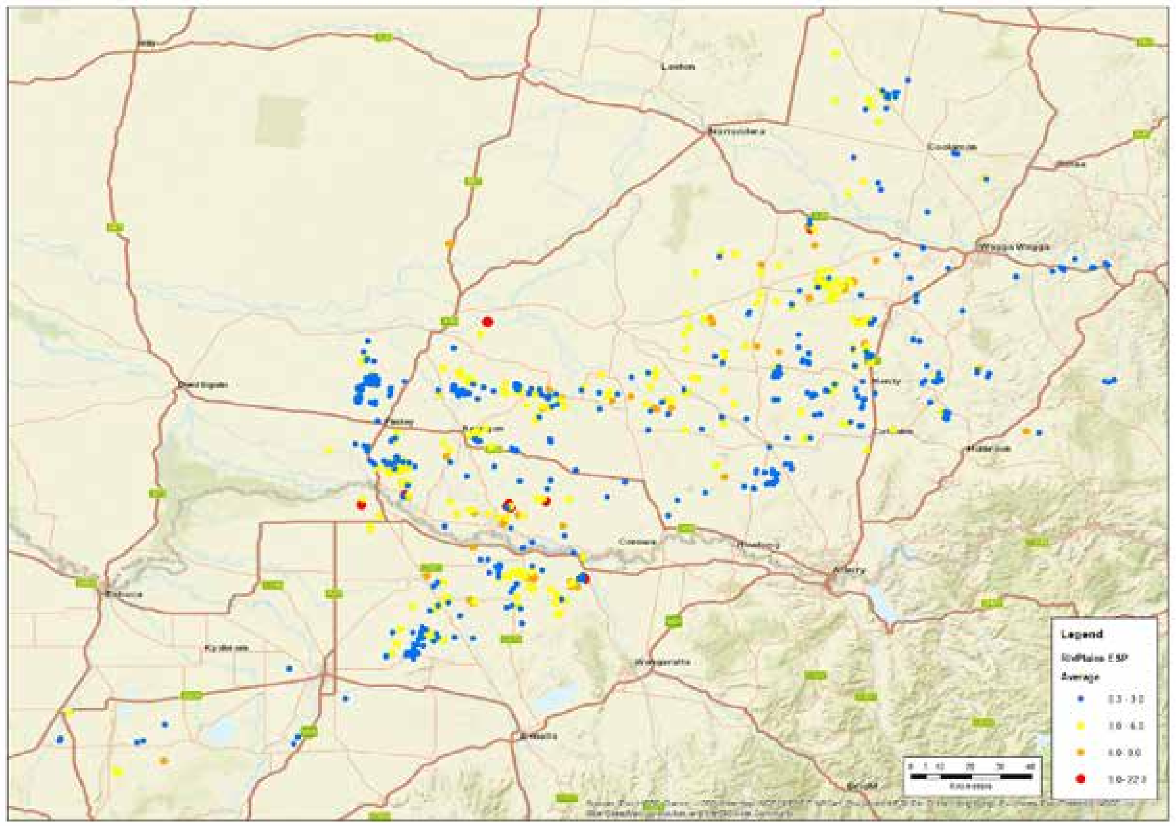


Figure 3. Shows the spatial distribution of the paddock average Exchangeable Sodium Percentage from the study, ranging from 0.3% to 22.8%.

Signature Partner contribution from Precision Agriculture.

