2023 RESULTS

UPPER NORTH FARMING SYSTEMS

ANNUAL RESEARCH
& EXTENSION **COMPENDIUM**

UNFS

Upper North Farming Systems

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CONTENTS

A MESSAGE FROM THE CHAIR

Michael Zwar

2023 has been yet another busy year for Upper North Farming Systems.

Our annual expo had over 80 attendees with a great range of speakers. This event also hosted our AGM, which saw myself come in as Chairperson and Beth Humphris as Vice chairperson. Sadly Barry Mudge announced his retirement from the Board and Operations Committee. Barry had been involved with UNFS since the groups inception in 2001. His dedication, knowledge and passion for agriculture has helped to guide the group over the years, whilst also providing project consultancy at times. Thank you Barry for your wisdom, input and friendship over so many years. We all wish you the very best in your retirement. We also saw Andrew Kitto step down from the strategic board after several years. We thank Andrew for his commitment to the group at a board level. Andrew remains on the operations committee. We welcomed Ziek Kay to the strategic board and operations committee. We look forward to Ziek working with the other members of the committee.

Thanks to our staff Jade Rose, Deb Marner and Rachel Trengrove for their outstanding efforts in project management, group governance, finance and administration. They have done a fantastic job, and we are very fortunate to have such great people working for UNFS. We look forward to working with you for years to come.

I would also like to thank all the board and committee members for their time and effort in keeping the group together and making things happen. The continued success of UNFS is only possible through your ongoing efforts.

And finally thank you to all the UNFS members. Without you attending our events and learning from our projects the group wouldn't be here. Thank you to the Laura and Nelshaby Ag Bureau's for your collaboration with UNFS. Bringing our members together to learn and get the most out of our events I think is proving very valuable.

ACCESS UNFS PODCASTS EASILY BY SCANNING THE QR CODE:

SOUNDCLOUD

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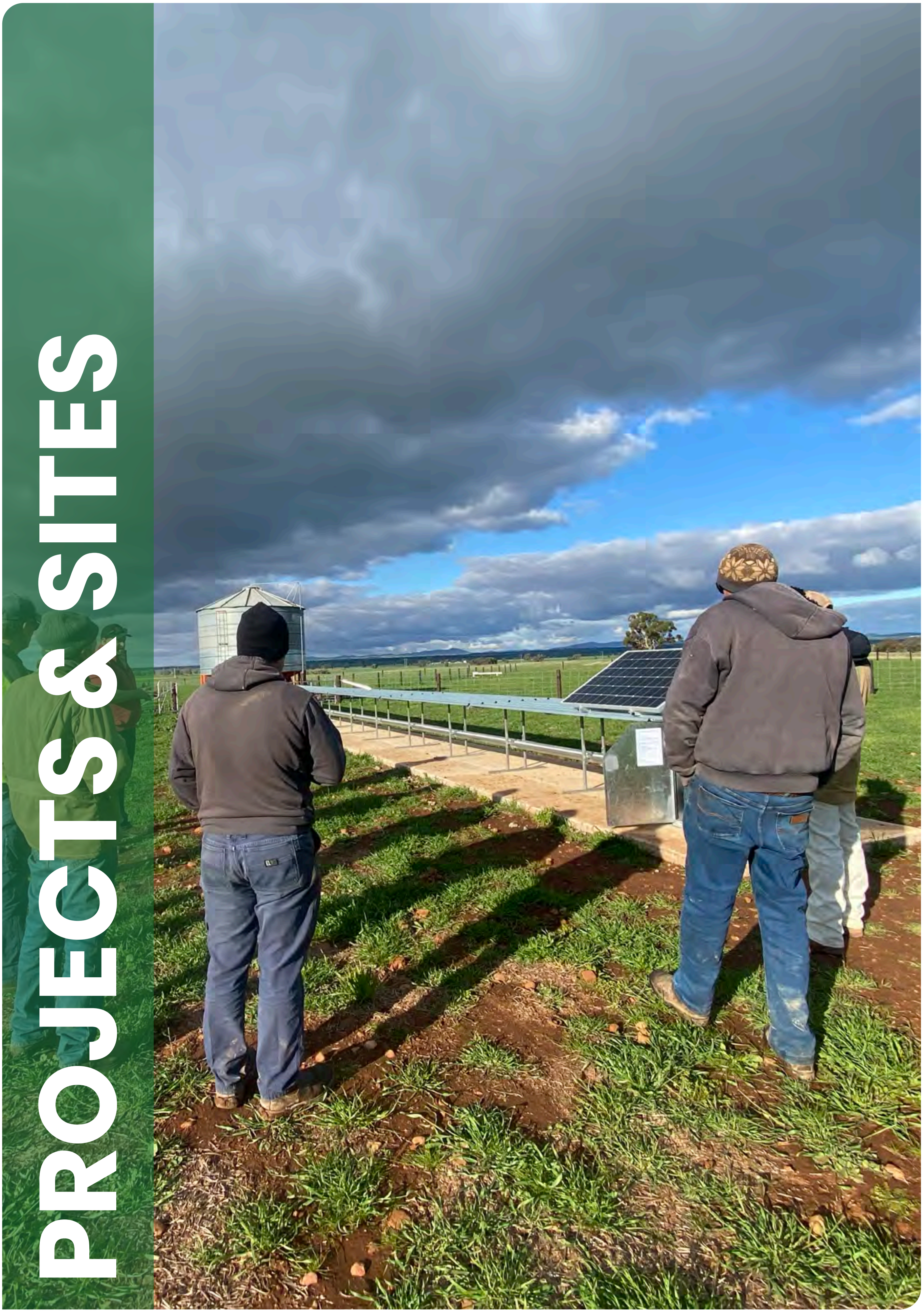
FIELD SYSTEMS Strategic Soil Management

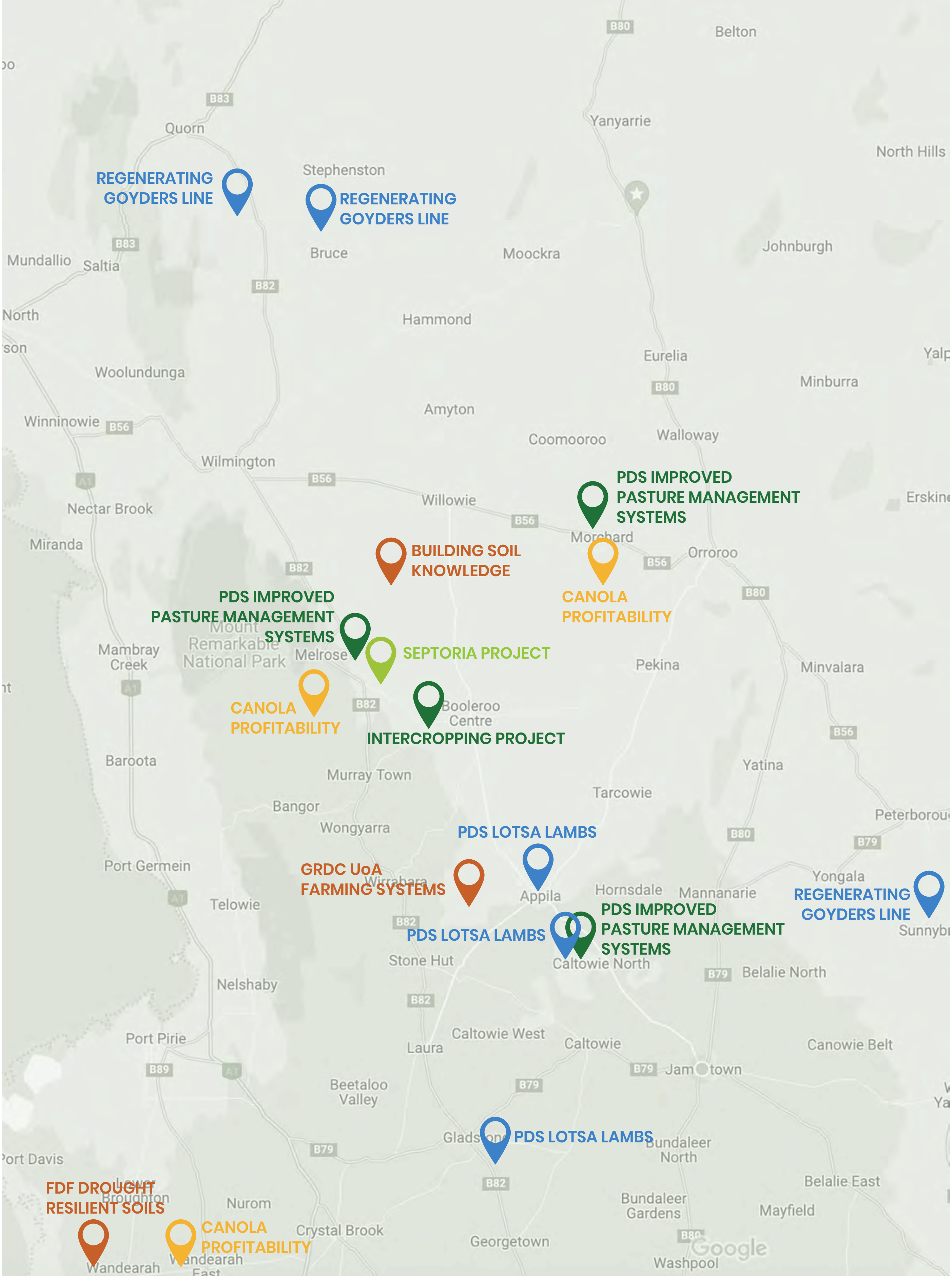
PROJECTS & SITES



UNFS 2023 PROJECT LIST

UNFS Project #	Other Names/ References	Full Name	Funding Source/Contact
102	Hub Activities	AgTech, LOTL, Jamestown, Booleroo, Nelshaby, Laura/Glastone, Wilmington, Quorn, New Farmers, Morchard/Orroroo/Pekina/ Black Rock	GrainGrowers, AGT, Davis Grain Sponsorship
104	Commercial Paddock	Fundraising for delivery of RD&E in UNFS Region	Northern Ag
231	Weather Station Network	Upper North Fire Danger Index Alerting Weather Station Network Project	Safecom/NSS
240	Septoria Epidemiology	Epidemiology of Septoria Tritici Blotch in the low and medium rainfall zones of the Southern region to inform IDM strategies.	GRDC/ SARDI
245	Pulse Extension	RD & E to close the economic yield gap & maximise farming systems benefits from grain legume production in SA	GRDC via SARDI
246	Pasture Systems	Improved Pasture Management Systems	MLA
247	Lotsa Lambs	Lotsa Lambs - Improving Reproduction Success	MLA
249	Canola Profitability	Canola Profitability in the UN	SAGIT
253	Heat Stress in Sheep	Improving Climate Resilience of the Australian Sheep Industry	Australian Government's Future Drought Fund
254	Farming Systems	Enterprise Choice & Sequencing for profitability & sustainability	GRDC via Uni of Adelaide
255	National Risk Management Initiative	Understand and improve risk-reward outcomes for Australian grain growers through participatory action research	GRDC via Hart FSG
256	Carbon ERF	Applying whole-of-farm carbon project methods for climate resilience and diverse co-benefits in low rainfall farming systems of the Upper North	PIRSA
258	Optimising Crop Establishment	Optimising crop establishment under dry and marginal soil moisture	SAGIT/Droughthub
259	De-Risking the Seeding Program	Reducing the risk of early/dry sowing through different management tactics in the decision making process	DroughtHub/Australian Government
260	FDF Drought Resilient Soils	Building farming systems resilience and future proofing the impacts of drought through accelerating the adoption of proven cost-effective and yield responsive soil and fertiliser management practices	Future Drought Fund via MSF
261	Wild Dog and livestock productivity project	SA Best Practice Wild Dog Control and Productivity Network	PIRSA
262	Containment Feeding	Sheep Containment Feeding - Boost sheep enterprise resilience and performance (pilot program)	SA Drought Hub
263	FDF Long Term Trials - Medics adapted to droughts	Annual medics with improved drought resilience for low rainfall areas	Future Drought Fund
235	Regenerating Goyders Line	Regenerating Goyders Line - re-establishing productive pasture in once cropped land	National landcare Program; Smart farming Partnerships iniative round
238	Soil Pathogen Project	Soilborne cereal pathogens national extension project - Workshops	GRDC via FarmLink/SAGIT via SARDI
		Soilborne cereal pathogens national extension project - Trial Sites	
239	Building Soil Knowledge	Building soil knowledge & capacity to implement change in the farmers of the Upper North Agricultural zone of SA. Improving soil structure & function to improve plant health, landscape function & farming system resilience.	National landcare Program; Smart farming Partnerships iniative round
242	Pulse Projects	Intercropping	Drought Hub
		Pasture Management Systems	
250	Mixed Farming Hub	Mixed Farming Cross Hub Project	

UNFS 2023 RESEARCH SITES



2023 EVENTS

UNFS 2023 EVENT SUMMARY

Date	Event	Location	Participants	Details
February				
22	It's The Summer of Weeds	Gladstone	70+	Presentations, Displays, Bus Tour of Demo Paddocks, followed by Dinner at Southern Flinders Sporting Complex Keynote Speaker WA's Ray Harrington OA Static Tech and Service Provider Displays
23	Lotsa Lambs	Melrose	41	Nathan Scott, Achieve AG Solutions - eID - What's in it for me? Deb Scammell - Talking Livestock - Improving Reproductive Success. Caleb Girdham - Demonstration of autodrafter, sticky beak at yards and containment feeding set-up
March				
6	UNFS Western Trial Results Post-Harvest Session	Napperby	26	Previous year results session with presentations from: Sarah Day (SARDI) on Pulse Extension, Navneet Arggwall (SARDI) and Stefan Schmitt (Agriculture Consulting and Research) on weeds in lentils and Kevin Stretton talking on Greenwheat Freekah Australia
14	UNFS Southern Trial Results Post-Harvest Session	Jamestown	17	Previous year results session with presentations from Chris Preston (UofA) Weeds going into 2023, Sarah Day (SARDI) on Pulse Extension in the Upper North, Jamee Daly (UofA) on Heat Stress in sheep and Michael Nash on 'Are you growing bugs with Nitrogen'.
22	Soil Pit Demonstration	Booleroo	15	Led by Beth Humprhis (Elders), Ed Scott and Michael Eyres - demonstrations of water infiltration, in field pH testing, soil dispersion in addition to pit analysis - open for conversation
30	UNFS Northern Trial Results Post-Harvest Session	Booleroo	18	Previous year results session with presentations from Tara Garrard (SARDI) and Marg Evans on the White Grain Disorder Outbreak, David Peck (SARDI) on pasture legumes for climate change, Will Van Wettere (UofA) on heat stress in sheep and Andrew Catford (Northern Ag) to discuss the canola profitability trial in Morchard.
June				
9	Improved Weaner Management	Wirrabarra	20	Guest presenters and sheep experts, Deb Scammell, Talking Livestock and Colin Trengove, ProAg Consulting, provided valuable insights and guidance on optimizing weaner management practices such as nutrition, health, and other relevant topics. Adelaide University also attended to update participants on the results of the Heat Stress in Sheep project in the Upper North
20	Improved Weaner Management	Wilmington	16	Colin Trengove - Pro Ag Consulting - Optimising weaner health, Deb Scammell - Talking Livestock -The weaning process, Megan - Adelaide University - UNFS results for Heat Stress in Sheep project, Michael Battersby - facilitated a farmer discussion and sticky beaked at his small paddocks for containment feeding and lambing.
21	Regional Soils Conference	Jamestown	60+	A regional "Soils Conference", part of the Building Soil Knowledge Project to discuss various issues of the UN region. Presenters: Andrew Polkinghorne, Sam Trengove, Beth Humphris, Dr Mark Thomas, Chris Davey, Dr Marg Evans, Ed Scott, Dr Therese McBeath, Farmer Panel: Jess Koch, Peter Kitsche, Andrew Sargent, Michael Zwar.

UNFS 2023 EVENT SUMMARY

Date	Event	Location	Participants	Details
August				
3	UNFS Annual Members Expo	Booleroo	80+	Key presentations from Pene Keynes (Livestock SA) on EID roll out, biosecurity and WA live export ban, Matt Casey (NAB) on agribusiness cyber security and avoiding scams, Oli Madgett (FarmLab) - Carbon accounting and simplifying the carbon conundrum, Phil Tickle (CIBO) on satellite imagery and grazing management, Andy Chambers (Airborne Logic) on drone technology and frost, John White (Rural Generations on succession and business planning, Gerard McMullen on the future of registered chemicals in Aus, Barry Mudge on the GRDC Risk Initiative and Ted Langley (grower) on successes and lessons learnt in farming
18	Nelshaby x UNFS Western Sticky Beak Day	Wandearah, Lower Broughton region	30	Bus tour went to Stefan Schmitt, Wandearah herbicide options at Nathan Crouchs, Chris Crouchs place for Jacks in lentils (Navneet Arrgwaal), soil pits x 2 at Chris Crouch, site at Daniel Joyces (Stefan Schmitt), site at Byron Johns, then Canola Profitability (Wandearah), Early seeding/ pulse sites with Dylan Bruce
September				
7	GRDC Harvester Set Up	Laura	105+	The workshop, hosted by UNFS, brought together harvester specialists, industry experts and researchers to discuss preventable harvester grain losses and how to measure these, improvements in efficiency and output, methods of harvest weed seed control (HWSC), the prevention of harvester fires and calibrating harvester technology.
22	Eastern Sticky Beak Day	Melrose	20	Dustin Berryman presented on the SAGIT Canola Profitability Trial - talking about different canola varieties and their fit in the UN. Sarah Day presented on the SARDI (DroughtHub) Pulse Trials (intercropping, early TOS), then a small presentation from Flinders Uni staff Peter Anderson and Crystal Sweetman on heat and chilling stress management.

SUMMER OF WEEDS

Laura Ag Bureau, "Summer of Weeds" was held at Gladstone on Wednesday 22 February 2023, in conjunction with Upper Northern Farming System group and with funding from Landscape South Australia Northern and Yorke. Farmers and commercial exhibitors had a rare chance to gather as one to hear many current and future ideas to control weeds.

Displays included a robot weeder, a large drone used for spraying and aerial mapping, and several sprayer mounted camera systems that detect weeds resulting in only spraying a fraction of the paddock.

Ray Harrington farmer and inventor from Darken WA, spoke about the green on green camera evolution. He is the Australian farmer representative on the Green on Green GRDC project. Using artificial intelligence technology, algorithms are developed and built on to detect weeds using cameras mounted on spray machines.

At Gladstone, Ray in his seventies was delighted to meet Jordy Kitschke, a young farmer from the mid north and founder of Flux Robotics whose team had a robotic weeder on display using this artificial intelligence technology.

Two buses transported the 70 farmers and display reps out to a local ag bureau members paddock where a trial site was sprayed about two weeks previously.

The area was mapped by a drone and then sprayed using a Bilberry camera spraying system off the gathered data. Bilberry was developed in France only four years ago and adapted to be used in agriculture.

Previously an area was blanket sprayed with chemical by a case patriot sprayer to compare and a Hydra boom with the WeedSeeker camera system

The areas on trial were cereals and legume stubbles as well as pasture.

After returning to the Gladstone Stadium for tea, Ray Harrington shared his wisdom about what farming and his farm will look like in 10 years and yes sheep are still necessary on his farm.

Report by Andrew Kitto

Summer of weeds crowd shot stadium

Summer of Weeds Midstate Drone Services Nick Heaslip and drone at Gladstone stadium

Summer of Weeds Nitro Billberry cameras close up in pd

Summer of Weeds Jordy and Flux team display robot weeder copy

PDS: LOTSA LAMBS 2ND WORKSHOP – IMPLEMENTING eID'S ON FARM AND IMPROVING REPRODUCTIVE SUCCESS

Since the announcement of mandatory eID's in Australia, sheep producers have been looking for information and options for hassle free implementation of an electronic system on farm. 40 Upper North Farming Systems (UNFS) farmers came together and braved the heat at Caleb Girdham's family property near Melrose to learn more about "Implementing eID's on farm and improving reproductive success". Farmers were treated to a sticky beak at Girdham's containment feeding pen set up, newly built shearing shed and yards as well as a demonstration of the BreedElite autodrafter. A wealth of knowledge and experience was shared throughout the morning amongst participants and with guest presenters Deb Scammell (Talking Livestock), Nathan Scott (Achieve Ag) and Mary Rowe (Zoetis).

Girdham's usually contain pregnant ewes for a couple of months and then release into paddocks just before lambing. The best lambing results are consistently achieved in scrub paddocks with mob size around 100. Caleb says he's happy with lambing results, especially through the drought and he considers containing ewes worth the effort to maintain ewe condition and preserve ground cover on paddocks during a time of feed deficit in the autumn months. Deb Scammell talked through Caleb's containment set up and shared the advice "you can save money on set-up, but it might cost you in labour later so that's something to consider when planning your containment feeding infrastructure".

Good rainfall in late spring/summer in the Upper North has seen feed abundances in paddocks, but Deb still sees containment feeding in 2023 a good fit in mixed farming systems in the region to ensure pastures get away to utilise high quality pastures for lambing. This can be achieved using small "sacrifice paddocks" if containment pens are not an option. Poor quality hay (low protein, high fibre) due to rain damage at hay making will be an issue this year and needs to be taken into account when feed budgeting. Mycotoxin tests are also worth considering this year to avoid issues. Deb's reasons for why to contain pregnant ewes:

1. Improved ground cover and food on offer
2. More effective management of ewes – keeping a closer eye on condition
3. Confidence to hold stock
4. Can achieve higher stocking rates
5. Improved marking percentages – or maintain %'s rather than experiencing a dip in the dry times
6. Reduced ewe mortality

Sheep were drafted using a BreedElite autodrafter as a demonstration for the group. Caleb explained that he purchased this handler because the "system had a lot of potential". He has had 'teething issues' to the point of not using it but has recently invested the time to work through setting up the system and inputting data and can now see the potential gains for his business in labour efficiency and improved data-based decision making in the future. Nathan Scott advised that these processes are complex, and they will not save you time at the start, they will take you more time in the learning and set-up phase, but the benefits will start to be apparent down the track. As mixed farmers we do not use these operations regularly with cropping being the main priority at certain times of the year so there are two things to consider when choosing a system:

1. Do you like the way it operates?
2. What back up support is provided – look for good reps and back up support – because you WILL be using them!

Nathan reiterated the importance of lead up race design for smooth operation of sheep handlers. The race needs to be as narrow as possible and an adjustable option is ideal to change race width when drafting lambs compared with ewes.

Nathan urged livestock producers to think about eID's as "precision ag for livestock". He said "you cant improve what you cant measure" and understanding the information is crucial. For instance, recording birth status against ewe hoggets can be very useful because visually we could be classing out our twins as lesser looking animals and potentially reducing fertility of our flock as a

result. The data collected and stored for each animal may not be utilised straight away, but down the track when dry conditions hit and feed is tight, we can refer to this data to make informed decisions on which ewes to keep and which to cull, for example holding onto ewes that have been pregnancy scanned with twins 2-3 years running to improve fertility.

Nathan talked through how crucial eID's are in managing biosecurity, especially in the case of a foot and mouth disease outbreak in Australia. He said "it's not just another cost but an investment in our industry".

PDS Lotsa Lambs is not only focussing on containment feeding of pregnant ewes but also lambing multiples in smaller mobs to improve reproduction success in our Upper North flocks. Nathan is a firm believer that mob size is an underestimated factor in lamb survival from his experience as a farmer as well as working with many sheep producers. He says, for singles, mob size doesn't matter too much, but for multiples, it is best to aim for as small a mob size as you can practically achieve, ideally less than 100. The time between the birth of the 1st & 2nd lamb and the 2nd & 3rd lamb is crucial and mob size significantly improves the chance of survival of these multiples.

Lastly, Mary Rowe came to talk about the importance of managing worms in our sheep flocks this season with large worm burdens developing locally due to substantial summer rainfall including the potentially harmful Barber pole worm. Mary emphasised that effective drenching will control a worm burden and also minimise the incidence and impact of drench resistance and listed 6 important principles to consider:

1. Only use drenches that work
2. Only drench when needed
3. Use paddock management to decrease worm risk
4. Use combinations
5. Use short-acting drenches preferentially
6. Rotate drenches

This workshop was funded by Meat and Livestock Australia, The Northern and Yorke Landscape Board and Red Meat & Wool Growth Program. If you'd like any additional information about future UNFS livestock events, please contact Project Officer - Rachel Trengove, 0438452003, rachel@unfs.com.au

by Rachel Trengove

PDS LOTSA LAMBS WORKSHOP - IMPROVED WEANER MANAGEMENT

Improved Weaner Management workshops were run in our region on 9th June at Lachie Smart's farm near Wirrabara and 20th June at Michael and Catherine Battersby's farm near Wilmington. The host farmers shared their experiences in livestock management and provided an opportunity to sticky beak at their containment feeding yard set-ups for workshop participants.

Guest presenters and sheep experts, Deb Scammell, Talking Livestock and Colin Trengove, ProAg Consulting, provided valuable insights and guidance on optimizing weaner management practices such as nutrition, health, and other relevant topics. Adelaide University also attended to update participants on the results of the Heat Stress in Sheep project in the Upper North.

Key messages for improved weaner management:

1. Plan – health, method of weaning (yard or paddock), paddock selection and imprint feeding
2. Monitor weight gain – watch your tail ends, not just your averages, draft off smaller weaners and feed more often in a smaller mob
3. Weaning time – 14 weeks standard recommendation but can vary due to seasonal conditions.
4. Feeding for growth – it's crucial to get the protein/energy/fibre balance right - aim for an absolute minimum of 50g per day weight gain post – weaning.

Weaning weight + post weaning growth = SUCCESS

Deb says to get weaners up around 45% SRW (Standard Reference Weight), you need to look closely at your lactating ewe nutrition – a small amount of supplement can make a massive difference to your lamb growth rate.

Impacts of lighter weights on flock productivity can be significant - a low liveweight at 9 months of age results in a decreased lifetime net reproduction rate (NRR), "weaners that struggle are not usually useful in your flock down the track"

Ewe recovery is also important when considering weaning time, "Good recovery time for ewes will set you up for success the following year with plenty of twins."

These workshops were funded by MLA and supported by the Northern & Yorke Landscape Board as part of the Living Flinders program through funding from the Australian Government's National Landcare Program

21st JUNE - LOCATION: Jamestown, UN Region

REGIONAL SOILS CONFERENCE – BUILDING SOIL KNOWLEDGE PROJECT

Overview:

Upper North Farming Systems hosted the regions first Regional Soils Conference, a pivotal part of the Building Soil Knowledge Project funded by National Landcare Program: Smart Farms Small Grants Round 4 project. The event convened on June 21st, 2023, at the Jamestown town hall. Over 80 growers, consultants and researchers attended the event from around the region.

The event, MCed by Michael Eyres, aimed to address diverse soil-related challenges prevalent in the UN region, in line with the project aims. There was an array of presenters and a farmer panel, providing valuable insights into soil management strategies, agricultural practices, and real-world examples of maximising soil productivity for profitability. The event also served as an opportunity for attendees to collect the four case studies produced as part of this project and discuss these with presenters throughout the day.

Presenters:

1. Andrew Polkinghorne shared insights from his soil management journey, highlighting past successes and mistakes. This went back as far as clearing land, covering soil amelioration throughout the evolution of his farming career, finishing with insights into nutrient management.
2. Sam Trengove explored the role of deep ripping and the significance of amendments in ensuring long-term yield response.
3. Beth Humphris presented real-world examples and strategies for managing soil resources profitably using precision ag concepts. This considered yield potential of common soil types found across the UN, linking economics back to product applications.
4. Dr. Mark Thomas discussed strategic management approaches for hard setting sandy soils, commonly found west of the ranges.
5. Chris Davey provided insights into managing soils from an agronomic perspective. This covered factors around nitrogen management, linked soil type to weed issues and considered the role soil type has on chemical decisions.
6. Dr. Marg Evans addressed soil-borne root diseases and recommended best management practices. As part of this, Marg presented on her work on Crown Rot in the UN area.
7. Ed Scott advocated for a precision agriculture approach in making better nitrogen decisions. Ed used real life examples of how protein and yield maps can help to develop a variable rate nitrogen strategy.
8. Dr. Therese McBeath offered guidance on managing nutrition in calcareous soils to match yield potential.

Farmer Panel:

The conference also featured a farmer panel comprising of Jess Koch, Peter Kitschke, Andrew Sargent, and Michael Zwar. Their firsthand experiences and perspectives enriched discussions on soil management practices and challenges faced in the field.

Sponsors:

The success of the event was made possible by the generous support of sponsors including Omnia, Viterra, and the Northern and Yorke Landscape Board.

Conclusion:

The Regional Soils Conference served as a platform for knowledge exchange, collaboration, and innovation in soil management. By bringing together experts, farmers, and sponsors, the event facilitated meaningful discussions and laid the groundwork for advancing sustainable soil management practices in the UN region.

A special thanks goes to the Soils Conference Committee that worked hard to make this event possible. The committee was comprised of Beth Humphirs, Ed Scott and Michael Eyres.

7th SEPTEMBER - LOCATION: 21km South of Laura

GRDC HARVESTER SET-UP WORKSHOPS

Overview:

Grain growers and industry stakeholders were invited to participate in one of a series of 2023 GRDC Harvester Workshops held in the lead-up to harvest in 2023. The workshops were hosted by Upper North Farming Systems. The sessions focused on improving harvester/combine performance through practical discussions, hands-on setups, and expert insights. Key areas included loss measurement, calibration of sensors, header front settings, feeder house optimization, threshing system analysis, sieve settings, harvest weed seed control, fire suppression, and grain storage. The event brought together harvester specialists, industry experts and researchers to discuss preventable harvester grain losses and how to measure these, improvements in efficiency and output, methods of harvest weed seed control (HWSC), the prevention of harvester fires and calibrating harvester technology.

Hosts included local facilitators, and numerous interstate and international speakers including Peter Broley (Primary Sales), Ben White (Kondinin Group), Brett Asphar (Harvest Specialist), Kassie van der Westhuizen (Harvest Specialist) and Chris Warwick (Primary Business).

The sessions included:

Combine Set-Up to Improve Performance: Discussion on successful and unsuccessful techniques in local conditions and hands-on loss measurements and grain sample analysis.

Loss Measurement and Sensor Calibration: The Importance of accurate loss measurement, Practical demonstrations of rotor and sieve loss measurement, Sensor calibration for future use.

Header Front Optimisation: Proactive fine-tuning of header front setting, Cutterbar setup for different crops, Auger and reel adjustments, Knowledge on lifters and header front setup for effective feeding.

Feeder House Setup: Efficient crop flow from header front through feeder house, Step-by-step feeder house setup for various crop conditions

Threshing System Optimisation: Analysis of threshing system performance, Minimizing grain cracks while maintaining efficiency and influence of concaves and crop variances on threshing

Sieve Settings Optimization: Utilizing sieves effectively and Mastering wind and sieve settings for optimal performance

Harvest Weed Seed Control: Overview of technologies and their costs and facilitated discussion on available technologies

Harvest Fire Suppression: Causes, costs, and minimization strategies and Building robust fire suppression plans

Grain Storage and Hygiene: Challenges, opportunities, and innovations in grain storage. The session concluded with a recap of key messages, opportunities, and challenges. Participants were encouraged to ask further questions and provide feedback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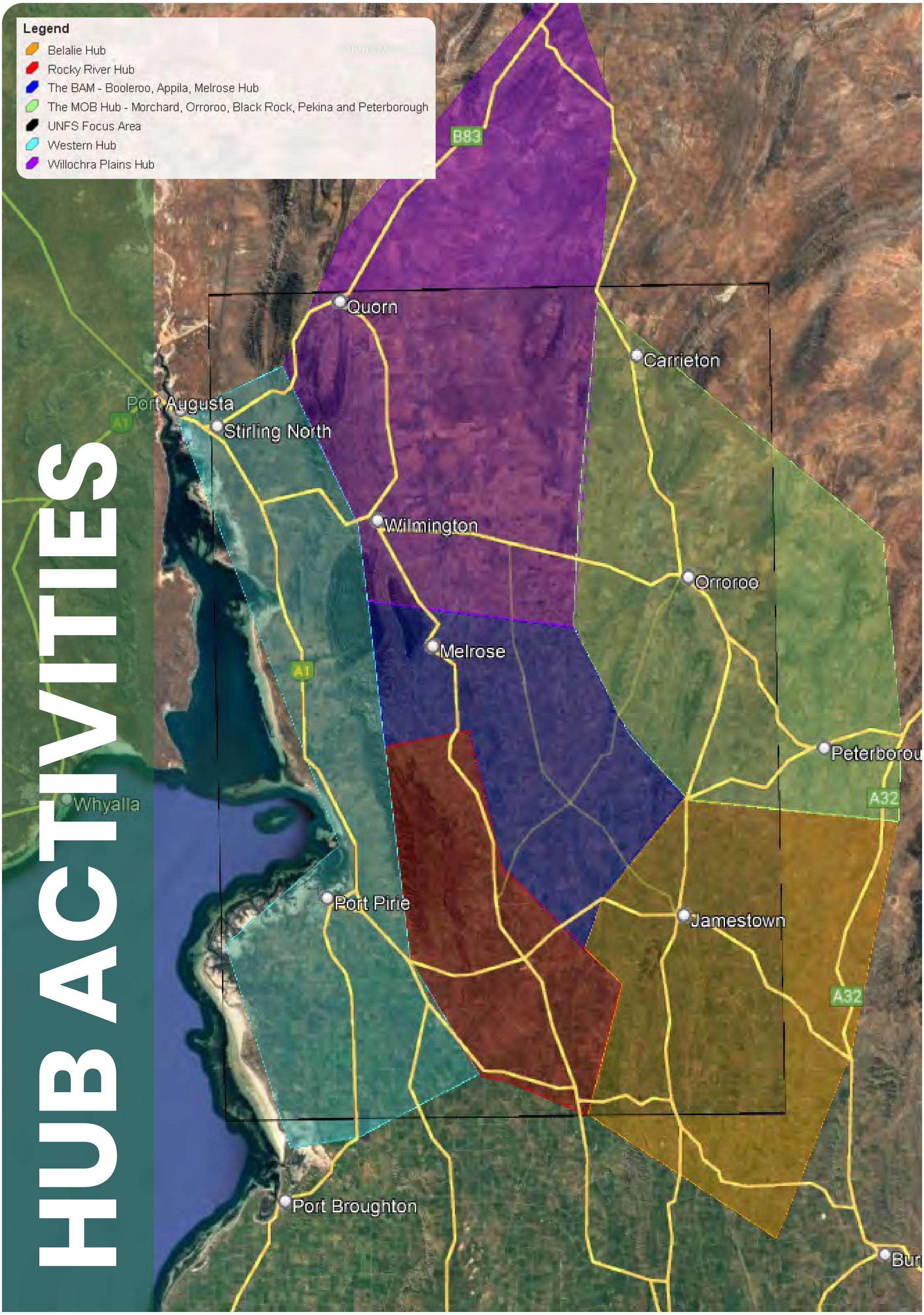
HUB ACTIVITIES



BOOLEROO, APPILA, MELROSE HUB REPORT

The year started off with a lot of optimism within the region, brought about by a full bucket of subsoil moisture from the previous summer and fair opening rains in April. This coupled with strong grain, livestock and wool prices (although volatile) set up the area well.

The region did however experience a dry season, with high input costs and sheep prices falling off a cliff, making the season as a whole very challenging. Growing season rainfall across the three towns averaged just 172mm, with disease and pest pressure remaining high from the previous high rainfall year. Good results crop wise were seen here and there, the main drivers being summer weed control and time of sowing to make the most of the subsoil moisture.

2023 marked the start of a 5-year project Field systems rotation trial, investigating the profitability of different crops on the Appila Plain, located on the corner of Booleroo-Gladstone and Appila-Wirrabara roads. Further details of the project are outlined in this compendium.

As a whole 2023 was a challenge, but growers in the region should be buoyant with what can be produced on such little rain. The year demonstrated how timely practices along with the integration of technological advancements, can have significant impact on end of year results.

by William Heaslip

BELALIE REPORT

Despite facing a dry year, many farms in the Belalie region experienced remarkable productivity. This success was primarily due to the stored moisture from the previous year and stable early commodity prices, which helped achieve good results despite the low rainfall. The previous year's moisture reserves played a crucial role in supporting crop growth throughout the season. Additionally, early stability in commodity prices contributed to a favourable outcome for the farms in the region. Mixed enterprise farms faced significant challenges, particularly due to an unexpected crash in livestock prices, which was difficult to manage amidst rising costs. Furthermore, a late-season frost adversely affected crop quality. This year highlighted the importance of storing soil moisture and timely sowing to achieve optimal results. The experiences reinforce the need for disciplined agricultural management to maximise productivity in challenging conditions. A main event highlight for the region was the Regional Soils Conference held in Jamestown on June 21st, 2023.

By David Moore

WANDEARAH HUB REPORT

The 2023 season was a very successful one for producers west of the ranges. Stored soil moisture from the pervious year, an early crop emergence and good winter rainfall meant average to well above average crops and pasture growth were achieved. The early crop establishment and warm early season conditions meant crops were well advanced by the time dry weather set in during spring and the earliest ever start to harvest followed for the region.

During the season we ran a group for the GRDC Risk Initiative looking at decision making during the year. This included a major focus on nitrogen management based on yield prophet sites around the region. We had several meetings during the season to discuss risk and decision making with Barry Mudge and Peter Hayman.

Other events held during the year included the AGM with guest speaker Dr Jay Cummins talking about his international agricultural work. We also had a meeting with ADM in August to discuss their site updates for Port Pirie and in September Tim Gurney gave us an update on how T-Ports were going and their fit for our region.

Our Annual Sticky Beak Day and Bureau Trips were once again very successful. On the Sticky Beak Day we looked at various local trials including controlling jacks in lentils, lentil herbicides, soil pits and crop emergence and growth on constrained soil types. This years' annual trip went to the mallee and included a visit to TFI's Southern Cross Feedlot, a look a soil amelioration with a Bednar, disc seeding and stripper fronts, mallee soaks, ripping compacted sands, breeding crickets for protein and much more.

A successful year for the group and farming in the region.

by Chris Crouch

MORCHARD, ORROROO, BLACK ROCK HUB REPORT

Rainfall across sites ranged from 105mm to 143mm (April-October). Despite the challenging conditions due to the lack of winter rainfall, many crops performed better than expected. This success was attributed to the retained moisture from the previous year's wet period. While several decent summer rainfall events occurred, they came too late to benefit the crops but were beneficial for grazing land, helping native grasses and bushes thrive. Some of the positives from the year was that there was better than expected crop performance despite low rainfall, due to retained moisture from the previous year. Furthermore, summer rainfall benefited the grazing land, enhancing native vegetation in the region. Some of the main challenges were lack of rain, high fertiliser prices and supply chain problems across various sectors.

A Weedseeker demonstration at Morchard by Ramsey Bros showcased technology to target onion weed, allowing for higher chemical application rates. Though promising, the technology's current cost is prohibitive for most farmers in the district. There's hope that future developments will make it more affordable. The ongoing trial located at Black Rock, of various medics, clovers, and lucerne varieties is showing promising resilience to dry conditions, indicating potential for these crops in challenging weather scenarios.

by Tom Kuerschner

GLADSTONE HUB REPORT

Following a wet 22/23 harvest, the start of 2023 was spent spraying summer weeds. This led to us organising the "Summer of Weeds" field day and dinner on 22nd Feb which was well attended by 70 farmers and display reps. Special thanks to UNFS new business manager Deb Marner for helping at her first event. See separate report.

In April, bureau members hosted the boot throwing competition at the Laura Fair with a new record of 33 meters. This made for good arm strengthening exercise for those returning the boots after every throw. Bad luck it also resulted in them getting covid from the event!

Our April meeting was held in Lucas Woolford's new shed near Laura with a BBQ supplied and talk by Incitec Pivot. Barry Mudge also spoke about the GRDC risk management initiative. Thanks Barry for jumping off the seeder with four hours notice to fill in after our other speaker cancelled.

In June we had a sticky beak ute tour inspecting the NVT trial site and lentil crops at Appila.

July was our AGM with Viterra Grower relationship rep Andrew Lehmann and Adam Crabb ADM – SA accumulation manager.

A very successful harvester workshop was organised on 7th September. In conjunction with UNFS and GRDC about 80 farmers listened to experts on harvester setups. Trying to find a central location in the area with a shed big enough to hold all the headers was a challenge. This paid off as it rained all day outside. Thanks to the Durrant family farm at Huddleston for hosting.

The end of the year saw us organising anther successful SOS Share Our Stockfeed run to the area around Orroroo. 950 bales and 180tn of grain was donated. Nelshaby bureau members also helped. The truck delivery convoy into Orroroo on Wednesday the 20th December was well received just in time for Christmas. Well done to all involved. It is good to be involved in a group so willing to share not only their feed but time and friendship with our mates in need.

By Andrew Kitto

UNFS 2023 COMMERCIAL PADDOCK REPORT

The Commercial Paddock stands as a testament to the remarkable generosity of the community, which has graciously donated land, time, and resources to support Upper North Farming Systems (UNFS). Situated on the outskirts of Booleroo Centre and owned by Northern Ag, the local NRI business, the paddock's impact on the group has been truly astounding.

From its inception, Northern Ag has been a steadfast supporter of UNFS, and their kindness was evident when they generously offered the use of the paddock as a sponsorship to the group. UNFS members now engage in various agricultural activities within the paddock, including sowing, spraying, spreading, harvesting, carting, and selling the grain produced. This initiative serves to generate income for the group independently of funding bodies or grants.

This financial autonomy equips the group with the flexibility to respond promptly to weather events or economic fluctuations and facilitates the pursuit of research endeavours that may not be prioritised by state or national funding bodies. We extend our heartfelt gratitude to Dustin Berryman and the Northern Ag team for enabling us to raise funds in this manner and for their exceptional generosity in giving back to the local community.

Thank you to all those involved in making the 2023 Commercial Paddock a success:

- Todd Orrock - Sowing
- Matt Nottle - Summer Spraying
- JP Carey - Desiccation spraying, spreading
- Tim Arthur - Grass spraying
- Flinders Machinery - repped/delivered
- Pioneer - Seed

In 2023/2024 the funds from the 2023 Commercial Paddock will be used for on-going maintenance of the region's weather stations, these weather stations provide widespread benefit to the Upper North region, with data publicly available 24/7 on the UNFS website and information shared amongst UNFS membership, CFS, SES & local communities to ensure widespread adoption and practice change as has occurred in other regions where similar weather station networks have been initiated.

Thank you to Northern Ag and our amazing group of volunteers that make this partnership an integral part of our delivery of high quality engagement and trial activities to the region.

UNDERSTANDING TRIAL RESULTS AND STATISTICS

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

The average (or mean)

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

The LSD test

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

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

Results from replicated trial

An example of a replicated trial of three fertiliser treatments and a control (no fertiliser), with a statistical interpretation, is shown in Table 1.
Table 1 Mean grain yields of fertiliser treatments (4 replicates per treatment)

Treatment	Grain Yield (t/ha)
Control	1.32 a
Fertiliser 1	1.51 a,b
Fertiliser 2	1.47 a,b
Fertiliser 3	1.70 b
Significant treatment difference P<0.05 LSD	(P≥0.05) 0.33

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

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

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

On-farm testing – Prove it on your place!

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

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

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

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

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

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

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

SOME USEFUL CONVERSIONS

Area
1 ha (hectare) = 10,000 m² (square 100 m by 100m)
1 acre = 0.4047 ha (1 chain (22 yards) by 10 chain)
1 ha = 2.471 acres

Mass
1 t (metric tonne) = 1,000 kg
1 imperial tonne = 1,016 kg
1 kg = 2.205 lb
1 lb = 0.454 kg

A bushel (bu) is traditionally a unit of volumetric measure defined as 8 gallons.
For grains, one bushel represents a dry mass equivalent of 8 gallons.
Wheat = 60 lb, Barley = 48 lb, Oats = 40 lb
1 bu (wheat) = 60 lb = 27.2 kg
1 bag = 3 bu = 81.6 kg (wheat)

Volume
1 L (litre) = 0.22 gallons
1 gallon = 4.55 L
1 L = 1,000 mL (millilitres)

Speed
1 km/hr = 0.62 miles/hr
10 km/hr = 6.2 miles/hr
15 km/hr = 9.3 miles/hr
10 km/hr = 167 metres/minute = 2.78 metres/second

Pressure
10 psi (pounds per sq inch) = 0.69 bar = 69 kPa (kiloPascals)
25 psi = 1.7 bar = 172 kPa

Yield
1 t/ha = 1000 kg/ha

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

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DECISION MAKING

AUTOMATIC WEATHER STATION NETWORK:

BETTER DECISIONS FROM BETTER INFORMATION

WEATHER STATION DATA - Booleroo Centre 2023

BY:

Jade Rose

Upper North Farming Systems

OVERVIEW

Installed in 2019 the Upper North Farming Systems Automatic Weather Station Network was funded through SAFECOM and aims to provide farmers in the Upper North Region of South Australia with timely and accurate weather data to enable better decision making on farm. The system will enable farmers to undertake spray and harvest operations safely and effectively and make decisions around frost and heat impacts and nitrogen application.

The initial network consists of 16 weather stations linked to either the 3G or the Telstra CAT M1 Narrowband IoT 700mHz network. Each site has a rain gauge, wind speed and direction sensors and air temperature and humidity sensors at 1.2m. It is hoped that this will be expanded to include 10m weather sensors in the coming year to enable inversion monitoring.

Accessing the data: Head to our website: www.unfs.com.au and follow the links to the Weather Station Network.

Interpreting the Data: It is important to understand the topography of each location, as this plays a significant role in the local weather. Ensure that the site you are selecting is representative for your location, not just the closest site.

Disclaimer: The UNFS Automatic Weather Station Network is a data provision service. It is not an advisory service. All decisions made using the information provided through this service are the responsibility of the user. UNFS takes no responsibility for any outcomes of use of this data. All weather sensitive activities should be undertaken with point of activity

2023

UNFS has a weather station located northwest of the Booleroo Centre township. This weather station, UNFS Booleroo 863071, was installed by Agbyte and is funded through income generated from the UNFS Commercial Paddock. The commercial paddock is made available to UNFS by Northern Ag and cropped by volunteers to provide a regular income to the group for projects of this nature that give back to the local community.