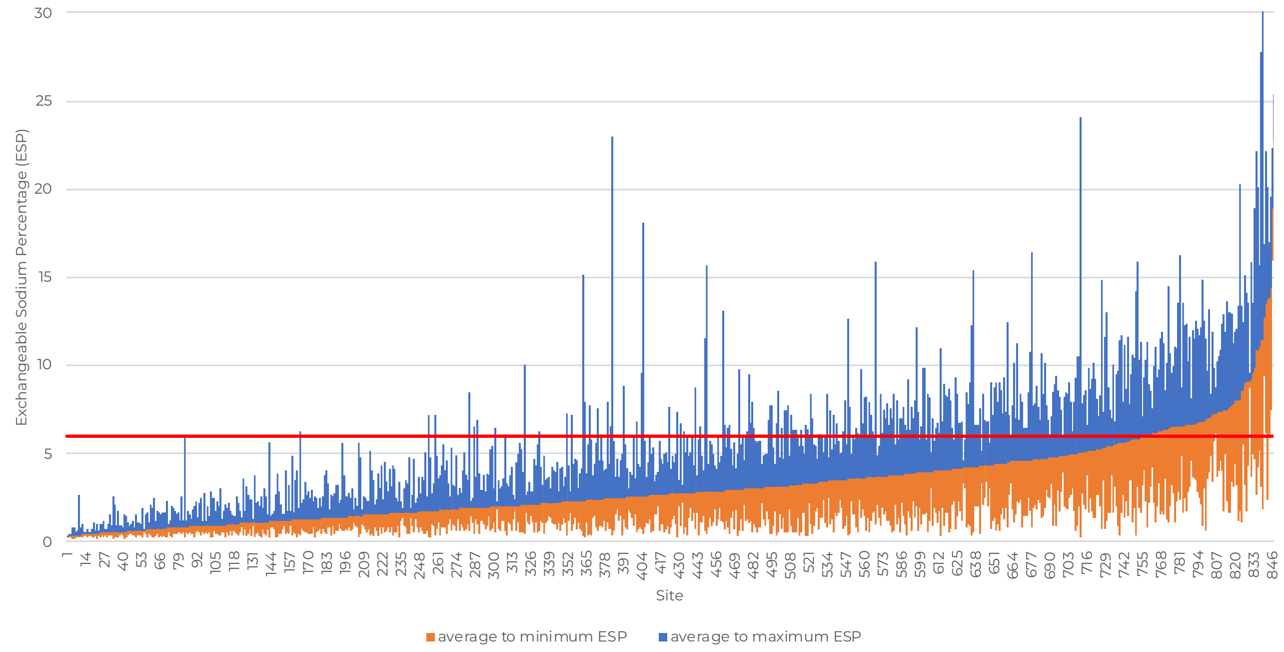


Figure 4 Exchangeable Sodium Percentage for individual paddocks sorted by paddock average, lowest to highest. The orange line is the minimum to average ESP and the blue line is the average to maximum ESP in individual paddocks. The red line shows the critical value of 6%, above which soils are generally considered sodic.

OBSERVATIONS AND COMMENTS

There are two main practical questions that these results help answer:

1. Are my paddocks likely to have a soils constraints problem and how big is it likely to be?
2. What is the best strategy for fixing it?

In this case, the potential soil problems are acidity and sodicity. The best strategy will depend both on the scale of the problem and since the solutions will involve spreading lime or gypsum, the degree of within-paddock variability. This will determine whether a variable-rate strategy (where different rates are applied based on varying needs) will be more efficient and effective.

Soil acidity

Soil pH is a measure of the concentration of hydrogen ions in the soil solution and is one of the fundamental soil properties governing nutrient availability, elemental mobility and toxicity, microbial activity, and plant growth. Soils with a pH below 5.2-5.5 are considered acidic and can significantly reduce crop yields as important nutrients become unavailable to plants and others become available at toxic levels. Lime applications are a reliable method of increasing pH to more productive levels, but the amount of lime required will vary based on the starting pH and soil type.

These results indicate that soil acidity is a widespread problem across the region. Only 31% of the paddocks in the dataset had an average pH above 5.2 – but even within those paddocks, three out of four still had areas that would be considered acidic. Based on this, it's more than likely that any given paddock will require lime and be variable enough to benefit from a variable rate application.

Soil sodicity

Exchangeable Sodium Percentage (ESP) is used as an indicator of soil sodicity, which refers to a high level of sodium held in the soil. This often leads to dispersive or hard-setting soils that reduce emergence and crop growth, and water and nutrient availability. An ESP of 6% is the threshold beyond which a soil is considered sodic.

Sodic soils can be managed by adding calcium – usually as gypsum – which displaces sodium and makes the soil more stable. However, as in this dataset, the requirement for gypsum is rarely uniform across a single paddock.