The below data shows some of the key readings for this weather station during 2023 and can be referred to as a reference for the 2023 trial program.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
AVG (°C)	25.1	24.3	20.8	15.7	11.6	10.4	8.8	10.8	15.1	16.2	20.8	22.2	16.8
MIN (°C)	6.8	4.5	6.5	3.8	0.4	1.6	-0.5	-1.2	-1.7	-0.9	5.8	7.1	-1.7
MAX (°C)	46.4	45.0	41.2	34.2	29.1	27.0	21.2	27.7	34.7	36.4	43.3	47.3	47.3
SUM (mm)	0.0	9.3	6.5	35.3	6.0	35.8	15.3	29.0	9.3	10.8	25.3	30.8	213.0
AVG (% RH)	49.9	47.7	57.9	64.3	75.2	76.2	78.1	72.0	52.4	53.8	53.8	57.2	61.6
MIN (% RH)	13.8	10.4	11.4	19.4	30.7	26.8	37.2	21.8	9.2	10.6	14.6	9.6	9.2
MAX (% RH)	96.9	95.8	99.2	98.9	98.9	99.2	99.0	99.2	99.0	99.0	96.0	99.1	99.2

Figure 1 *– Booleroo AgByte site weather station data for 2023. Records include - Temperature (Average, Min and Max °C), Monthly Rainfall (Sum mm), and Relative Humidity (Average, Min and Max %RH). Growing season rainfall (Apr-Oct) was 141.5 mm and yearly rainfall was 213 mm*

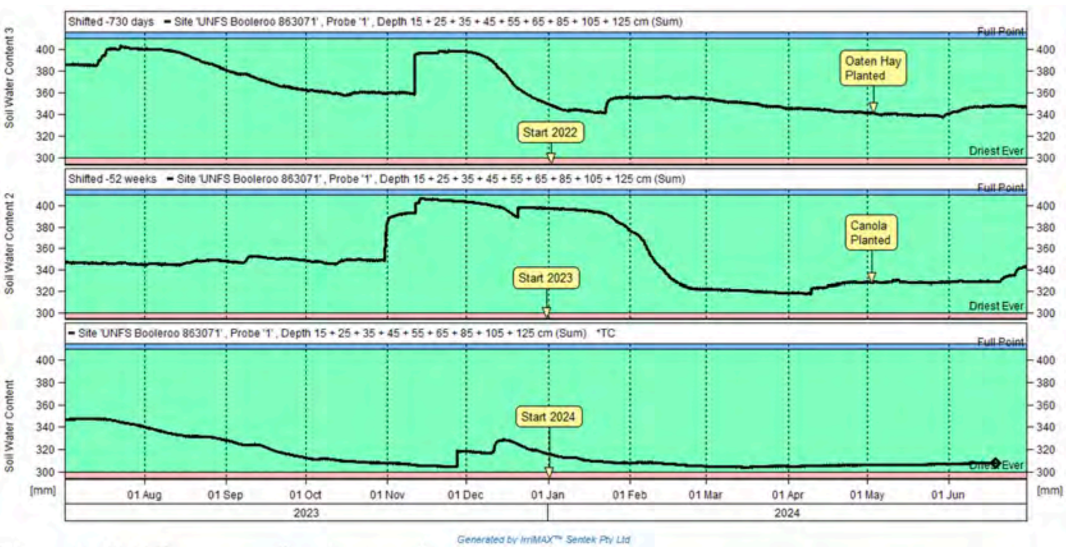


Figure 3 *-2023 Summary soil moisture probe data.*

This location has soil moisture probes that showed no moisture infiltration beyond 65cm (data not presented. Figure 3 shows the cumulative stored soil moisture for 2023 through to 2024, the cumulative graph shows that the soil moisture towards the driest ever with no major increase in soil moisture until late 2022. The soil moisture increased at the start of 2023 and the profile stayed between 340mm during the growing season, dropping towards the end of the year. The season for 2024 is starting at a very low profile at "Driest Ever" around 300mm which has continued into June 2024

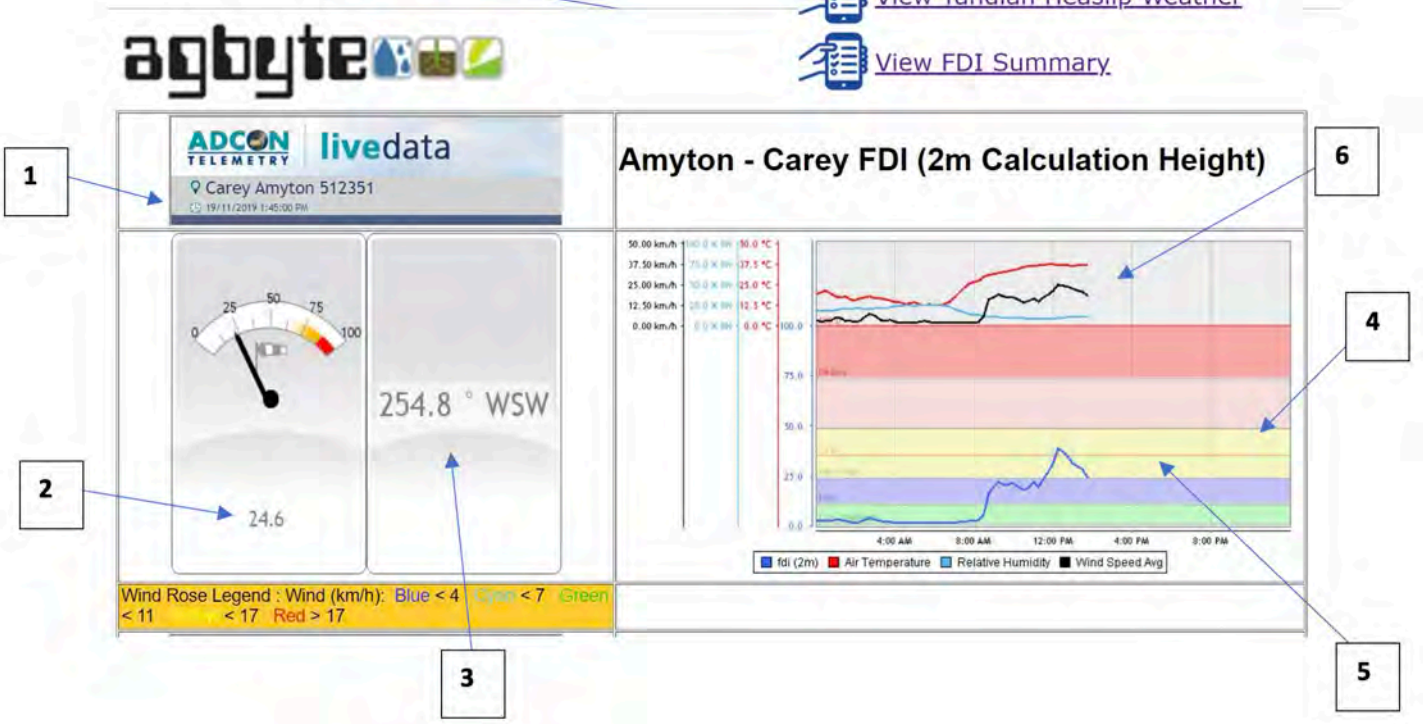
USING UNFS WEATHER STATION DATA TO DETERMINE FDI FOR YOUR AREA

Each station is displayed as a dashboard.

1. Top left is location and update time. Please check that this is within 15mins of the current time. These weather stations rely on the Telstra Network and sometimes uploads can be delayed due to network interruptions.
2. The current Grassland Fire Danger Index rating is listed here. Please ignore the "gauge" and only refer to the number. 35 is the "cease all activities" number with 20 being considered "Very High" risk of an uncontained fire occurring.
3. Wind direction
4. FDI Trend - This graph shows the trend of the Fire Danger Index over that day. When the FDI is in the yellow zone it is considered a Very High risk of uncontained fire occurring.
5. The red line shows the "cease all paddock activities" as per the Harvest Code of Conduct.
6. The top blue, red and black lines are the wind, temperature and humidity data.

Finding FDI information on the UNFS Weather Station Network:

For a district wide view of FDI - Scroll to the bottom of the list of weather stations and click on "View FDI Summary"



Fire Danger Index: The Harvest Code of Conduct & Safe Paddock Practices:

The Grain Harvesting Code of Practice was established by the CFS and Grains Industry Bodies to reduce the risk of fires from unsafe practices at harvest. It is applicable to the harvest of all flammable crops and all in-paddock practices that may pose a risk of fire including but not limited to; operating harvesters or augers and movement or operation of vehicles used for transporting grain.

The Harvest Code of Conduct is built on the Grassland Fire Danger Index. The GFDI is calculated on wind speed, temperature and humidity at 2m. All in paddock practices must cease when the GFDI is at **35**. In paddock harvest activities when the GFDI is above **20** are to be reviewed regularly and appropriate measures to ensure that a fire can be contained if it were to ignite. A fire at a GFDI above 20 has a "Very High" risk of being uncontrolled at the point of ignition with an average fire size at an GFDI of 20 being 450ha.

For more information on the code head to : http://grainproducerssa.com.au/producers/hot-topics/know-your-code/

Grassland Fire Danger Index (GFDI)

Fire Behavior Relationships

FIRE DANGER INDEX	RATE OF SPREAD (km/h)	DIFFICULTY OF SUPPRESSION	MAXIMUM AREA AT VARIOUS TIMES FROM START (hectares)				AVERAGE FINAL SIZE OF FIRE (hectares)
			½ hr	1 hr	2hr	4hr	
2	0.3	**Low** Headfire stopped by road and tracks	3	20	80	320	3
5	0.6	**Moderate** Head attack easy with water.	6	40	160	640	16
10	1.3	**High** Head attack generally successful with water	15	90	360	1440	65
20	2.6	**Very High** Head attack will generally succeed at this Index	35	210	840	3360	450
40	5.2	**Very High** Head attack may fail except in favourable circumstances and close back burning to the head may be necessary	80	480	2000	8000	2400
50	6.4	**Extreme** Direct attack will generally fail. Backburn from a secure good line with adequate personel and equipment. Flanks must be held at all costs.	105	630	2500	10000	4000
70	9.0		170	1000	4000	16000	10000
100	12.8		300	1800	7000	28000	32000

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SOUTH AUSTRALIAN FARMERS FEDERATION

NRI NORTHERN AG NRI agbyte

FAST GRAPHS FOR SLOW THINKING ABOUT NITROGEN

BY:

Barry Mudge
Barry Mudge Consulting

Peter Hayman
SARDI Climate Applications

BACKGROUND

Most people will agree that agriculture is a "risky" business. Uncertainty, primarily around seasons and commodity prices, create challenges for decision making. Fortunately in Australia, we have a long history of farmer experience, combined with an excellent R,D and E system which gives us knowledge in how to deal with this uncertainty. But there still remains some decisions that are tough calls - and getting these more right, more often can be important to long term profitability of farm businesses.

GRDC have recognised this issue and have supported a program called the National Risk Management Initiative - or RiskWi$e for short, to address it. This project aims to improve growers' management of risks, by empowering them with better understanding of upside and downside of important decisions. RiskWi$e is a participatory research project involving farming systems groups and research partners from across Australia. In the Upper North, Upper North Farming Systems is leading the project.

Through RiskWi$e, GRDC has recognised the importance of farmer psychology. The famous psychologist, Daniel Kahneman, in his excellent internationally best-selling book, "Thinking Fast and Slow", investigates human rationality and irrationality. He observed that "...most of our judgements and actions are appropriate most of the time...But not always." Kahneman distinguishes between fast thinking, which is instinctive, recognises patterns and jumps to conclusions, and slow thinking, which is more deliberative and logical.

The developing field of behavioural science provides us with understandings of why we may not be the pillars of rational decision making that we like to think we are - things like loss aversion, cognitive bias's, effect of stress etc. The authors also believe that there also remains a significant gap in analytics - tools which apply relatively simple techniques at a farm level to aid decision making.

Comparing the upside and downside of a decision involves weighing up a range of possible futures. This is mentally demanding to do in your head, but relatively easy in a spreadsheet. Our idea is to get the information quickly into a graph that shows the upside and downside of the decision in question (we estimate less than 20 minutes), so that we can then have a useful conversation about the judgement we need to make. This follows the advice of Professor Bill Malcolm, the Farm Management economist from the University of Melbourne: 'simple figuring and sophisticated thinking'. Below we provide an example of how this process looks

THE NITROGEN DECISION EXAMPLE

Figure 1 describes the decision dilemma of applying additional nitrogen to a mildly deficient crop. Investing in nitrogen is highly profitable when sufficient rainfall is received to take advantage of the additional fertiliser. The simple rule of thumb is that 40 kg of N/ha is required for an additional one tonne per ha of wheat grain. With urea at, say, $700/tonne (and an application cost of $10/ha) this means that investing around $70/ha (approx 40 kg N/ha) could result in a return of one tonne of wheat at, say, $350-400. But low spring rainfall would not allow this return to be realised. On the other hand, farmers are often consoled by the thought that N applied which is unused may still carry-over to other crops in subsequent years.

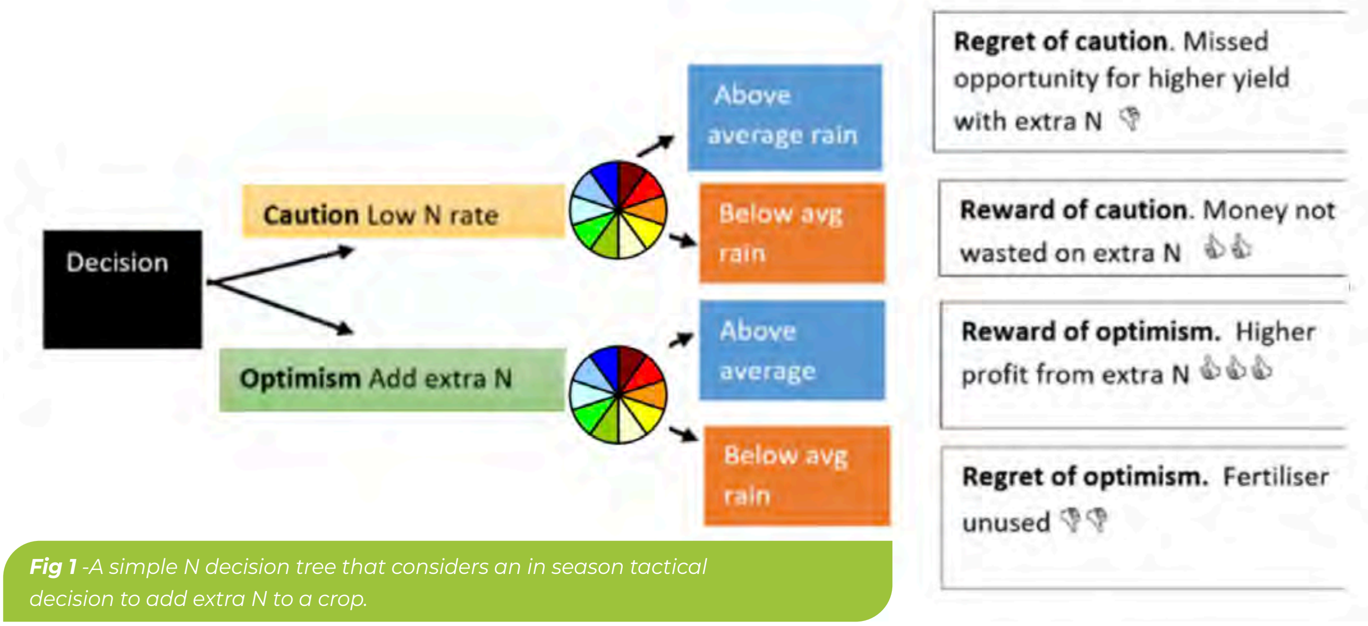
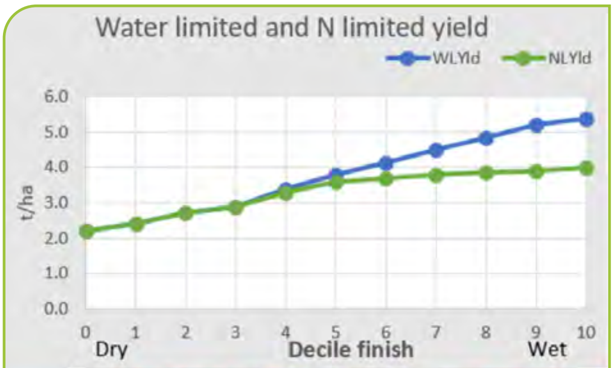


***Fig 1** -A simple N decision tree that considers an in season tactical decision to add extra N to a crop.*

Estimating the **supply** of N can be challenging - we can use deep soil testing or look at paddock history for starting N levels then use some estimate for in-season mineralisation from organic matter. And estimating the crop **demand** for N is even more difficult because of the uncertain finish to the season. The traditional approach is to select a target yield, based on soil moisture, seasonal conditions to date and some guesstimate of what the season might do from now on. The N required for this target yield is then matched up against the estimate of supply to arrive at the additional N which needs to be supplied as fertiliser.

We believe that applying some simple economics and risk to this discussion does not involve a lot of extra work but can provide a rich source of information to aid the N decision question.

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



	0	1	2	3	4	5	6	7	8	9	10
WLYld	2.2	2.4	2.7	2.9	3.4	3.8	4.2	4.5	4.9	5.2	5.4
NLYld	2.2	2.4	2.7	2.9	3.3	3.6	3.7	3.8	3.9	3.9	4.0
GAP	0.0	0.0	0.0	0.0	0.1	0.2	0.5	0.7	1.0	1.3	1.4
N req	0	0	0	0	4	8	18	28	40	52	56

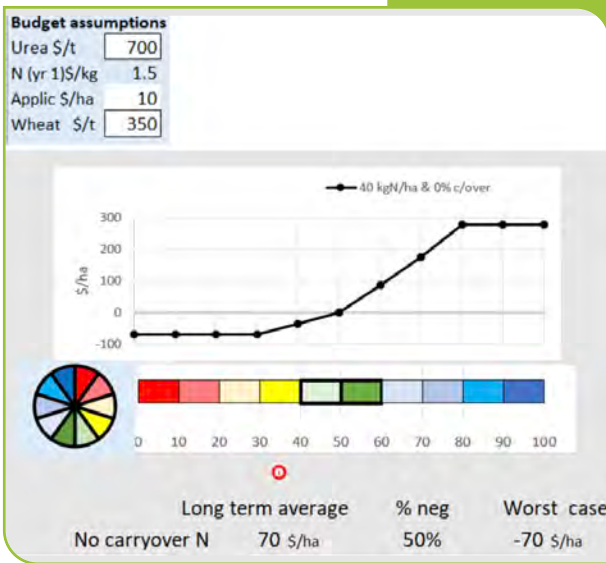


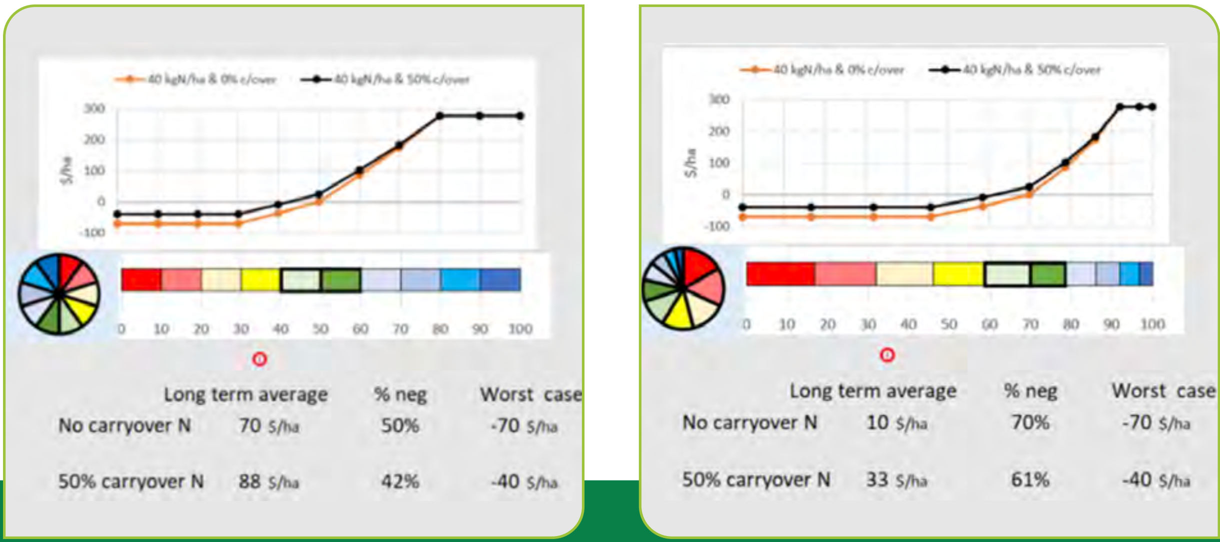
Fig 2 – Screenshot of Fast Graphs for Slow Thinking. Left hand panel showing the yield with adequate N and limited by water (WL) and the yield limited by nitrogen (NL). Right hand panel shows the profit by decile graph for the application of 40 kg N/ha, which is similar to aiming for decile 8 where the gap between the water and N limited yield is 1 t/ha.

Figure 2 shows that the long-term average return from adding 40 kg N/ha to this crop is assessed at $70/ha with a break even at around Decile 5. If a farmer was to have a similar crop over a long period, then applying 40 kg/ha of N would result in an average gain of $70/ha/year and the result would be positive in 50% of the years.

As indicated earlier, we can also look at changes in seasonal outlook probabilities along with the considerations for carry over N.

A forecast doesn't change the future, it changes the likelihood of different future outcomes occurring. Figure 3a and 3b show the result when the probability of receiving above average rainfall is shifted from 50% to 30%.

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



***Figures 3a and 3b** showing the return (profit/ha y axis) from adding 40 kg N/ha assuming urea is $700/t, urea spreading is $10/ha and wheat is valued at $350/t. In Figure 3a, the probability of achieving above average rainfall is set at 50% (i.e. historic climatology). In Figure 3b, this probability is shifted down to 30%. The % neg is the probability of making a loss.*

In assessing the value of N carry-over, the assumptions are that (i) a proportion between 0% and 90% (as selected) of the unused N will be available for subsequent crops, and (ii) the N carried forward to the next crop is valued as a saving in N fertiliser for the subsequent crops. Figure 3a and 3b show how carryover N of 50% reduces the loss in poor seasons but has no impact in rainfall deciles 8 and above because all the N applied in the first year is used by that crop. Including a 50% carryover of unused nitrogen changes the probability weighted average from $70 to $88 where there is an equal distribution of rainfall deciles (Figure 3a) and from $10/ha to $33/ha where there is skewed distribution of rainfall deciles toward drier outcomes (Figure 3b).

CONCLUSION

The RiskWi$e project is about better understanding risk and reward in all parts of the grain farm and is therefore more than an initiative about N risk-reward. It does however provide a rich opportunity for conversations about the risk and reward of N use in our grain production systems. Because getting N topdressing exactly right is almost impossible due to the variable climate, it is better to consider the consequences of erring on the side of applying a bit extra N or too little N. Budgeting tactically across deciles takes a bit longer than budgeting for a single target yield, but we have found that once growers see the graph showing the upside and downside, decision making becomes more informed and easier.

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

A short video describing the use of the Fast Graphs for Slow Thinking N tool in one situation in SA can be accessed through the following link:

https://youtu.be/G8nUHXOLR90

ACKNOWLEDGEMENTS

RiskWi$e (the National Risk Management Initiative), is a 5-year national initiative of around $30 million that will run from 2023 to 2028. It seeks to understand and improve the risk-reward outcomes for Australian grain growers by supporting grower on-farm decision-making.

RiskWi$e was established through an investment of the Grains Research and Development Corporation (GRDC).

RiskWi$e

– the National Risk Management Initiative

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CSIRO

BCG HART GROWER GROUP ALLIANCE Queensland Government Charles Sturt University AIR EP

HOW DID 2023 COMPARE WITH THE **HISTORICAL RECORD** OF **RAINFALL** AND **TEMPERATURE?**

BY:
Bronya Cooper &
Peter Hayman
SARDI Climate Applications
APRIL 2024

The monthly decile maps (Figure 1) show that after a wet finish to 2022, most of the Upper North had around average January to March. November to march rainfall was Decile 5 at port Pirie and Booleroo and Decile 2 at Jamestown. The Upper North missed the above average April on EP and South East, experienced an average to dry May and a very wet June. After June the season turned dry with well below average for July to October. Apr-Oct rainfall ended up decile 3, 2 and 1 at Port Pirie, Booleroo Centre and Jamestown respectively.

One-page summaries of rainfall and temperature have been produced for Upper North locations of Port Pirie, Booleroo

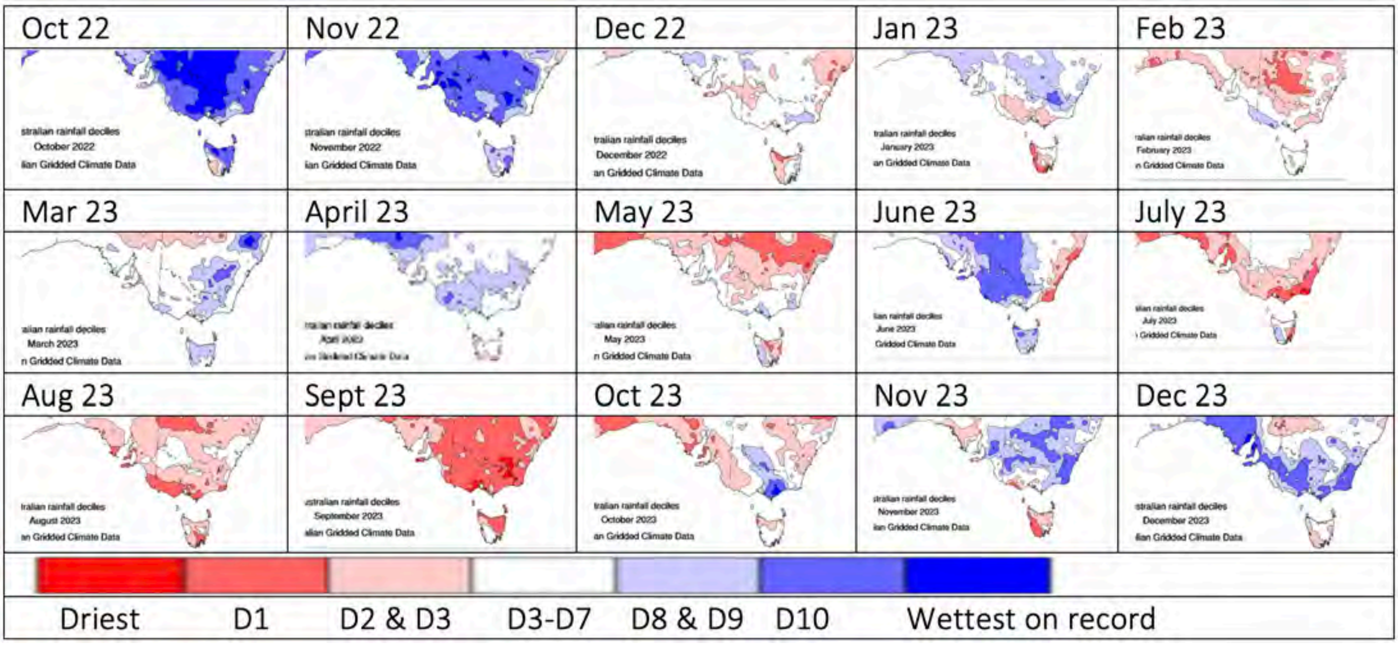


Fig 1 *-Decile maps of monthly rainfall from the Bureau of Meteorology.*

Centre and Jamestown. There is a lot of data in these summaries, we are trying to put the year in context and we are interested in any feedback. These are standard graphs that we could produce for another location on request. Because they are standard graphs, we have defined spring as Sept to November. We are aware that for lower rainfall cropping areas, spring is August and September.

Figures at the top show the cumulative rainfall for April to October (left) and spring (right), compared to Decile 1, 5 and 9 ranges. Under the rainfall section, coloured deciles 1 to 10 are shown along with the corresponding Apr-Oct rainfall, with the 2023 amount sitting above the relevant decile. The daily timeseries of rainfall is given for 2023, and the table directly beneath highlights which decile category each month fell into with red/orange colours representing lower deciles (drier) and blue colours representing higher deciles (wetter). Also shown are decile colours for annual, Apr-Oct and Sep-Nov rainfall in 2023.

The average monthly rainfall during 1900 to 2023 are shown along with those during the selected year. The monthly rainfall during the selected year is coloured according to the decile from 1900 to 2023.

Similarly, the number of rainfall days (days with any amount of rainfall) and days with rainfall greater than 5mm are shown for selected periods and for each month for the 1900 to 2023 period and for the selected year (in this case 2023). The 2023 values are coloured according to the decile from 1900 to 2023.

Moisture Balance positive days are calculated as days when todays rain plus yesterdays moisture balance exceeds todays evaporation. An upper threshold of 10mm Moisture Balance is set to reduce the longevity of high rainfall events. $MB_{today} = MB_{yesterday} + Rain_{today} - Evaporation_{today}$

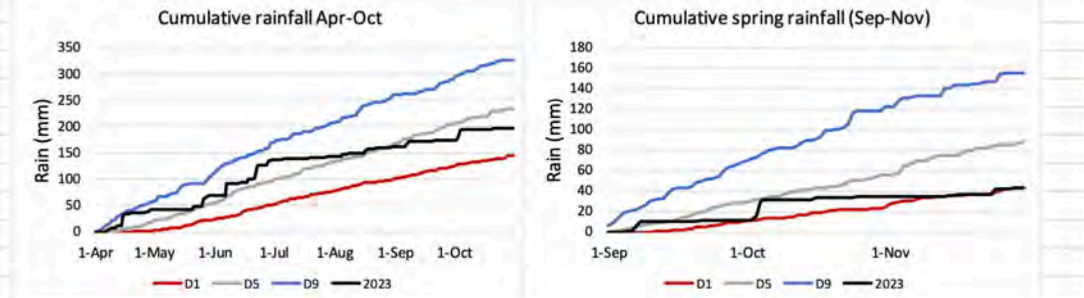
The number of days considered Moisture Balance positive are shown for selected periods and for each month for the 1900 to 2023 period and for the selected year (in this case 2023) with the 2023 values coloured according to the decile from 1900 to 2023.

The temperature section gives the relevant Apr-Oct decile amounts for maximum (upper) and minimum temperature, and the corresponding 2023 amount. The final two figures are the daily timeseries for maximum (upper) and minimum (lower) temperature for 2023, with the median (black line), 10th and 90th percentile (grey lines) of the 7 days centred on each day for the years 1957 to 2023. Daily values warmer than the 90th percentile are shown as red symbols, while daily values cooler than the 10th percentile are shown as blue symbols. Pink symbols are values within the envelope of the 10th to 90th percentile. Dashed lines are displayed as guides to define thresholds. The tables beneath give average monthly maximum and minimum temperatures during 1957 to 2023 along with those in 2023. The 2023 temperatures are coloured according to the deciles from 1957 to 2023 with red/orange colours representing higher deciles (warmer) and blue colours representing lower deciles (cooler).

Patched data from SILO was used in this analysis (Get Point Data | LongPaddock | Queensland Government)

PORT PIRIE NYRSTAR: Comparing 2023 to the long-term climate

Met station number 21043

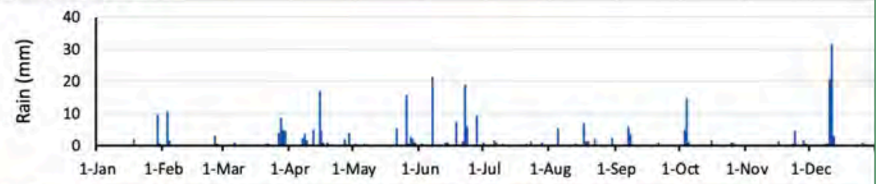


Rainfall (1900-2023)

2023: 197 mm

Apr-Oct (mm)	143	171	201	213	234	254	266	303	326	529
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Daily rainfall (mm) for 2023



	Annual	Apr-Oct	Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1900-2023	340 mm	234 mm	88 mm	10 mm	10 mm	11 mm	19 mm	33 mm	33 mm	32 mm	33 mm	29 mm	24 mm	22 mm	19 mm
2023	314 mm	197 mm	43 mm	12 mm	15 mm	24 mm	41 mm	28 mm	67 mm	7 mm	20 mm	11 mm	24 mm	9 mm	57 mm
Rainfall days (1900-2023)															
	84 days	63 days	21 days	3 days	3 days	3 days	5 days	9 days	10 days	10 days	11 days	8 days	7 days	5 days	4 days
	110 days	78 days	19 days	5 days	5 days	8 days	13 days	15 days	14 days	10 days	13 days	5 days	8 days	6 days	8 days
Rainfall days wetter than 5 mm (1900-2023)															
	21 days	15 days	5 days	1 days	1 days	1 days	1 days	2 days	2 days	2 days	2 days	2 days	2 days	1 days	1 days
	17 days	12 days	2 days	1 days	1 days	1 days	1 days	2 days	5 days	0 days	2 days	1 days	1 days	0 days	2 days
Moisture Balance Positive days wetter than 0 mm (1900-2023)															
	60 days	53 days	10 days	0 days	1 days	1 days	3 days	8 days	12 days	10 days	8 days	5 days	3 days	2 days	1 days
	54 days	45 days	4 days	1 days	1 days	4 days	6 days	8 days	18 days	4 days	5 days	1 days	3 days	0 days	3 days

Temperature (1957-2023)

Maximum

2023: 21.4 °C

Apr-Oct	19.4	19.7	20.0	20.3	20.5	20.8	20.9	21.0	21.5	22.0
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Minimum

2023: 7.8 °C

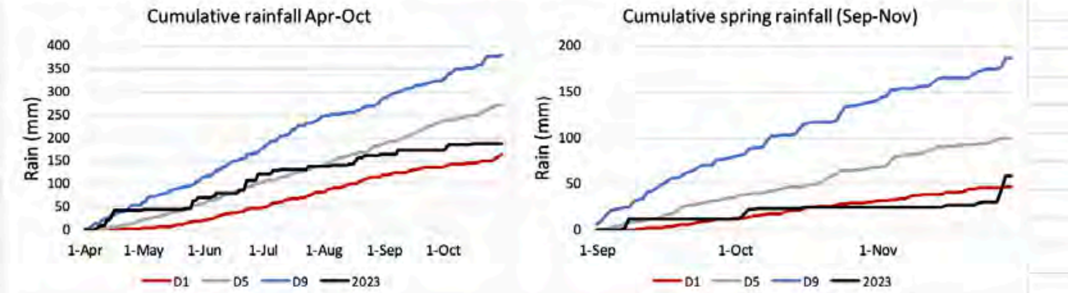
Apr-Oct	7.8	8.7	9.6	9.7	10.1	10.2	10.4	10.6	10.9	11.2
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Brief description of growing season, June and July as an example of how to read the data

In 2023 Port Pirie received 197mm GSR (decile 2), the 67mm in June was double the average and decile 9 followed by a very dry July with only 7mm in total (decile 1), an average number of rain days but no days over 5mm and only 4 days where rainfall exceeded evaporation compared to the long term record of 10 days.

BOOLEROO CENTRE : Comparing 2023 to the long-term climate

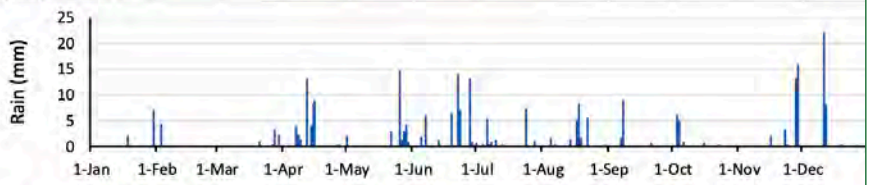
Met station number 19006



Rainfall (1900-2023)

2023		187 mm								
Apr-Oct (mm)	153	190	221	243	271	292	312	349	379	487
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Daily rainfall (mm) for 2023



	Annual	Apr-Oct	Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1900-2023	386 mm	271 mm	99 mm	12 mm	7 mm	9 mm	19 mm	34 mm	37 mm	38 mm	42 mm	34 mm	29 mm	23 mm	18 mm
2023	272 mm	187 mm	58 mm	9 mm	4 mm	7 mm	42 mm	28 mm	51 mm	17 mm	24 mm	11 mm	13 mm	34 mm	31 mm

Rainfall days (1900-2023)

	Annual	Apr-Oct	Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	89 days	67 days	23 days	3 days	3 days	3 days	6 days	10 days	11 days	12 days	12 days	9 days	8 days	6 days	4 days
	66 days	50 days	13 days	2 days	1 days	4 days	8 days	7 days	9 days	9 days	9 days	3 days	5 days	5 days	4 days

Rainfall days wetter than 5 mm (1900-2023)

	Annual	Apr-Oct	Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	23 days	17 days	6 days	1 days	0 days	1 days	1 days	2 days	3 days	3 days	3 days	2 days	2 days	2 days	1 days
	22 days	17 days	5 days	1 days	0 days	0 days	3 days	1 days	5 days	2 days	3 days	1 days	2 days	2 days	2 days

Moisture Balance Positive days wetter than 0 mm (1900-2023)

	Annual	Apr-Oct	Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	76 days	69 days	14 days	1 days	0 days	1 days	4 days	9 days	17 days	15 days	12 days	7 days	4 days	2 days	1 days
	61 days	54 days	6 days	1 days	0 days	0 days	8 days	7 days	18 days	13 days	5 days	2 days	1 days	3 days	3 days

Temperature (1957-2023)

Maximum

2023									19.1 °C	
Apr-Oct	16.9	17.4	17.6	17.9	18.0	18.5	18.7	18.8	19.1	19.5
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Minimum

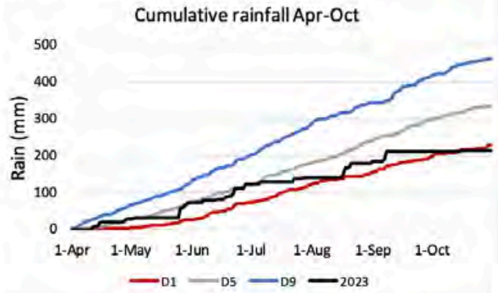
2023				6.1 °C						
Apr-Oct	5.7	5.9	6.0	6.1	6.3	6.3	6.5	6.6	6.8	7.3
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

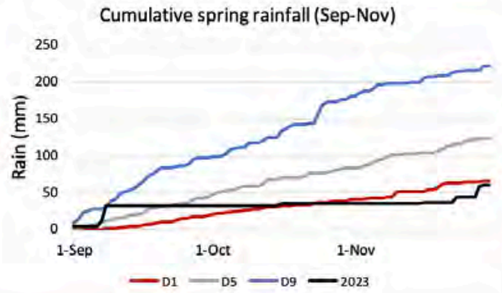
Brief description of growing season, June and July as an example of how to read the data

In 2023 Booleroo Centre received 187mm GSR (decile 2), the 51 mm in June was decile 7 followed by July which was dry 17mm (D2) but with only a modest reduction in rain days (9 days D4) and decile 5 days wetter than 5mm and moisture positive days.

JAMESTOWN : Comparing 2023 to the long-term climate

Met station number 21027

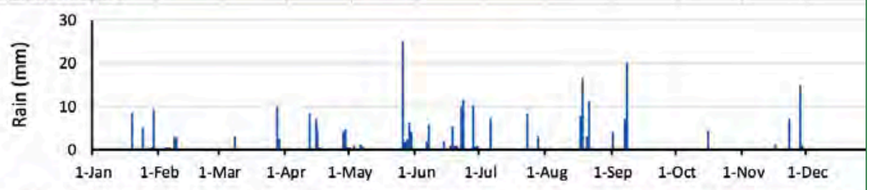




Rainfall (1900-2023)

2023	214 mm									
Apr-Oct (mm)	214	258	287	312	334	360	394	429	460	607
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Daily rainfall (mm) for 2023



	Annual	Apr-Oct	Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1900-2023	468 mm	334 mm	123 mm	13 mm	11 mm	11 mm	25 mm	42 mm	49 mm	55 mm	59 mm	44 mm	39 mm	27 mm	22 mm
2023	284 mm	214 mm	59 mm	23 mm	7 mm	15 mm	29 mm	43 mm	51 mm	19 mm	38 mm	31 mm	4 mm	24 mm	0 mm
Rainfall days (1900-2023)															
	90 days	68 days	23 days	3 days	3 days	3 days	6 days	9 days	12 days	13 days	12 days	9 days	8 days	6 days	4 days
	58 days	41 days	8 days	5 days	5 days	3 days	7 days	10 days	12 days	4 days	4 days	3 days	1 days	4 days	0 days
Rainfall days wetter than 5 mm (1900-2023)															
	29 days	22 days	8 days	1 days	1 days	1 days	1 days	3 days	3 days	4 days	4 days	3 days	2 days	2 days	1 days
	22 days	16 days	4 days	3 days	0 days	1 days	2 days	2 days	5 days	2 days	3 days	2 days	0 days	2 days	0 days
Moisture Balance Positive days wetter than 0 mm (1900-2023)															
	100 days	88 days	19 days	1 days	0 days	1 days	5 days	13 days	21 days	20 days	16 days	9 days	5 days	3 days	2 days
	67 days	61 days	8 days	1 days	0 days	2 days	9 days	6 days	18 days	15 days	8 days	5 days	0 days	3 days	0 days

Temperature (1957-2023)

Maximum

2023									18.4 °C	
Apr-Oct	16.4	16.8	16.9	17.2	17.4	17.8	18.0	18.3	18.4	18.9
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Minimum

2023								5.6 °C		
Apr-Oct	4.9	5.0	5.1	5.3	5.4	5.5	5.6	5.8	6.0	6.5
Deciles	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Brief description of growing season, June and July as an example of how to read the data

In 2023 Jamestown received 214 mm GSR (decile 1), the 51 mm in June was only slightly above the average (D6) followed by a very dry July with only 19 mm in total (decile 1), only 4 rain days (D1) but the average number of days over 5mm and 8 days (D1) where rainfall exceeded evaporation compared to the long term record of 16 days

CROP AGRONOMY

CANOLA PROFITABILITY *as a* BREAK CROP *in the* UPPER NORTH?

Author: Jade Rose, *Upper North Farming Systems* | **Funded By:** *South Australian Grains Industry Trust*
Project code: *UNF-02822-R* | **Project Duration:** *2022-2025* | **Project Delivery Organisations:** *Upper North Farming Systems, AgXtra*

Key Points

- Canola varieties performed moderately across all three trial locations averaging between 0.4 - 1.7 t/ha in 2023, yielding significantly less than in the 2022 season.
- Oil content was high in most varieties at all trial sites averaging between 39 - 43%, leading to oilseed premiums.
- Canola varieties were not profitable at all trial sites in 2023, with gross margins ranging from - $29 - $441 per hectare.
- At Wandearah in 2023, it was more profitable to grow wheat. At Melrose, neither wheat nor canola were profitable (treat results with caution, trial affected by weeds). At Morchard, growing the variety Emu TF was more profitable than wheat.

Background

This project aims to:

- Assess the profitability of different canola agronomy packages in local validation trials (GM vs open poll TT) against wheat over a three-year project.
- Inform grower decision making by exploring if new technology in canola could see it become a more reliable and viable break crop option in the Upper North Agricultural Zone (UN).
- A key factor of this project is improving the profitability and soil health of farming enterprises, particularly those without sheep in the system.

Methodology

There were three trial sites (Wandearah, Melrose and Morchard) based in the Upper North, to represent a vast and diverse area in terms of rainfall, rotations, and soil types of the region. Nine varieties of canola were selected for the trials (Table 1), these were selected after in-depth discussion from UNFS members and breeders. The varieties selected were based on their agronomy packages (TT, Truflex, RR, CL) pollination type, genetically modified and maturity characteristics. Each trial included four replications and was a split plot design separated by two buffers for each block.

Table 1 . *Treatment list including canola varieties and control (wheat) and trial layout in 2023 for sites at Morchard, Wandearah and Melrose, SA.*

Treatment	Description
1	Nuseed ATR Bonito TT
2	Nuseed HyTTec Velocity
3	AGT Renegade TT
4	Pioneer 43Y92 CL
5	Pioneer 44Y94 CL
6	Pioneer 44Y95 CL
7	Pioneer 44Y30 RR
8	Pioneer 44Y27 RR
9	Nuseed Emu TF
10	Wheat (AGT Calibre)

Table 2 . *Sowing details in 2023 for each trial site location, Wandearah, Melrose and Morchard, SA.*

Trial Location	Sowing Date	Sowing Depth
Wandearah	*27th April 2023*	*Moist, 10 mm depth*
Melrose	*27th April 2023*	*Moist, 10 mm depth*
Morchard	*28th April 2023*	*Moist, 10 mm depth*

Table 3 . *Rainfall data per month (mm) for the three trial sites at Wandearah, Melrose and Morchard, SA from April to December 2023.*

Site	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Wandearah	43.5	26.8	73.4	12.7	21.6	21.4	10.2	3.1	8.3	221
Melrose	33.8	22.8	49.2	12.2	15.8	9.5	18.5	33.5	31	226
Morchard	68		61.3	10.5	16.2	15.5	10.9	13.4	49.3	281

Results and Discussion

Average rainfall was received in many areas of South Australia during April, May and June,enabling a strong start to the cropping season (Table 3). Carryover moisture from the wet spring in 2022 provided a level of confidence for achieving successful crops in many districts despite the forecast for drier conditions. It was estimated that 28,300 ha of canola was predicted to be sown in 2023 in the Upper North district, with a 5 year average of 222,100 ha being planted. Below average rainfall was received in significant areas of South Australia during July and August, which limited crop potential after a promising start during autumn and early winter. Significant frost events occurred in September and October and impacted grain production in some areas. Canola yields were average to slightly above, but with lower oil contents reported in early finishing crops. Overall, pest and disease impacts across South Australia were generally low, and outbreaks were managed well by most producers.

- The Wandearah canola and wheat established well, with good sub-soil moisture for early germination. The Melrose and Morchard canola had a slightly drier seed bed, with the canola germinating later than the wheat at the site.
- At Wandearah, wheat yielded significantly highest at 3.5 t/ha, out - yielding all canola varieties by almost double. All canola varieties were equivalent in yield statistically.
- At Melrose, the variety Emu yielded significantly highest at 1.1 t/ha, above wheat and all other varieties at the site. However, there was a higher weed burden at this site, which could confound results.
- At Morchard, wheat yielded significantly highest at just over 2 t/ha followed by Emu canola yielding at just under 2 t/ha, however equivalent to 45Y95 and NCH19T588 TT. Pioneer 44Y30 had the highest oil content at 41.7 %, despite only yielding over 1 t/ha.
- In 2023, wheat had significantly higher yields at all sites except Melrose.