Unlike pH, most paddocks (89%) were not sodic on average. However, close to one in two still had areas that were above 6% ESP. The degree of variability, both between and within paddocks, was extreme: visible in both the length of each paddock bar in Figure 4 and the high average CoV of 41%.

This means that a paddock is unlikely to be sodic across its entire area, and a conventional soil

sampling strategy may 'average out' any actual issue. If you observe symptoms of sodicity in your paddocks, more intensive or targeted sampling is justified to diagnose and treat sodicity via a variable rate strategy.

An illustrative example

These results may be best understood by applying them to a representative paddock that reflects the averages shown in the data. Figure 5. shows a paddock in the region which might be considered as representative, it has a mean pH of 5.1 and a mean ESP of 3.1%. This means that it would be close to the centre of both graphs in Figure 2 and Figure 4. The pH map (Figure 5a.) shows the level of variability with some areas of the paddock as low as pH 4.5 and as high as 6.6 – highly acidic on the one hand, and above the critical value on the other. Similarly, ESP (Figure 5b.) is highly variable, with areas as high as 8.6% and as low as 0.5%. In this case, the farmer would be well justified in a Variable Rate Application (VRA) of lime and gypsum to help optimise growing conditions efficiently across the paddock.

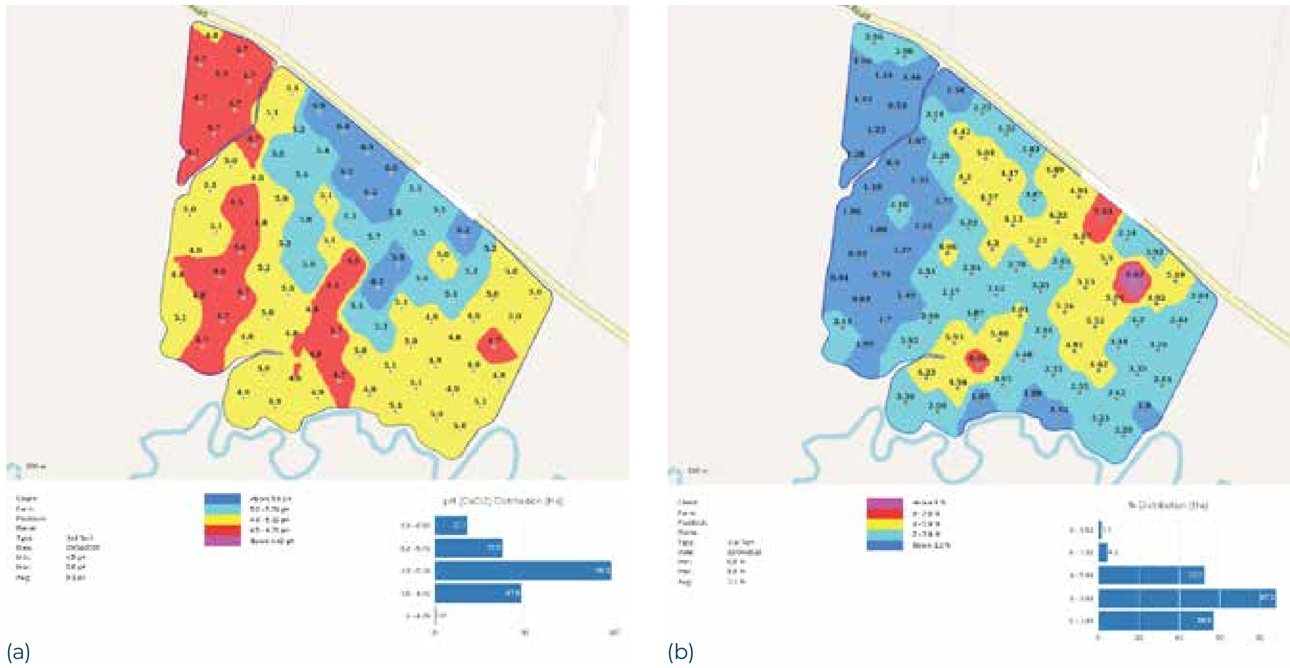


Figure 5 Nutrient maps based on grid soil sampling which highlight the variability in (a) Soil pH, and (b) Exchangeable Sodium Percentage.

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