Table 4 . *Summary of oil content (%) for canola varieties trialled at Wandearah, Melrose and Morchard, SA in 2023. Shaded values in each column show the highest performing varieties for each location. Treatments with the same letter at the same site are not significantly different.*

Technology	Variety	Wandearah	Melrose	Morchard
		Oil Content %		
Triazine Tolerant and stacked	HyTTec Velocity	40.8 b	43.1	38.3 c
	ATR Bonito	41 b	43.8	40.8 ab
	Renegade TT	39.7 cd	42.1	40.4 b
	Nuseed Emu	42.2 a	43.3	38.6 c
Roundup Ready®, TruFlex® and stacked	Pioneer 44Y30RR	40.5 c	43.9	41.7 a
	Pioneer 44Y27RR	39.7 cd	42.8	40.6 b
	Pioneer 43Y92CL	39.9 cd	43.5	40.8 b
Clearfield®	Pioneer 44Y94CL	39.5 d	42.9	40.8 ab
	Pioneer 44Y95CL	39.4 d	42.8	40.5 b
LSD P = 0.05		0.88	NS	0.91

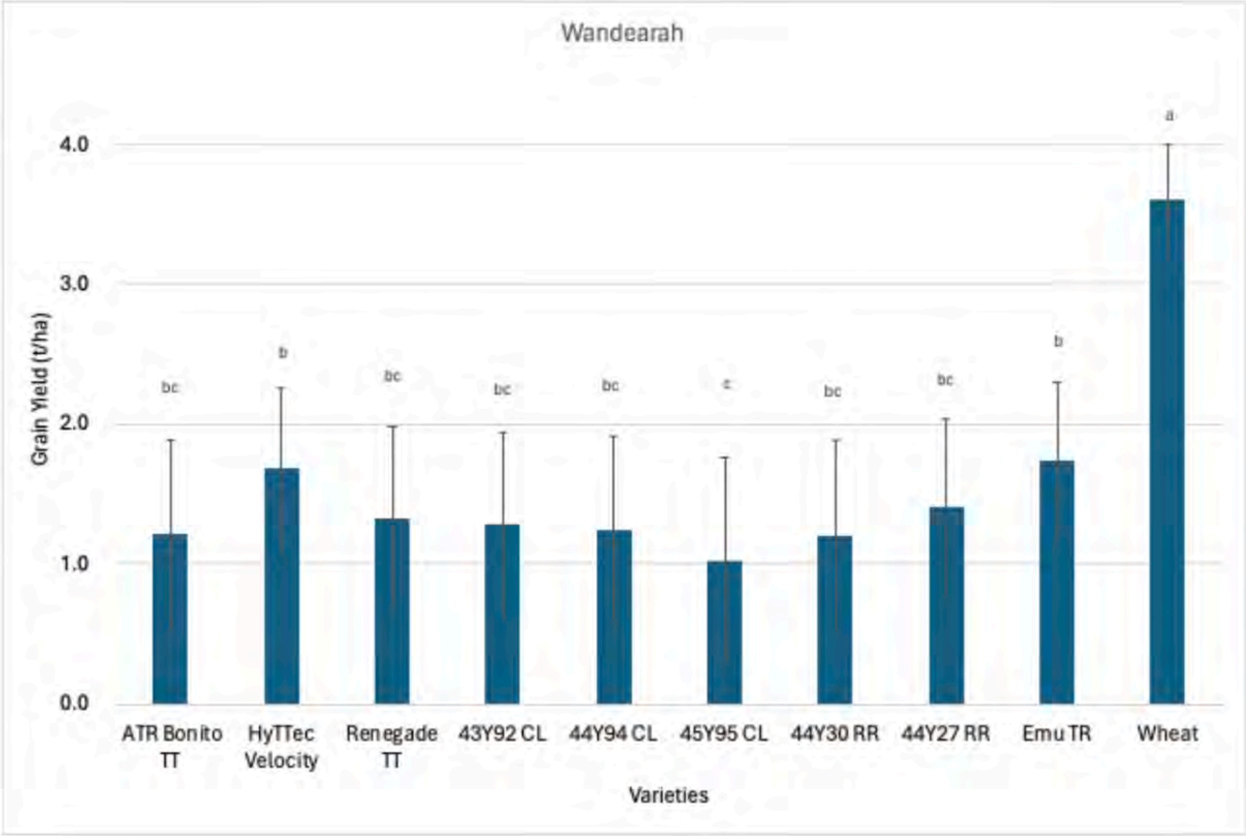


Figure 1 . *Yield data for canola varieties against wheat variety Calibre located at Wandearah, SA in 2023. Values are means of yield for each variety, error bar is (±SE). Letters above bars reflect outcomes of ANOVA and posthoc Tukey's tests.*

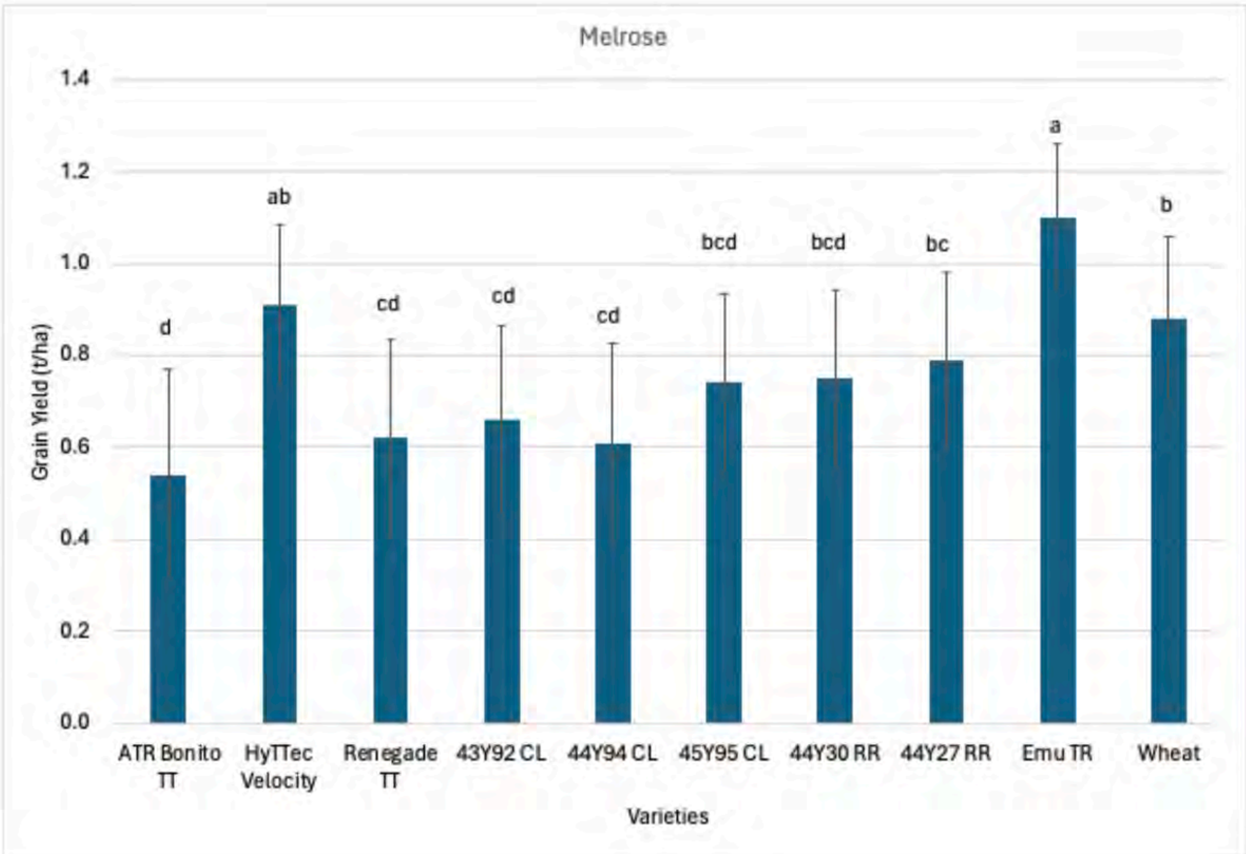


Figure 2 . *Yield data for canola varieties against wheat variety Calibre located at Melrose, SA in 2023. Values are means of yield for each variety, error bar is (±SE). Letters above bars reflect outcomes of ANOVA and posthoc Tukey's tests.*

Figure 3 . *Yield data for canola varieties against wheat variety Calibre located at Morchard, SA in 2023. Values are means of yield for each variety, error bar is (±SE). Letters above bars reflect outcomes of ANOVA and posthoc Tukey's tests.*

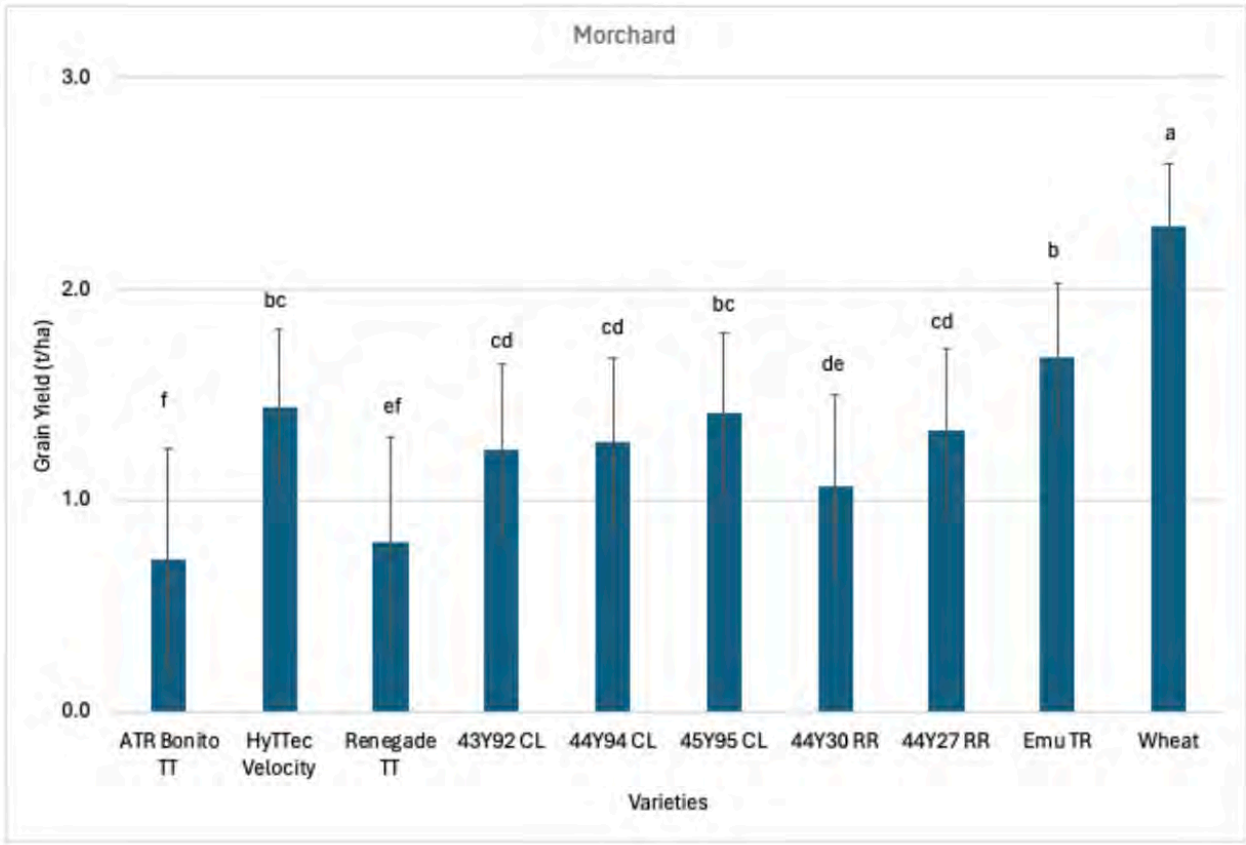


Table 5 . *Indicative Gross margins for Canola and Wheat treatments in 2023. Price assumptions based on the PIRSA Gross Margin Guide 2024, prices forecast for LOW rainfall zone and contract rates for machinery Ops. Canola prices adopted by technology type: Conventional = $650/tonne, Clearfield = $650/tonne, RR = $620/tonne, Tri-Tolerant = $650/tonne. Wheat = $340/ tonne.*

Variety	ATR Boni-to TT	HyTTec Velocity	Rene-gade TT	43Y92 CL	44Y94 CL	44Y95 CL	44Y30 RR	44Y27 RR	Emu TF	Wheat Calibre
Site	**Wandearah**									
Yield	1.2	1.6	1.3	1.2	1.2	1.0	1.2	1.4	1.7	3.6
Gross Margin ($/ha)	87	323	146	93	93	-24	160	272	441	685
	Melrose									
Yield	0.5	0.9	0.6	0.6	0.6	0.7	0.7	0.7	1.1	0.88
Gross Margin ($/ha)	-304	-89	-266	-259	-259	-200	-119	-119	104	-113
	Morchard									
Yield	0.7	1.4	0.8	1.2	1.2	1.4	1.0	1.3	1.6	2.3
Gross Margin ($/ha)	186	205	-148	93	93	211	48	216	385	303

**This data should only be used a guide, pricing sourced from 2024 forecasts.*

Image 1: *Western UNFS/Nelshaby Ag Bureau Sticky Beak Day in August 2023 at the Wandearah site. The Morchard site on the 1st September 2023.*

Acknowledgements

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- A big thankyou to our trial hosts Andrew Catford, Andrew Walter and Brendon Johns, we truly appreciate your help.

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2024 Farm Gross Margin and Enterprise Planning Guide https://sagit.com.au/2024-farm-gross-margin-guide/

ABARES Research Topics – Agricultural Outlook – Oilseeds https://www.agriculture.gov.au/abares/research-topics/agricultural-outlook/oilseeds#value-of-canola-production-to-fall

EARLY SOWING OPPORTUNITIES IN LOW *to* MEDIUM RAINFALL ENVIRONMENTS

Author: Dylan Bruce & Penny Roberts | **Funded By:** *Upper North Farming Systems*

Project Duration: *2023* | **Project Delivery Organisations:** *South Australian and Development Institute (SARDI) & UNFS*

Key Points

- Grain yield increases up to 0.43 t/ha and 0.75 t/ha were achieved through early sowing lentil and faba bean, respectively compared to a traditional sowing time.

Background

The traditional sowing window for lentil and faba bean is well researched for the low to medium rainfall zone of the southern growing region, falling within mid to late May (GRDC, 2018b, GRDC, 2018a). Conventionally, the sowing of most pulse crops is delayed to avoid the potential of high disease pressure associated with large canopies, and flowering and podding during periods of increased frost risk. However, delayed sowing often results in reduced yield due to less growth and dry matter production, and flowering and pod fill occurring during periods of increased temperature and moisture stress. Unlike cereal crops, where flowering and reproductive development occur within a narrow window, pulses are indeterminate in their growth pattern, meaning that vegetative and reproductive growth occur concurrently. Flowering and podding often occur over an extended period, where developing flowers and pods are subjected to a broader range of climatic conditions than those experienced by a cereal crop. Negative conditions, such as frost occurrence during this time can result in flower and pod abortion, however, this can be compensated for by the continuation and later development of flowers and pods. It is this indeterminacy and adaptability in growth habits of pulses that has potential for exploitation to overcome environmental constraints. Early sowing offers the opportunity to extend the growing season and maximise yield potential, compared to traditional sowing times in lower rainfall environments.

Methodology

A field experiment was undertaken at Warnertown, South Australia (Mid North) in 2023, to investigate the opportunistic early sowing of lentil and faba bean compared to a traditional sowing time. The first time of sowing (ToS) was completed on the 14th of March, followed by the 4th of April and 1st of May. Supplementary irrigation equivalent to 20 mm of rainfall was applied via in-furrow drippers directly post-first and second ToS and pre-third ToS, to best simulate a singular rainfall event that could trigger sufficient germination and establishment. Three varieties of faba bean and lentil were selected based on known differences in phenological characteristics of flowering time and crop maturity (Table 1). The experiment was sown in a split-plot design, with crop type and ToS randomly assigned to the main-plot and variety randomly assigned to the sub-plot to ensure each crop received appropriate agronomic management. Harvest was conducted on the 17th of October. Data was analysed in Genstat 23rd edition using mixed model (REML).

Table 1. Phenological characteristics of lentil and faba bean varieties sown at Warnertown, 2023.

Crop	Variety	Flowering Time	Maturity Time
Lentil	PBA Highland XT	Early	Early
	GIA Leader	Mid-late	Mid-late
	GIA Metro	Late	Mid-late
Faba Bean	PBA Marne	Early	Early-mid
	PBA Bendoc	Mid	Early-mid
	PBA Samira	Mid	Early-mid

Results and Discussion

Seasonal rainfall at Warnertown in 2023 was below average, with growing season rainfall (GSR [Mar-Oct]) of 217 mm, compared to a long-term average GSR of 283 mm (Table 2). An early break was received during April with 26 mm falling over the site across the 14th and 15th, totalling 39 mm for the month. Only April and June recorded above average rainfall across the growing season. Air temperatures immediately following the first ToS were high with 8 days exceeding 30°C across the remainder of March. More high temperature events were recorded during the Spring months of September and October, including a 34.9°C event on the 17th of September, forcing a tight finish to the season. A few frost events were also recorded during late winter/early spring. This resulted in some flower and pod abortion in the earlier ToS, and more notably in the early maturing lentil and faba bean varieties (Figure 1).

Table 2. Monthly rainfall (mm) across the growing season for Warnertown, 2023, against the long-term average (green = above monthly average, red = below monthly average), and number of days where temperatures reached equal to or less than 0°C and equal to or above 30°C across the growing season (greater intensity shading of blue = greater number of cold events, greater intensity shading of orange = greater number of heat stress events).

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2023 GSR	13	39	27	73	13	22	21	10	217
Long-term Average GSR	19	28	37	45	39	37	42	36	283
No. Days ≤0°C 2023	0	0	0	0	1	2	1	0	4
No. Days ≥30°C 2023	13	2	0	0	0	0	5	4	24

Figure 1. Stages of frost damage exhibited on Mar-14 sown PBA Highland XT pods from 0°C event on 17th of July, left image taken on 24th July, right image taken on 7th August.

Phenological development in both lentil and faba bean differed in response to ToS (Figure 2). Mid-March sown lentil reached mid flowering (50% of plants with open flowers) between the last week of May and the first week in June. The duration of flowering from the earliest sowing time lasted up to 106 days for GIA Leader, with all varieties flowering up to early to mid-September. Pod formation began during early-June for all varieties. A two-week delay in sowing time caused lentil to flower approximately two months later, thereby increasing the duration of vegetative growth and reducing the duration of reproductive development. Sowing an additional month later in early-May reduced the duration of both vegetative and reproductive development in all lentil varieties. The reproductive phase was shortened due to a lack of Spring rainfall and number of heat stress events during September.

Faba bean exhibited a greater level of stability within the duration of vegetative and reproductive development across each ToS compared to lentil. Like the earliest sown lentil, mid-March sown faba bean reached mid-flowering between the last week of May and the first week of June. Flowering continued through to late August/early September. Pod formation began during the first week of June for PBA Marne, approximately 75 days post-emergence, while later maturing PBA Bendoc and PBA Samira commenced pod formation around the end of July. The phenological development of early-April sown PBA Marne was earlier than both PBA Bendoc and PBA Samira by two weeks. In contrast, PBA Marne had very similar phenological timings to PBA Bendoc and PBA Samira, when sown in mid-March. The time between emergence to 50% flowering, 50% flowering to end of flowering and pod development to >50% senescence shortened from the mid-March to the early-April sowing times. A further delay in sowing time from early-April to early-May saw little difference in duration of vegetative growth, but noticeable differences in reproductive development duration.

Grain yield results indicated varied responses to ToS, depending on maturity characteristics in both lentil and faba bean (Figure 3). For faba bean, mid-March and early-April sown PBA Marne achieved the highest grain yields at the site yielding 4.39 and 4.31 t/ha, respectively. All faba bean varieties benefitted from pre-May sowing, with PBA Bendoc yielding 3.83 t/ha when sown mid-March and PBA Samira yielding 3.67 t/ha when sown early-April. For lentil, PBA Highland XT sown early-April was the highest yielding at 2.97 t/ha. The yield of PBA Highland XT was the same as GIA Leader at all other ToS. All three lentil varieties had the lowest yields when sown early-May. GIA Metro across every ToS yielded less than other varieties. The greatest yield of GIA Metro was achieved when sown mid-March, yielding 2.33 t/ha, with declines in yield progressively thereafter for later sown dates.

The ratio of grain to total shoot dry matter, or harvest index (HI), was measured to determine the reproductive efficiency of lentil and faba bean grown at Warnertown (Figure 4). Mid-March sown PBA Marne recorded the highest HI (0.42) out of the faba beans, while mid-maturing varieties PBA Bendoc and PBA Samira recorded their highest HI when sown early-May. This result indicates that early maturity during a tight finish has delivered greater yield potential with greater efficiency in the partitioning of assimilated photosynthates. PBA Highland XT and GIA exhibited their highest HI when sown early-May, recording 0.44 and 0.36, respectively. The HI of GIA Metro did not differ between ToS 1 and 2, and 1 and 3, with the only difference occurring between ToS 2 and 3.

The success of this opportunistic early sowing strategy is highly dependent on the arrival of emerging rains and/or the presence of subsoil moisture. How much starting subsoil moisture is needed to assist with risk management decisions requires further investigation. Decisions regarding paddock and variety selection should also be considered as paddocks with low weed burdens along with improved herbicide tolerant varieties should be chosen, as the pre-sowing window for an effective herbicide knockdown is restricted. However, as the crops are emerging during warmer daily temperatures, they are more vigorous and competitive with weeds earlier on. The excessive early growth from early sowing, although favouring disease pressure and intensity, can increase harvestability. Disease management is crucial, especially during above average seasons, but how disease is managed in these bulky canopies through fungicide application timing, frequency, product selection and the flow on effect of these decisions on gross margins are unknown. Sowing time can have a profound effect on phenological timing, where environmental frost risk should be assessed for the targeted environment. The difference between mid-March and early-April sowing times may only be two weeks, however, up to an eight-week difference has been seen in the flowering time between these two ToS in pulses, suggesting there is a threshold for sowing early to target maximum yield potential while avoiding potential frost risk. Whilst this practice shows great potential, it has not been validated in frost prone environments and still requires significant research efforts to understand and develop suitable management packages for early sowing in the low rainfall zone.

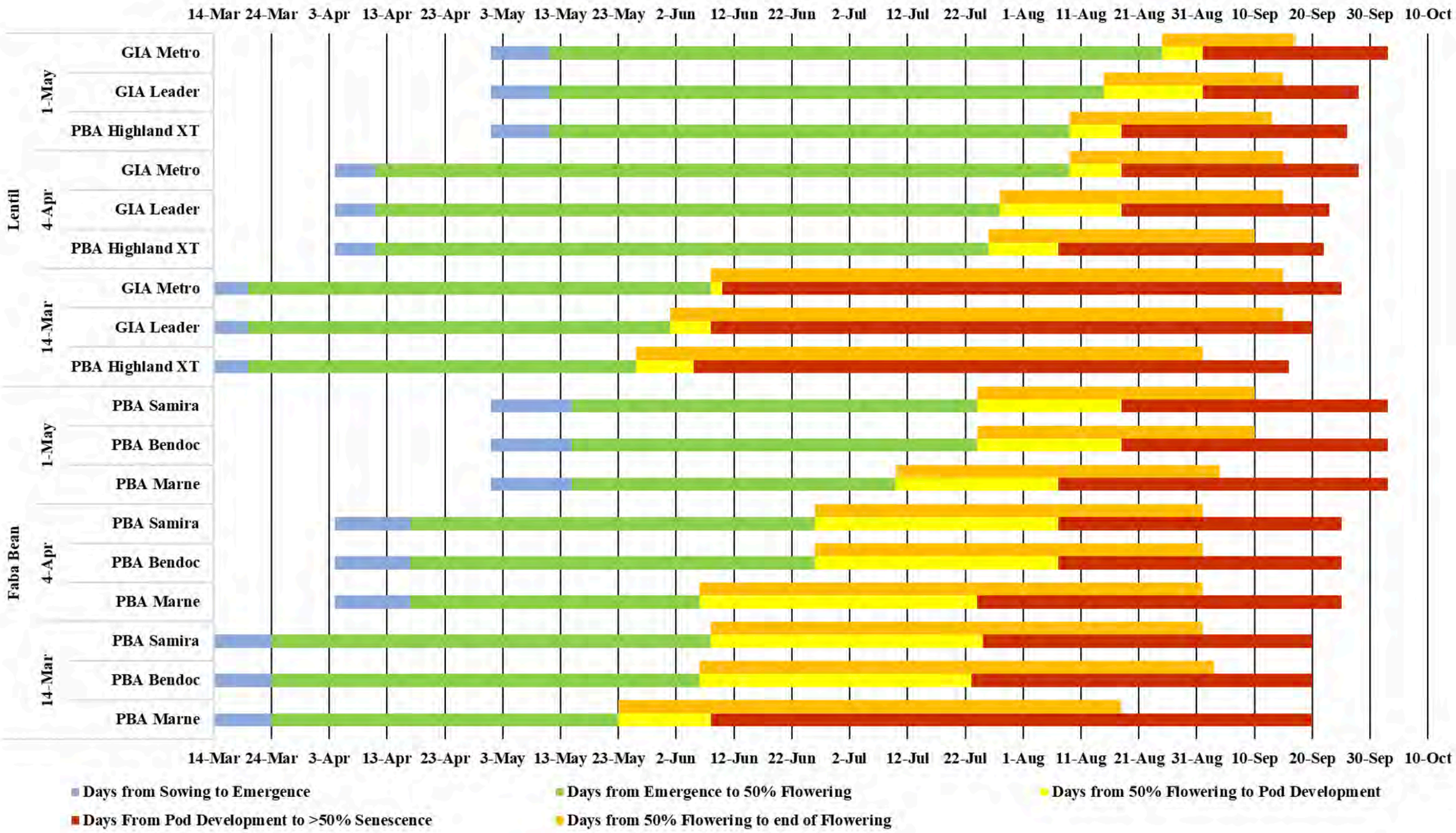


Figure 2. *Observed phenological characteristics of faba bean and lentil varieties sown at different times at Warnertown, 2023. Note: phenological assessments presented in this figure were taken at one-to-two-week intervals. The data provides only an approximate guide to differentiate between crop types and their phenological progression when sown at different times.*

Figure 3. *Grain yield (t/ha) response of lentil and faba bean to different times of sowing at Warnertown, 2023. Error bars represent standard error (P<0.05).*

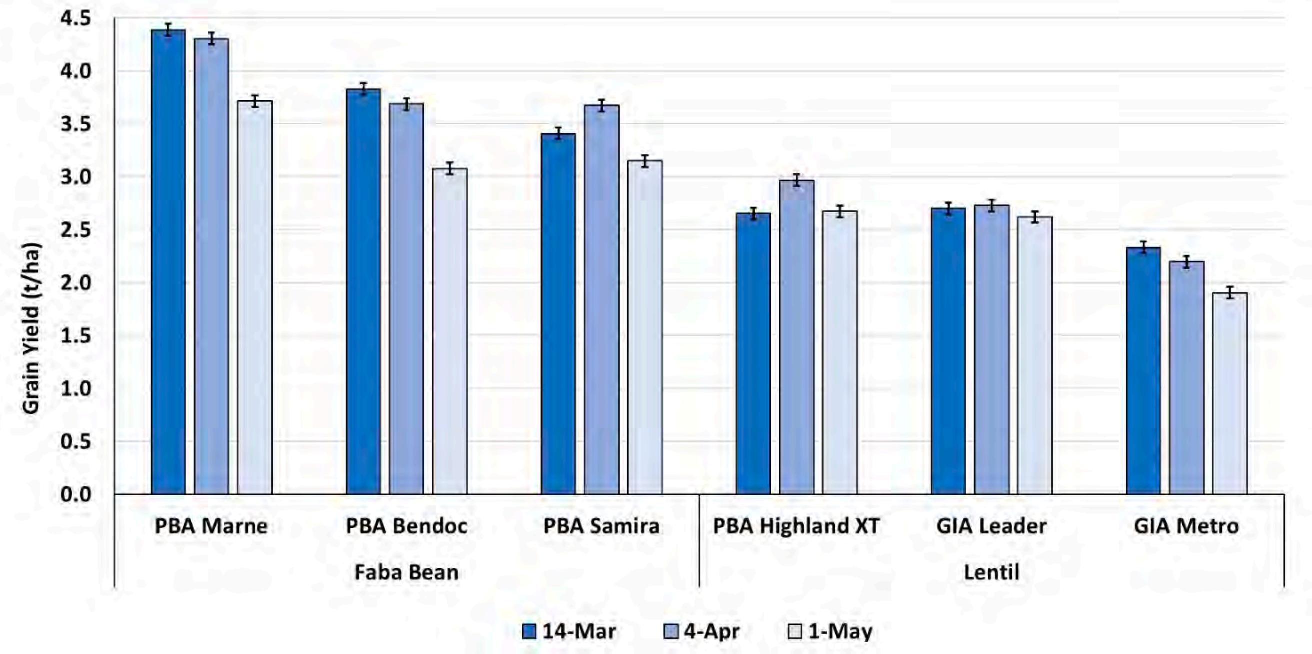
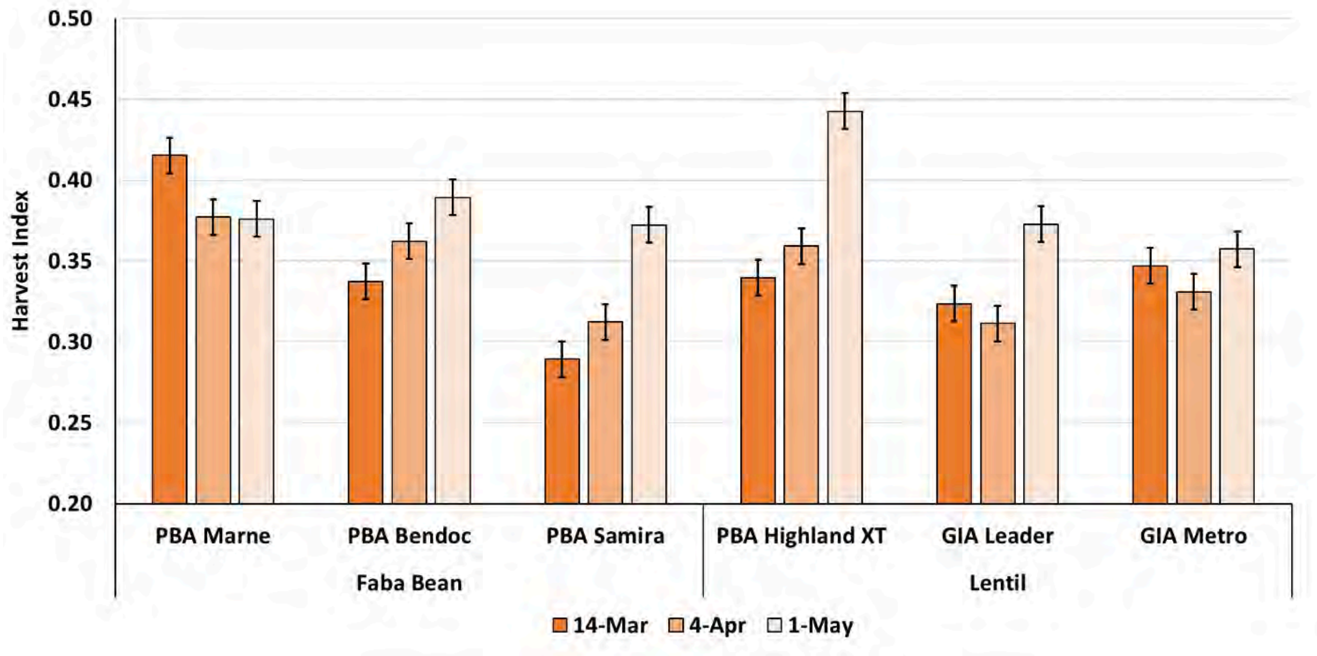


Figure 4. *Harvest Index response of lentil and faba bean to different times of sowing at Warnertown, 2023. Error bars represent standard error (P<0.05).*



Acknowledgements

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EVALUATING *the importance of* SOWING RATE, DEPTH *and* TIME OF SOWING *on* EMERGENCE *and* YIELD – WHEAT AND CANOLA

Kaidy Morgan - *Hart Field - Sit Group*, **Glenn McDonald** - *The University of Adelaide*, **Rebekah Allen** - *Hart Field Site Group*, **Mick Faulkner** - *Mid North High Rainfall Zone*, **Sam Trengove** - *Trengove Consulting*

Key Points

- Despite observed differences in establishment between times of sowing (TOS) for wheat and canola, early sown crops resulted in higher yields due to better utilisation of early growing season rainfall for biomass and grain production at Hart.
- With a dry subsoil there was no benefit from deep sowing of canola or wheat. In general, similar yields were achieved from shallow and standard sowing depths.
- Increasing sowing rates to compensate for anticipated lower establishment did not increase yields of canola and wheat in most cases.
- Preliminary data from Hart suggests that soil moisture at sowing may be an indicator of plant establishment (%), with an approximate 2% reduction in establishment noticed for every 1% decline in soil moisture for both wheat and canola, regardless of TOS.

Background

An increase in the average farm size and variation in autumn rainfall means that it is becoming increasingly important for farmers to sow earlier in the season without significantly reducing production potential (Flohr et al. 2021). Despite recent cultivar development improving resilience to drought stress, significant risks remain when dry sowing. Poor establishment and uneven crop development associated with dry sowing, particularly into marginal soil moisture, may lead to significant issues such as poor weed control and a reduction in crop productivity.

Simulation modelling of the effects of dry sowing has suggested potential yield benefits of up to 35% compared to delayed sowing in wet conditions (Fletcher et. al. 2015). The greatest benefits were noticed at locations with lower annual rainfall, heavier soils and where there was a large cropping program (Fletcher et. al. 2015). By testing the impact of sowing depth on plant establishment in dry conditions, the risks associated with dry sowing can be quantified. In order to combat potential yield losses associated with poor establishment in dry conditions, the efficiency of increasing sowing rates was explored.

In 2023, trials were sown at three sites across the Mid-North of SA; Hart, Giles Corner and Bute. Trial objectives investigated techniques to improve the effectiveness of dry or early sowing by quantifying effects of sowing depth and rate on plant establishment, growth and yield under varying soil moisture conditions and times of sowing.

Methodology

Five replicated trials were sown across three sites; a calcareous clay-loam at Hart, dark grey vertosol at Giles Corner and a loam to clay-loam soil at Bute. At each site, crops were sown at three or four sowing dates between late April and early June, with three sowing depths and two or three plant densities. Sowing rates for Hart targeted 100%, 125% and 150% of the standard sowing rate. For canola, these rates were 45, 56 and 68 plants/m^2 respectively, for wheat the rates were 180, 225 and 270 plants/m^2. Similar rates were targeted at Bute and Giles Corner sites (Table 1). All trials were sown with a knife-point press wheel system. The same seeder was used at both Hart and Giles Corner sites, however very low bulk density of the vertosol soil at Giles Corner resulted in seeder wheels sinking. Tynes also caused variability in depth at Giles Corner due to soil clods. Clods are often present in high clay content soils and can range from 1-30 cm in size and caused a relatively large spread of seeding depth across the wheat trial. The canola trial at Giles Corner was sown on a bean stubble and had a slightly lower clay content compared to the wheat, which was reflected in more stable depths.

The number of plants/m^2 was measured to determine the effect of treatment on establishment. Soil moisture in the top 10 cm was recorded at sowing and monitored until final emergence of all TOS. Normalised Difference Vegetation Index (NDVI) was also measured frequently after emergence to track plant growth (higher NDVI values indicate less exposed soil and greener vegetation). Additionally, timing of key phenological events (e.g., flowering) were recorded for all plots to determine potential treatment effects on plant development. Data was analysed using REML spatial model (Regular Grid) in Genstat 23rd edition.

Table 1 . *Trial details for the three sites at Hart, Giles Corner and Bute.*

Crop type	Hart	Giles Corner	Bute
Rockstar Wheat	**TOS 1:** April 27 **TOS 2:** May 5 **TOS 3:** June 2 **Depth** 10 mm, 40 mm, > 50 mm **Sowing rates** 180, 225, 270 plants/m^2	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** June 2 **Depth** 20 mm, 35 mm 70 mm **Sowing rates** 180, 240 plants/m^2	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** May 19 **Depth** 35 mm, 46 mm, 56 mm **Sowing rates** 180, 270 plants/m^2
Enforcer CT canola	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** June 2 **TOS 4:** June 20 **Depth** 10 mm, 20 mm, 30 mm **Sowing rate** 45, 56, 68 plants/m^2	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** June 2 **Depth** 10 mm, 20 mm, 50 mm **Sowing rate** 50, 70 plants/m^2	

Hart *Time of sowing*

Plant establishment (%) differences were observed between all TOS at Hart in 2023 (Table 2).

Establishment results were consistent in wheat and canola, with sowing on June 2 (TOS 3) recording the highest establishment counts (plants/m^2). Crops sown on May 5 (TOS 2) into marginal soil moisture with little follow up rain recorded the lowest plant establishment.

Average plant establishment for canola (TOS 1 – 4) was 54%, 32%, 89% and 71% respectively. The corresponding values for wheat were 75%, 64% and 84%. This shows that plant establishment of canola was more sensitive to TOS and soil moisture at seeding than wheat. Although similar trends were noticed, canola had higher variation across TOS for plant establishment (%) than wheat (Figure 1). Establishment and soil moisture at seeding for both wheat and canola suggests a decrease of approximately 2% in establishment for every 1% decrease in soil moisture at sowing time at Hart, highlighting that soil moisture at sowing is a key indicator of plant establishment, regardless of time of sowing (Figure 1).

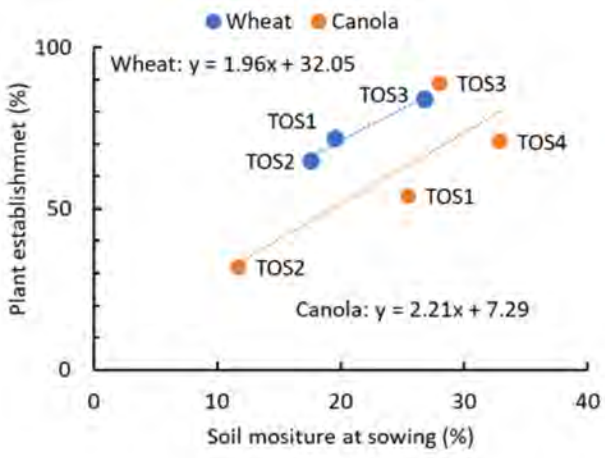

Figure 1 . *Plant establishment (%) and soil moisture (%) at sowing for each wheat and canola TOS.*

Time of sowing had significant effects on grain yield in wheat and canola at Hart In 2023. In wheat and canola, the highest grain yields were achieved with the earliest sowing date (Figure 2 & 3).

TOS 1 shallow and standard sown wheat treatments performed best, averaging 4.3 and 4.4 t/ha respectively, while canola TOS 1 recorded the highest yield at 2.16 t/ha.

Table 2. *Treatment effects on plant establishment (plants/m^2)and establishment % for both wheat and canola. Significant differences in plant establishment between treatments are indicated by different letters after plant count (plants/m^2). Shaded values indicate the treatments with the highest plant establishment.*

Effects of sowing date			**Effects of sowing depth**			**Effects of sowing rate**		
Canola								
Sowing date	**Plants/ m^2**	**Establishment %**	**Sowing depth**	**Plants/ m^2**	**Establishment %**	**Sowing rate**	**Plants/ m^2**	**Establishment %**
April 21 (TOS 1)	30^{b}	54	**10 mm**	40^{b}	71	**45/m^2**	28^{a}	62
May 5 (TOS 2)	18^{a}	32	**20 mm**	37^{b}	66	**56/m^2**	37^{b}	66
June 2 (TOS 3)	50^{d}	89	**30 mm**	27^{a}	48	**68/m^2**	39^{b}	57
June 20 (TOS 4)	40^{c}	71						
Wheat								
Sowing date	**Plants/ m^2**	**Establishment %**	**Sowing depth**	**Plants/ m^2**	**Establishment %**	**Sowing rate**	**Plants/ m^2**	**Establishment %**
April 27 (TOS 1)	168^{b}	75	**10 mm**	190^{b}	84	**180/m^2**	136^{a}	75
May 5 (TOS 2)	145^{a}	64	**40 mm**	172^{b}	76	**225/m^2**	168^{b}	75
June 2 (TOS 3)	190^{c}	84	**55 mm**	142^{a}	63	**270/m^2**	202^{c}	75

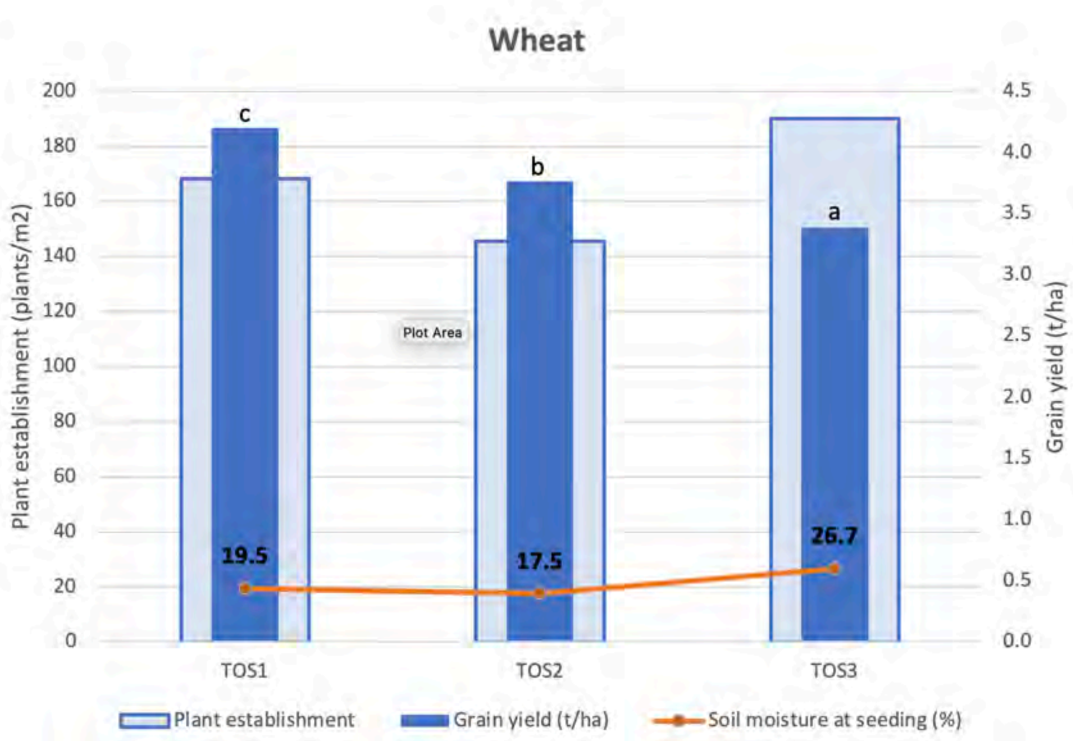

Figure 2. *Plant establishment (plants/m^2), grain yield (t/ha) and soil moisture % (displayed) at seeding for wheat TOS at Hart. Time of sowing (TOS) with the same letter above yield are not significantly different.*

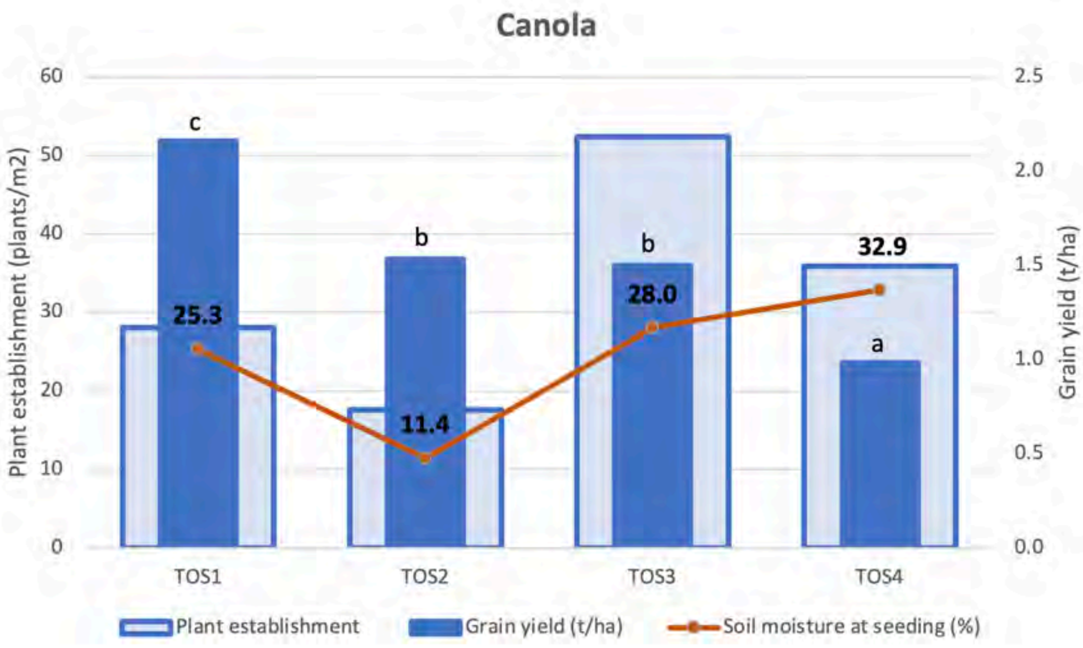

Figure 3. *Plant establishment (plants/m²), grain yield (t/ha) and soil moisture % (displayed) at seeding for canola TOS at Hart. Time of sowing (TOS) with the same letter above yield are not significantly different.*

Sowing depth

Deep sowing reduced plant establishment for both wheat and canola, with shallow sown treatments achieving approximately 20% higher establishment than deep sowing for both crop types. (Table 2).

Sowing depth influenced wheat yield with shallow sown treatments yielding higher than standard and deep. Plant establishment for canola ranged from 27 - 40 plants/m² across three depths, however the ability of canola plants to branch out and fill space resulted in no yield differences despite variation in establishment (Figures 4a and 4 b).

Sowing rate

Sowing at the standard rate resulted in the lowest plant density for both canola (target 45 plants/m²) and wheat (target 180 plants /m²), achieving 28 and 136 plants/m², respectively (Table 2). Seeding rates targeting 125% and 150% increased plants/m², however despite this increase there was no yield benefit from a higher plant density, either in canola or wheat. Despite differences in plants/m² for sowing rates, establishment % of both wheat and canola remained relatively consistent at 75% for wheat and 57% – 66% for canola.

These results suggest that increasing sowing rate above grower standard practice may improve crop establishment, but this does not result in grain yield increases.

Grain quality

Oil content for all canola treatments was high, with both TOS 2 and TOS 4 exceeding 42%, therefore receiving oil content premiums (Table 5). Although TOS 1 had the highest yield, it had a lower oil content than TOS 4 which yielded only 0.99 t/ha. This may indicate a relationship between oil content and grain yield in dry spring conditions. Previous studies have found a positive link between yield (t/ha) and oil content (%), however this was not evident in this trial (McBeath et. al., 2020).

Differences in wheat grain protein (%) were small and ranged from 10.1% to 10.7% (Table 6). Proteins for TOS 1 and 2 were below the 10.5% minimum for APW1 receival standards, while TOS 3 recorded 10.7% protein and therefore met APW1 protein receival standards.

Test weight for all wheat treatments exceeded 76 kg/hL, ranging from 82.8 to 85.1 kg/hL, therefore meeting maximum receival standards (Table 6).

Limited rainfall in the second half of the growing season resulted in high screenings for all treatments, however a trend between TOS and screenings was noticed (Table 6). Earlier sown treatments that were better able to utilise early GSR had lower screenings than later sown treatments where season length and therefore access to early season rainfall was limited.

Flowering dates were impacted by TOS, with canola 50% flowering date ranging from August 11 to September 18 (Table 3). Wheat 50% flowering date ranged from August 31 to September 25 across three TOS (Table 4). The extended flowering window of TOS 1 wheat and canola prior to water and heat stress towards the end of the season is likely a contributing factor for higher yields and reduced screenings from early sown treatments.

Time of sowing had a larger effect on wheat protein, screenings and test weight than sowing depth and sowing rate, with TOS 1 performing best for both screenings and test weight (Table 6).

Table 3. *Time of sowing effect on 50% flowering date for canola at Hart.*

TOS	50% flowering date
April 27	August 31
May 5	September 11
June 2	September 25

Table 4. *Time of sowing effect on 50% flowering date for wheat at Hart.*

TOS	50% flowering date
April 21	August 11
May 5	August 31
June 2	September 11
June 20	September 18

Table 5. *Oil content in comparison to yield data for canola TOS trial at Hart in 2023. Significant differences in oil content and yield are indicated by different letters. Shaded values indicate the best performing TOS.*

TOS	Oil content (%)	Yield (t/ha)
April 21	41.9^{b}	2.16^{c}
May 5	42.2^{b}	1.53^{b}
June 2	41.1^{a}	1.50^{b}
June 20	44.5^{c}	0.99^{a}

Table 6. *Quality data for the wheat trial at Hart in 2023. Significant differences in quality between TOS, depth and sowing rate are indicated by different lettering. Shaded values indicate the best performing treatments.*

Treatment	Grain Protein (%)	Screenings (%)	Test Weight (kg/hL)
April 27	10.4^{b}	4.6^{a}	85.1^{c}
May 5	10.1^{a}	6.4^{b}	84.1^{b}
June 2	10.7^{c}	7.4^{c}	82.8^{a}
10 mm	10.5^{b}	6.6^{b}	83.7^{a}
40 mm	10.3^{a}	5.8^{a}	84.2^{b}
55 mm	10.4^{ab}	5.9^{a}	84.1^{b}
180/m^2	10.4	6.3^{b}	83.9^{a}
225/m^2	10.4	6.12^{b}	84.0^{ab}
270/m^2	10.4	5.7^{a}	84.3^{b}

Results from other sites

At Giles Corner, canola establishment was lowest (approx. 60%) at the first two sowing dates (April 21 and May 5) compared to June 2 date (80%). However, despite the low establishment, yields were highest at the first two sowing times, while delaying sowing until June 2 resulted in a yield penalty of 20%. Increasing sowing rate had no effect on yield, except when canola was sown deep at 50 mm. At each time of sowing, varying sowing rates and depths to alter plant establishment had little to no effect on canola yield.

In the experiment with wheat, establishment with sowing on April 21 and May 5 were 55% and 45% respectively and increased to 87% when sown on June 2. These differences reflected the rainfall and soil moisture at sowing. Sowing at 70 mm reduced establishment to 44% compared to 80% with 20 mm sowing depth. The response to time of sowing depended on the sowing depth (Table 7). When sown at 20 mm, yields declined with later sowing, whereas when sown at 35 mm or 70 mm the lowest yields occurred with sowing on May 5, when the emergence was lowest due to the dry conductions.

Yield reductions of delaying sowing from April 21 to May 5 were 5% at 20 mm, 9% at 35 mm and 16% at 70 mm. There was only a single significant fall of rain in the two weeks following sowing on May 5 and the shallow sowing may have been better able to utilise this moisture for faster germination and establishment. Compared to canola, wheat was more responsive to changes in plant density.

Established plant densities ranged from about 50 plants/m^2 up to 225 plants/m^2 and yield responded to increased plant density up to about 125 plants/m^2. Increasing the sowing rate by a third from 180 seeds/m^2 to 240 seeds/m^2 resulted in a 6% yield increase.

Table 7. *The effects of sowing depth on the grain yield of wheat at Giles Corner. Grain yields followed by the same letter are not significantly different. Shaded values indicate the best performing treatments.*

Grain yield (t/ha)			
Sowing date	Depth		
	20 mm	35 mm	70 mm
April 21	6.99[a]	6.47[abc]	5.81[d]
May 5	6.67[ab]	5.90[cd]	4.89[e]
June 2	6.19[bcd]	6.36[abcd]	5.99[bcd]

At Bute, the average wheat establishment was 74%, but ranged from 48% – 100% among individual treatments. Establishment varied little across TOS and the most consistent effect was a reduction in establishment with deep sowing and an increase in plants/m^2 with a higher sowing rate.

Time of sowing and sowing depth affected wheat grain yield at Bute in 2023.

The highest yields were achieved at the second TOS with the first and last sowing dates producing equivalent yields (Table 8). A significant frost event on September 9 caused damage to wheat at Bute, with the April 21

Table 8. *The effects of sowing date on the grain yield of wheat at Bute. Grain yields followed by the same letter are not significantly different. Shaded values indicate the best performing treatments.*

Sowing date	Grain yield (t/ha)
April 21	1.83[b]
May 5	2.26[a]
May 19	1.89[b]

sown treatment affected more than later sowing dates. Frost damage to the early sown crop may be a factor contributing to lower yields when compared to the May 5 sowing.

There was a small (5%) but significant reduction in grain yield when wheat was sown at 53 mm with no difference between 35 mm and 46 mm sowing depths. Despite a wide range in crop establishment among the treatments, there was no significant effect of sowing rate on yield.

Summary

Despite lower establishment from late-April toearly-May sowing in wheat and canola at Hart and canola at Giles Corner, these sowing times produced the highest yields due to better utilisation of earlier growing season rainfall for biomass and grain production. Wheat at Giles Corner and Bute was less sensitive to time of sowing in 2024.

Deep sowing showed no benefit in either plant establishment or yield. This is most likely because soil moisture was still low at the deepest sowing depth. Sowing deep into dry soil to promote germination and improve establishment may be a risky tactic.

Increasing crop sowing rates to compensate for anticipated reductions in crop establishment from sowing into dry soil did not improve yields in most experiments and using standard recommended sowing rates may be adequate.

Further investigation into the relationship between soil moisture at sowing, crop establishment and yield potential will be explored in future years of this project. This trial is in its first of two seasons and final results will be published following the conclusion of the project to provide a more comprehensive investigation across multiple seasons and sites.

Figure 4. *(a,b) showing differences in canola development between TOS at Hart. Figure 4a was taken in August, with Figure 4b taken one month later.*

Acknowledgements

We would like to acknowledge the SA Drought Hub and South Australian Grains Industry Trust (SAGIT) for their financial contributions to conduct these trials. We would also like to thank our research partners, Mid-North High Rainfall Zone (MNHRZ), Trengove Consulting and the various growers hosting these trials on-farm.

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EVALUATING *the importance of* SOWING RATE *and* TIME OF SOWING *on* LENTIL EMERGENCE AND YIELD

Kaidy Morgan - *Hart Field - Site Group,* **Glenn McDonald** - *The University of Adelaide,*
Rebekah Allen - *Hart Field Site Group,*

Key Points

- Despite all times of sowing (TOS) having high starting soil moisture (21 – 30%), TOS influenced lentil establishment (plants/m^2), with reduced plant numbers observed at later sowing times (TOS 3).
- Lentil grain yields achieved from late April (TOS 1) and early June (TOS 2) sowing dates were similar, however a 13% yield reduction was observed when sown in late June (TOS 3).
- Increasing seed densities above 120 plants/m^2 did not improve lentil grain yield (t/ha).

Background

In recent years, lentil production in Australia has increased significantly with over 525,000 tonnes produced in 2022 (Maphosa et.al., 2023). Although the cropping area of lentils is much smaller than wheat, it is a high value crop and remains a common inclusion within farming systems where climatic conditions are suitable. The Mid-North of South Australia is one of the largest lentil producing areas in the nation, meaning that constraints limiting production should be prioritised and explored (Maphosa et.al., 2023).

As a result of increased farm size and inconsistent autumn rainfall, many farmers are opting to sow dry, or earlier in the growing season to ensure seeding programs are completed in a timely manner, in some cases improving crop access to early moisture and early establishment prior to cold conditions (Flohr et al., 2021).

Recently, new research across the Mid-North of SA has investigated early sown pulses including lentil and faba bean as a frost avoidance tool, in addition to other agronomic opportunities aiming to improve pulse yield in areas outside high production zones (Roberts et.al., 2023). A lentil trial at Hart, SA in 2023 investigated techniques aiming to improve the effectiveness of dry or early sowing, complimenting current and past research. The effects of sowing rate on plant establishment, crop growth and grain yield under varying conditions and times of sowing (TOS) were explored.

Methodology

A split-plot trial was implemented at Hart to investigate the effect of time of sowing (TOS) and seeding rate on lentil establishment, crop biomass and grain yield. Lentil variety GIA Thunder was sown at three TOS, ranging from April 27 to June 20 (Table 1), with three sowing rates. Sowing rates targeted 120, 150 and 180 plants/m^2, equivalent to 100%, 125% and 150% of the standard sowing density respectively.

Table 1. *Site details for 2023 lentil TOS trial at Hart, SA. performing treatments.*

Plot size	1.75 m X 10.0 m	**Fertiliser**	Seeding: MAP Zn 1% @ 80kg/ha
Seeding date (TOS 1)	April 27, 2023		
Seeding date (TOS 2)	June 2, 2023		
Seeding date (TOS 3)	June 20, 2023		
Harvest date	November 2, 2023		
2022 crop	Mulgara oaten hay		

The number of plants/m² was measured to determine the effect of TOS and sowing rate on establishment. Soil moisture in the top 10 cm was also recorded at sowing and monitored until emergence for each TOS was complete. Normalised Difference Vegetation Index (NDVI) was measured frequently after emergence to track plant growth (higher NDVI values indicate less exposed soil and greener vegetation). Additionally, the timing of key phenological events (e.g., flowering) was recorded for all plots to determine potential treatment effects on plant development. Data was analysed using a REML spatial model (Regular Grid), in Genstat 23rd edition.

Season and rainfall

The first TOS was April 27, one week after a 20 mm rain event observed across a four-day period. At this time, soil moisture in the top 10 cm was high at 21.1%, the lowest of all three TOS (Figure 1). The TOS 1 lentils emerged early May after only 6 mm of follow up rain. Rainfall continued to be marginal until May 26 when the site received 16 mm rain. Soil moisture at TOS 2 (June 2) was 27.5%. The late sowing time (TOS 3) was completed on June 20, when soil moisture was 30.4%.

June recorded above average rainfall (68 mm), however the remaining months of the growing season received below average rainfall. Early TOS were able to utilise the significant June rainfall for growth, however TOS 3 was still emerging at this time.

Dry spring conditions resulted in a quick finish for all TOS. Despite the variation in sowing time, desiccation dates and harvest dates were the same for all three treatments. The dry finish to the season shortened the season length of late sown crops.

Results

Time of sowing

Lentil establishment (plants/m²) was influenced by TOS and was highest at TOS 1 (April 27) and TOS 2 (June 2) (Table 2). When sowing was delayed until late June (TOS 3), lentil establishment was reduced by up to 14%, although soil moisture (%) was similar at each TOS (Figure 1). Average plant establishment for TOS 1 – 3 was 82%, 87% and 73% respectively.

Lentil grain yield was reduced from sowing late (TOS 3 on June 20), however there was no significant difference in yield between TOS 1 and 2 (Figure 1). Time of sowing 1 and 2 lentils were able to use earlier rainfall to establish, increasing their growing season length. Additionally, TOS 1 and TOS 2 lentils flowered up to two weeks earlier than TOS 3 (Figure 2) and had a longer period to set pods in cool conditions, prior to water and heat stress later in the season, likely contributing to higher grain yields.

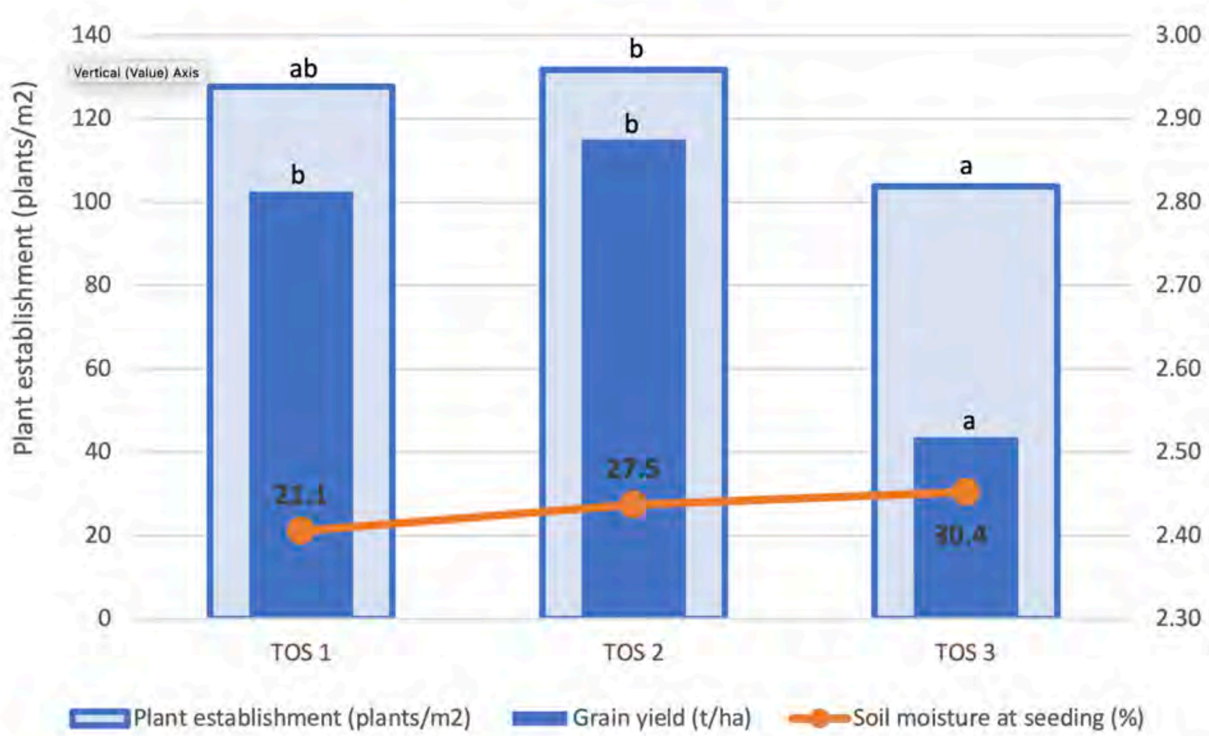
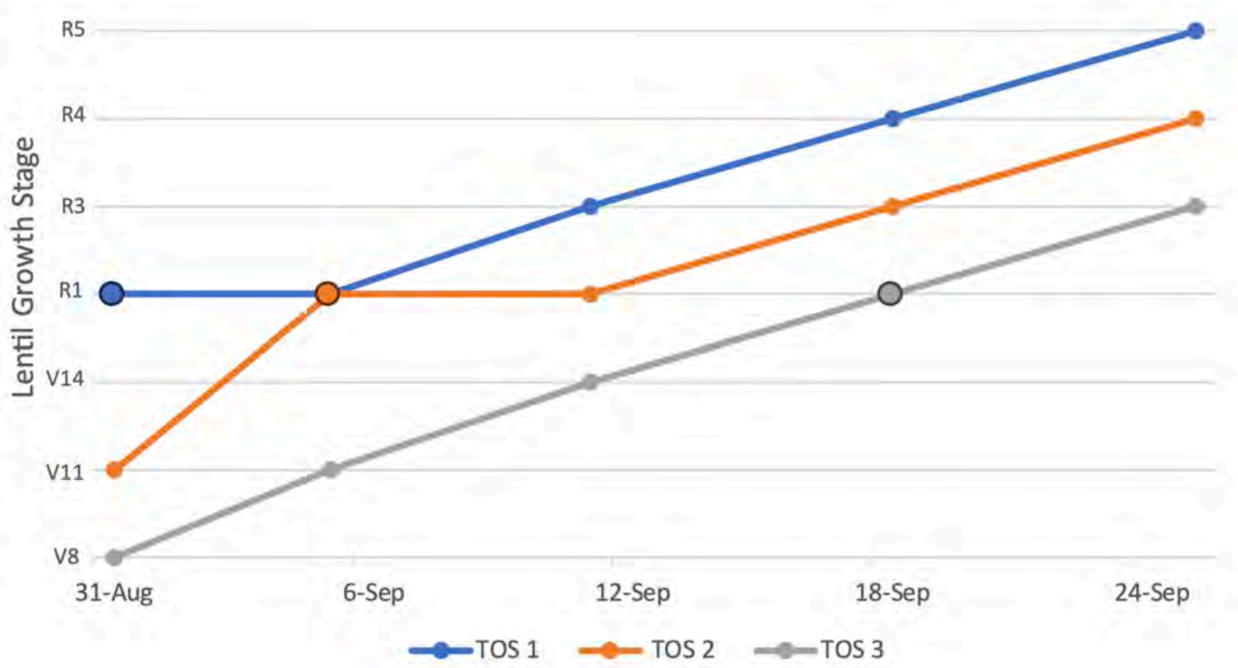


Figure 1. *Plant establishment (plants/m²), grain yield (t/ha) and soil moisture at seeding (%) for lentil TOS at Hart. Plant establishment ( ) or grain yield ( ) for each TOS with the same letter are not significantly different.*

Figure 2. *Growth stages for lentil TOS trial at Hart. Large, coloured circles indicate the date of first bloom for all TOS*



Yield reductions in lentil crops sown on June 20 likely resulted from a shortened growing season and exposure to higher temperatures and water stress during critical periods of growth later in the season. In similar 2023 trials with canola and wheat, delayed sowing resulted in improved emergence due to higher soil moisture levels (Morgan et. al., 2023), however later sowing dates showed a negative effect on lentil emergence. Recent studies conducted by NSW Department of Primary Industries found optimum sowing dates for lentils to be between late April and mid-May, with yield penalties noticed outside of this window (Maphosa et.al., 2023). The Hart trial found no yield difference between late April and early June sowing in 2023, however sowing on June 20 resulted in a 13% yield reduction when compared to earlier sowing.

Table 2. *Treatment effects on plant establishment (plants/m²) for lentil. Significant differences in plant establishment between treatments are indicated by different letters after plant count (plants/m²). Shaded values indicate the treatments with the highest plant establishment.*

Effects of sowing date			**Effects of sowing rate**		
Sowing date	**Plants/m²**	**Establishment %**	**Sowing rate**	**Plants/m²**	**Establishment %**
April 27 (TOS 1)	123[ab]	82	**120/m²**	101[a]	84
June 2 (TOS 2)	131[b]	87	**150/m²**	119[b]	79
June 20 (TOS 3)	109[a]	73	**180/m²**	143[c]	79

Sowing rate

The standard sowing rate targeting 120 plants/m² recorded the lowest plant establishment (Table 2), however this treatment had the highest level of crop establishment (84%) compared to sowing rates targeting 150 and 180 plants/m² (79% establishment). Sowing rates targeting 180 plants/m² recorded the highest plant density, achieving 143 plants/m². Despite sowing rate influencing plant establishment, this did not translate to differences in crop yield. Results at Hart in 2023 show that no yield benefits were observed by increasing lentil sowing rate above standard practice.

Grain weight

Grain weight of lentils was negatively affected by early sowing in 2023 (Table 3). This may result from an extended reproductive window, increasing crop branching and seed set, reducing individual seed weight due to a dry spring finish. Delayed maturity time of lentils sown on June 20 (Figure 2) would have reduced yield potential as a result of below average rainfall during reproductive stages, resulting in larger individual seed weight despite lower yields.

TOS	1000 Grain weight (g)
April 27	32.5[a]
June 2	36.4[b]
June 20	38.3[c]

__Table 3.__ Time of sowing effect on 1000 grain weight (g) for lentils. Significant differences in grain weight are indicated by different letters. Shaded value indicates best performing treatment. establishment.

Summary

No yield gains were observed by increasing seeding rates of lentil above 120 plants/m^2 target (101 plants/m^2 achieved). Similar to wheat and canola, earlier sowing also resulted in higher yields for lentils, regardless of sowing rate (Morgan et, al., 2023). Delaying sowing until late June reduced both plant establishment and yield. Sowing in late April and early June provided opportunities for lentils to improve water use efficiency and crop biomass. Further investigation into the relationship between soil moisture at sowing, crop establishment and yield potential will be explored in future years of this project.

Acknowledgements

We would like to acknowledge the SA Drought Hub and South Australian Grains Industry Trust (SAGIT) for their financial contributions to conduct these trials. We would also like to acknowledge our research partners Mid-North High Rainfall Zone (MNHRZ), Northern Sustainable Soils and Trengove Consulting.

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ENTERPRISE CHOICE *and* SEQUENCE STRATEGIES *that* DRIVE SUSTAINABLE *and* PROFITABLE SA FARMING SYSTEMS

Author: Jade Rose, *Upper North Farming Systems* | **Funded By:** *GRDC via University of Adelaide*
Project Title: *Enterprise choice and sequence strategies that drive sustainable and profitable Southern Australian Farming Systems*
UNFS Project Number: *254* | **Project Duration:** *2023 – June 2027* | **Project Delivery Organisations:** *UNFS and AgXtra*

Background

Improving farm profitability involves identifying profit-driving factors and adopting management practices that optimise returns while mitigating risks. Growers face increasing challenges to maintain profitability due to rising input costs, herbicide resistance, declining soil fertility, increasing soil-borne pathogens, and climatic variability.

A farming systems approach enables the assessment of strategic options (such as enterprise choice, sequence, livestock integration, risk positioning, and greenhouse gas mitigation) and tactical decisions (such as timing of sowing, fertiliser application, and crop protection) over time. Growers often lack the resources to thoroughly test all enterprise choices, which can lead to short-term gains with potential long-term impacts on profitability. The type and sequence of crops affect yearly profitability, while long-term farming system profitability is driven by the lasting effects of crop sequence and fertiliser strategy.

Australian farmers use crop benchmarking tools to compare individual crop performance against potential yields in water-limited conditions. However, resource efficiency and carry-over effects on water, nitrogen, weeds, and disease across years are crucial in dryland farming systems.

Investments in farming systems research that integrates field research, modelling, and economic analysis can highlight opportunities and risks for system profitability. By comparing different farming systems across diverse environments for factors such as water use efficiency (WUE), disease impact, weed control, and nutrition management, growers can make more informed decisions. Contrasting systems with varied treatments across sub-regions, measured using common metrics, provide comprehensive data to support modern and emerging farming systems.

Methodology

The project aims to build upon extensive past research on cropping sequences assessing the value and sustainability of risks associated with different farming systems. Through the use of field trials across southern Australia, the project seeks to provide new long-term insights into the drivers of profitability and sustainability.

The Southern Farming Systems project, commencing in 2023 consisted of:

- Four core sites across SA and Victoria, where 10-14 systems are being evaluated, with intensive data collection analysis. These are located at Hart (SA), Manangatang (Vic) and Streatham (Vic)

- Five satellite sites, where 3-7 systems are being evaluated with less analysis and data collection located at Appila (UNFS), Wallup (Vic), Edillilie (SA), Warrambine (Vic) and Roseworthy (SA)
- System performance of each trial assessing productivity and profitability and sustainability indicators such as soil N, soil organic carbon, greenhouse gas emissions, disease risk and microbiome diversity. Furthermore, innovative systems are also being tested by some groups.

Results and Discussion

Site selection and rationale:

The site needed to be a low rainfall <350mm area on a red Chromosol, heavy clay soil type. It represented a soil type that is more challenging to grow pulses on and has generally grown a high proportion of cereals and pastures.

Trial Location	**Appila, -33.0417359, 138.3827728**
Trial Host	**James and Will Heaslip**

Figure 1. *UNFS trial site located at Appila, South Australia.*

Table 1. *Monthly and annual rainfall in 2023 at Appila, South Australia (BOM)*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
16.6	*7.4*	*1.6*	*31.4*	*28.0*	*40.2*	*18.6*	*15.4*	*16.2*	*7.0*	*30.8*	*56.2*	*269.4*

Average rainfall statistics: Growing season rainfall at Appila was 157mm in 2023 (Table 1)

Cropping History:

2022: Oats/Vetch

2023: Awnless wheat

Systems being evaluated at Appila:

Table 2. *Systems evaluated at Appila, South Australia in 2023.*

No	System ID	Focus	Rotation	Tactical Treatments
1	Baseline		**Vetch (grazed)-Wheat-Barley**	Standard District Practic
2	High-risk alternative 1	High pulse frequency	**Lentil-Wheat**	Decile 5
3	Higher-risk alternative 2	High value crops	**Lentil-Canola-Wheat-Wheat**	Decile 5
4	Lower-risk 1 alternative	Crop end use	**Mix (Oats + Vetch) (hay)-Wheat-Barley**	Decile 5
5	Responsive 1	Risk averse	Barley	Standard District Practice
6	Responsive 2	Risk tolerant	Canola	D 7

The systems and treatments applied were discussed through the UNFS operations committee and based on a number of factors i.e. adapting based on seasonal conditions and climate outlooks, basing N requirements on starting soil N tests and applying under optimal conditions. The wheat yield for this site was calculated based on 100 years of historical rainfall data. GSR was 269mm, using the French Shulz Equation (269 (GSR)- 60 (Evap) x 23 (WUE)) = 4.8 t/ha Potential Yield on average. With the heavy soil type and average springs, yield is often reduced in this area. The site is also prone to frosts and hot north winds in spring therefore yield potential is skewed. An average estimate is 2-3 t/ha average. Therefore, we think it is best to work off an average yield of 2.5 t/ha using the stated observations.

2023 Trial Details

Table 3. *Trial details at Appila in 2023*

Crops/Cultivars						
Variety	**Wheat**	**Barley**	**Canola**	**Lentil**	**Vetch**	**Oats**
	Scepter	Commodus	44Y94	Hurricane	Volga	Kingbale
Sowing						
Date	31/5/2023					
Depth	25	25	10	25	25	25
Target density	100	80	5	20	20	100
Nutrient Management						
Application 1	31st May	MAP + Flutriafol	All	104kg/ha	At sowing	
Application 2	17th August	Urea	Cereals/Canola	Varied - responsive	Top dressing	

__Table 4.__ Initial soil test results (characterisation). Values are mean of pH (CaCl), Soil Texture, Organic Carbon, Ammonium-N, Nitrate-N, Colwell P and PBI + Col P at the Appila site, 2023.

Sample Depth (cm)	pH CaCl2 (following 4A1)	MIR - Aus Soil Texture	Organic Carbon (W&B)	Ammonium - N (2M KCl)	Nitrate - N (2M KCl)	Colwell Phosphorus	PBI + Col P
	pH units		% (40°C)	mg/kg	mg/kg	mg/kg	
0-10	6.58		0.98	23	23.0	65	42.7
10-30	7.27	Loam		<1.0	3.1		
30-60	7.76			<1.0	1.3		
60-90	7.95			<1.0	<0.1		

The soil test results in 2023 were 'background' soil characterisation measurements only made in year 1, annual plot by plot measurements will be made of the more dynamic properties (e.g. soil water and N, disease), while soil OC (and soil biology for some sites) will be assessed at the end of the project". General observations of this soil show that the topsoil (0-10 cm) is slightly acidic with the subsoil (below 10 cm) ranging from neutral to slightly alkaline. The values indicate low organic carbon content, which might suggest low organic matter in the soil.

Further results from 2023 will be published in the coming year for the project.

__Figure 2.__ The trial site at Appila on 17th of August (L) and 5th October (R) in 2023.

Acknowledgements

- Thankyou to the Heaslips for the provision of the site
- Thankyou to AgXtra for sowing and maintenance of the site
- Thankyou to Stefan Schmitt for agronomic advice for the project

PEST & DISEASE MANAGENT

MANAGING SEPTORIA TRITICI BLOTCH *in the* LOW RAINFALL ZONE

Author: Tara Garrard[1,2], Hari Dadu [3]
[1]South Australian Research and Development Institute, [2]The University of Adelaide, [3]Agriculture Victoria

Key Points

- Understanding yield losses caused by Septoria tritici blotch in the low and medium rainfall zones is critical in disease management decision making
- The Booleroo Centre (LRZ) trial in the 2023 growing season showed no significant yield loss due to disease in varieties rated from SVS through to MS

Background

Previous research on septoria tritici blotch (STB) in wheat has been targeted at the high rainfall zone where yield losses from the disease are high. However, the prevalence of the disease is widespread and there is less known about the yield losses and economics of disease management in the low and medium rainfall zones. Developing our understanding of seasons where yield losses are significant will aid growers in decision making when managing the disease.

This work is part of the GRDC investment DJP2104-004TRX led by Agriculture Victoria. SARDI, UNFS, and AgXtra are working together to deliver integrated disease management trials at Booleroo Centre in the LRZ. Variety selection trials have been conducted to provide growers and advisors with yield loss vs disease resistance rating data to aid in variety selection and fungicide application economic decisions.

Methodology

A field trial was conducted at Booleroo Centre during 2023 to evaluate yield and quality loss in wheat cultivars with contrasting resistance/susceptibility to STB. The trial contained had six wheat varieties ranging from SVS to MS resistance ratings to STB. Two treatments: 1) Maximum disease and 2) Minimum disease were applied to each wheat variety with six replications and arranged in split plot designs with treatment considered as the main plot and varieties as subplots. Maximum disease treatments were established by inoculation with infected stubble and minimum disease treatments were established by fungicide applications at GS 31 & 39 (Zadocks).

Plots were visually assessed for STB severity on multiple occasions during the growing season. Grain was harvested at the end of the season using a plot harvester. A sub-sample from each plot was used for grain quality testings such as protein percentage, screenings (percentage of grain less than 2.2 mm in width), retentions (percentage of grain greater than 2.5 mm width) and grain weight. All data was analyzed by ANOVA using Genstat.

Trial details

Locations:

Location	Rainfall zone	Soil type	Growing season (Apr – Nov) rainfall (mm)
Booleroo (SA)	LRZ	Red loam	221

Treatments:

1. Minimum disease – Seed + foliar applied fungicides at Z31 and Z39
2. Maximum disease - No disease control with 1 Kg STB infected wheat stubble or inoculated with spore inoculum at a concentration of > 10,000 spores/mL

Varieties:

Variety	RatingA
LRPB Lancer	MS
Hammer CL Plus	MSS
Scepter	S
Calibre	S
Razor CL Plus	SVS
LRPB Impala	SVS

[A]Hollaway, McLean and Dadu (2023) Cereal Disease Guide 2023

Trial design: Split plot design

Replicates: 6

Sowing and harvest details:

Location	Rainfall zone	Soiing Date	Sowing rate (plants/m²)	Harvest date	Trial average yield (t/ha)
Booleroo (SA)	LRZ	1st June 2023	150	25th November 2023	2.0

Chemical applications*:

Fungicide application timing	Product	Active ingredient (gai/L)#	Rate
Seed	Jockey Stayer®	Fluquinconazole 167g/L	300 mL/100 Kg seed
Foliar at Z31	Soprano®	Epoxiconazole 500 g/L	125 mL/ha
Foliar at Z39	Elatus Ace®	Benzovindiflupyr 40g/L + Propiconazole 250g/L	500 mL/ha

*# gai = grams active ingredient *Tebuconazole applied at 145mL/ha to all plots and sites in Victoria to selectively control stripe rust.*

Results

No significant yield losses were associated with STB infection at the Booleroo Site in South Australia (Table 1). Disease severity remained low at the site even in SVS varieties Razor CL Plus and LRPB Impala with less than 1% of the leaf area affected by STB. This is likely due to the low grain yield potential (<3 t/ha) at the site which did not allow differences between minimum and maximum disease treatments. Trials from MRZ and LRZ sites in SA and VIC over the last three seasons have shown yield losses due to STB were only found when the yield potential was greater than 3 t/ha. It is therefore likely that STB has no economic impact where grain yields are less than 3 t/ha. At sites and in seasons where yields exceeded this less susceptible varieties (i.e. MSS-MS) showed lower disease incidence and reduced risk of yield loss than SVS-S varieties.

***Table 1.** Septoria tritici blotch severity (% leaf area affected) and associated grain yield loss of six wheat varieties treated with low and high disease levels at Booleroo (LRZ), SA during 2023.*

Variety	Rating	Severity (% LAA) in Max. treatment[A]	Grain yield (t/ha)	
		16 Oct	Min.	Max.[C]
LRPB Lancer	MS	0[a]	1.77	1.63[ns]
Hammer CL Plus	MSS	0[a]	2.13	2.26[ns]
Scepter	S	1[abc]	2.12	2.32[ns]
Calibre	S	1[ab]	2.15	1.93[ns]
Razor CL Plus	SVS	1[c]	2.04	2.09[ns]
LRPB Impala	SVS	1[bc]	1.73	1.94[ns]
P		0.004	-	-
LSD (0.05)		0.59	-	-

*[A]Within column means with one letter in common are not significantly different. [B]Average of ten tillers per plot; [C]Max. = Maximum disease; Min. = Minimum disease; ** = statistically significant at 5% LSD; * = statistically significant at 1% LSD, [ns] = not significant at 5% LSD.*

Conclusion

In 2023 at the Booleroo LRZ site seasonal conditions were not conducive for enough STB disease development to result in significant yield loss, even in SVS and S varieties. Further years of data will better develop our understanding of which seasons provide conducive disease development so that fungicide use can be targeted to seasons and timings that are the most economically beneficial.

SOIL PATHOGEN IDENTIFICATION *and* MANAGEMENT STRATEGIES *for* WINTER CEREALS

Authors: *Jonno Mudge and Jade Rose* | **Project Title:** *Soil pathogen identification and management strategies for winter cereals*
Funded By: *FarmLink via GRDC* | **Project Duration:** *2021-2023* | **Project Delivery Organisations:** *Upper North Farming Systems*

Background

A steady increase in Crown Rot damage has been observed (primarily in Wheat) in the past 20 years, both on the property of this demo and now more broadly across the district. During this time, cereal intensity in the rotation has generally increased, and at the same time this grower's farming system has moved to direct drill using knife points. It is considered likely that these two aspects are exacerbating the crown rot problem. There is insufficient time between susceptible crops to break down the residues carrying inoculum, compounded by a lack of cultivation which isn't allowing the accelerated break down of residues. The high incidence of below average spring rainfall has further contributed to the problem.

Crop losses being experienced are believed to be up to 50% reduction in yield in bread wheat in affected areas.

The growers response has been in part to broaden the rotation, looking to move to a two-year non-cereal break on our worst affected paddocks using a legume then canola. There will also be a level of cultivation back into the system. This either involves sowing the legume phase "on-row" to attempt to disturb the previous years cereal crowns, or, alternatively, using a disc chain or similar to aggressively cultivate the previous cereal stubble.

We would like to explore the interaction between the level of cultivation in the cereal break phase with the time needed to break down residues and crown rot inoculum. We recognise that cultivation is seen as a two-edged sword- it may help to increase the breakdown of residues by soil incorporation but may also act to move residues around to allow more contact with future crops and hence increasing the potential for inoculum transfer. In this context, it is important to recognise that the cultivation being considered here occurs at the start of the non- cereal phase of the rotation allowing sufficient time for residue breakdown prior to any further planting of cereals.

Trial Objectives

To assess the impact that different cultural treatments (including cultivation and crop type) which influence residue breakdown have on the breakdown of Crown Rot inoculum across a three-year period. To also assess the influence seed treatment fungicides have on the expression and carryover of crown rot.

Methodology

Site selection and establishment of demonstration trial sites

This project was established at Mambray Creek, South Australia on a site with a history of severe crown rot.

Site management and treatments

This project comprised two distinct trials conducted simultaneously at the same site. The first trial was a full-scale farmer demonstration that spanned three years. The second trial involved smaller plot trials conducted during the second year of the project.

Trial site design and treatments

FARMER SCALE DEMO:

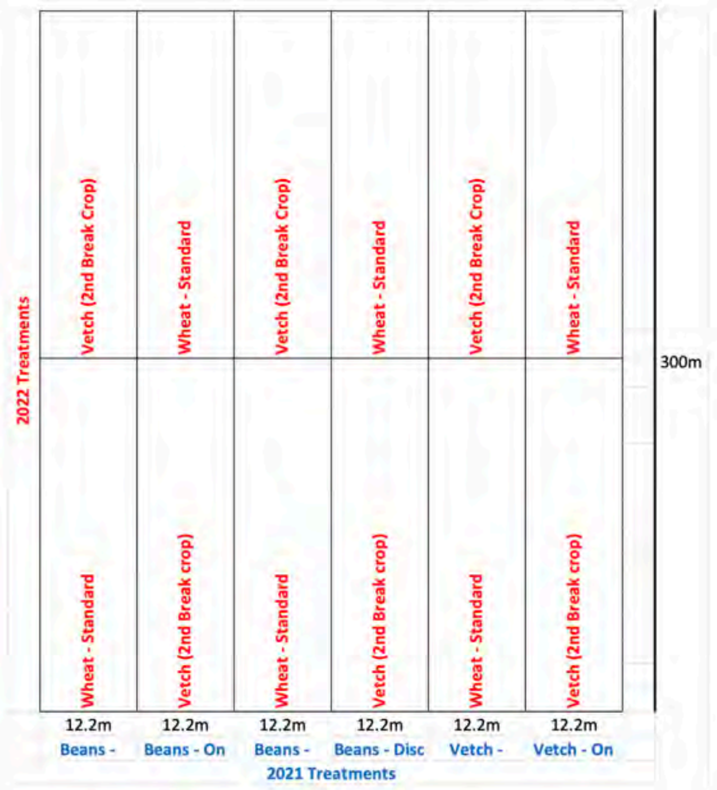

Figure 1. *Site layout and treatment location for the farmer scale demonstration located at Mambray Creek, SA.*

Figure 1 shows the site layout of the farmer scale demonstration. The information below explains in more detail the treatments and assessments conducted over the three-year time frame.

Year 1 (2021)

- Beans/Vetch treatments established into Barley stubble with high Crown Rot infection.
- Treatments not harvested due to poor crop growth and excessive weed pressure
- Differing levels of cultivation treatments (see trial layout)

Year 2 (2022)

- Two alternative crop treatments overlayed on Year 1 plots.
- Plan was Canola however due to ease of logistics Vetch to be used as second break crop option.
- Wheat treated with standard seed treatment (Veto)
- Crown Rot incidence/severity ratings on cereal treatments

Year 3 (2023)

- Predicta B assessment of Crown Rot infection prior to year 3 (April 2023)
- All plots sown to Wheat.
- Crown Rot incidence/severity ratings on cereal treatments

SMALL PLOT TRIAL:

Number	CROP	VARIETY	Seed Treatment	Rate	Additional Seed Treatment	Rate
1	Wheat	Calibre	Vibrance	180ml/100kg	Cruiser 350	100ml/100kg
2		Calibre	Vibrance	360ml/100kg	Cruiser 350	100ml/100kg
3		Calibre	VICTRATO®	200ml/100kg	Vibrance + Cruiser 350	180ml/100kg + 100ml/100kg
4		Vixen	Vibrance	180ml/100kg	Cruiser 350	100ml/100kg
5		Vixen	Vibrance	360ml/100kg	Cruiser 350	100ml/100kg
6		Vixen	VICTRATO®	200ml/100kg	Vibrance + Cruiser 350	180ml/100kg + 100ml/100kg
7	Barley	Compass	Vibrance	180ml/100kg	Cruiser 350	100ml/100kg
8		Compass	Vibrance	360ml/100kg	Cruiser 350	100ml/100kg
9		Compass	VICTRATO®	200ml/100kg	Vibrance + Cruiser 350	180ml/100kg + 100ml/100kg

Figure 2. *Treatment list of small plot trial at Mambray Creek, SA. VICTRATO® is not yet registered and is under evaluation by the Australian Pesticides and Veterinary Medicines Authority*

Figure 2 shows the treatment list conducted in the small plot trial. This trial consisted of four reps fully randomised for crop/variety type and fungicide seed treatment. A bulked Predicta B test was done on the site prior to the 2022 season. In-season crown rot incidence/severity assessments were then conducted as well as yield and final predicta B assessments taken at the beginning of the 2023 season.

DATA COLLECTION & MONITORING:

Table 1. *List of data collection and monitoring for the farmer scale demo between 2021-2023 season at Mambray Creek, SA.*

Element	Method	Timing
Site Selection	Selection of appropriate demonstration sites prior to implementation of the trial, with input from Alan Umbers	Feb - April 2021 Prior to seeding
Pre-trial Predicta B assessment	Three Predicta B assessment of Crown Rot infection, 1 in each rep	April 2021
Pre-season Predicta B assessment	Predicta B assessment of Crown Rot inoculum level prior to year 2, every plot (12 tests)	March 2022
In-season Crown Rot assessment	All cereal treatments assessed on incidence and severity of crown rot through white head counts and stem infection scores	September 2022
Yield	Harvest yield for all treatments were undertaken	October 2022
End of trial Predicta B assessment	Predicta B assessment taken from every treatment in both reps	April 2023
Yield	All plots sown to wheat, yield for all treatments to be undertaken	October 2023

Table 2. *List of data collection and monitoring for the small plot trial during the 2022 season.*

Element	Method	Timing
Pre-trial Predicta B assessment	A bulked up predicta B test was taken prior to the plot trial being sown	March 2022
In-season Crown Rot assessment	All cereal treatments assessed on incidence and severity of crown rot through white head counts and stem infection scores	September 2022
Yield	Harvest yield for all treatments were undertaken	October 2022
End of trial Predicta B assessment	Predicta B assessment taken from every treatment in every rep	April 2023

Results & Discussion

DEMO SITE

Table 3. *Baseline Predicta B at the demonstration site in 2021*

Code Number	Site	Predicta B Result
BD16222	East	3.78
BD16223	Mid	3.92
BD16224	West	3.88
High disease risk across the site		

Table 4. *Crown Rot incidence and white head % from 2022 assessments in the demo site. (L) Yield comparisons of interrow vs on row treatments from 2023 demo harvest. (R) Note: Highlighted treatments affected by overspray.*

	Incidence	White Head %
Plot 1	94	7
Plot 2	94	9
Plot 3	98	6
Plot 4	86	10
Plot 5	99	2
Plot 6	95	19

	2023 Yield t/ha	
	Interrow	Onrow
Plot 1	2.55	2.34
Plot 2	2.35	2.07
Plot 5	2.33	2.35
Plot 6	2.19	1.95

Table 5. *Crown rot inoculum from 2022 and 2023 samples. Raw data measured as pgDNA/g sample.*

	2022				
	Sample 1	**Sample 2**	**Sample 3**	**Average**	**S.D**
Interrow Beans	781	445	840	689	174
Onrow Beans	1640	177	965	927	598
Cultivated	692	610	1030	777	182
Disc Chain	698	1341	854	964	274
Interrow Vetch	944	360	1360	888	410
Onrow Vetch	438	353	580	457	94
	2023				
Interrow Beans	817	18	[redacted]	418	565
Onrow Beans	21	2047	[redacted]	1034	1433
Cultivated	1174	25	[redacted]	600	812
Disc Chain	26	24	[redacted]	25	1
Interrow Vetch	1187	1582	[redacted]	1385	279
Onrow Vetch	41	4256	[redacted]	2149	2980

Summarising the large demo site results, table 4 shows no apparent trends indicating any effect of cultivation or interrow sowing in both the assessments taken in 2022 as well as the yields taken in 2023. Furthermore, the predicta B test results shown in table 5 from both 2022 and 2023 show no trends in the level of crown rot inoculum following the two seasons and the size of the standard deviations from the mean indicate the inaccuracies of large-scale demos when assessing different treatments.

REPLICATED PLOT TRIAL

Treatment	**Severity score**		**Visual incidence (%)**		**White heads (%)**		**Crown Rot Inoculum (pgDNA/g sample)**	
	mean	**s.e.**	**mean**	**s.e.**	**mean**	**s.e.**	**mean**	**s.e.**
Calibre Vibrance	2.19	0.04	90	1	4	1.1	1478	855
Calibre Vibrance x 2	2.20	0.14	92	5	5	2.2	2113	1360
Calibre Vibrance+Victrato	1.52	0.12	78	5	0	0.5	978	729
Compass Vibrance	2.19	0.08	97	1	1	0.6	1118	511
Compass Vibrance x 2	2.03	0.15	93	3	1	0.5	1487	542
Compass Victrato	1.84	0.08	97	2	0	0.3	1253	561
Vixen Vibrance	2.63	0.08	95	2	8	1.4	880	533
Vixen Vibrance x 2	2.69	0.03	97	1	9	1.3	1595	942
Vixen Victrato	1.97	0.24	88	5	3	1.8	2244	1355

Table 6. *Plot trial assessment data, 2022 showing means for severity score, visual incidence, white heads, crown rot inoculim at Mambray Creek, SA.*

The combination of Vibrance at 180ml and VICTRATO® at 200ml demonstrated reduced mean white head percentage and visual crown rot severity scores in both wheat varieties Vixen and Calibre and barley variety Compass in initial crown rot assessments (Table 6). The VICTRATO® treatment also decreased the visual incidence of crown rot in both wheat varieties however did not affect this assessment when applied to the barley. There appears to be no apparent trends in level of crown rot inoculum following each treatment (Table 6).

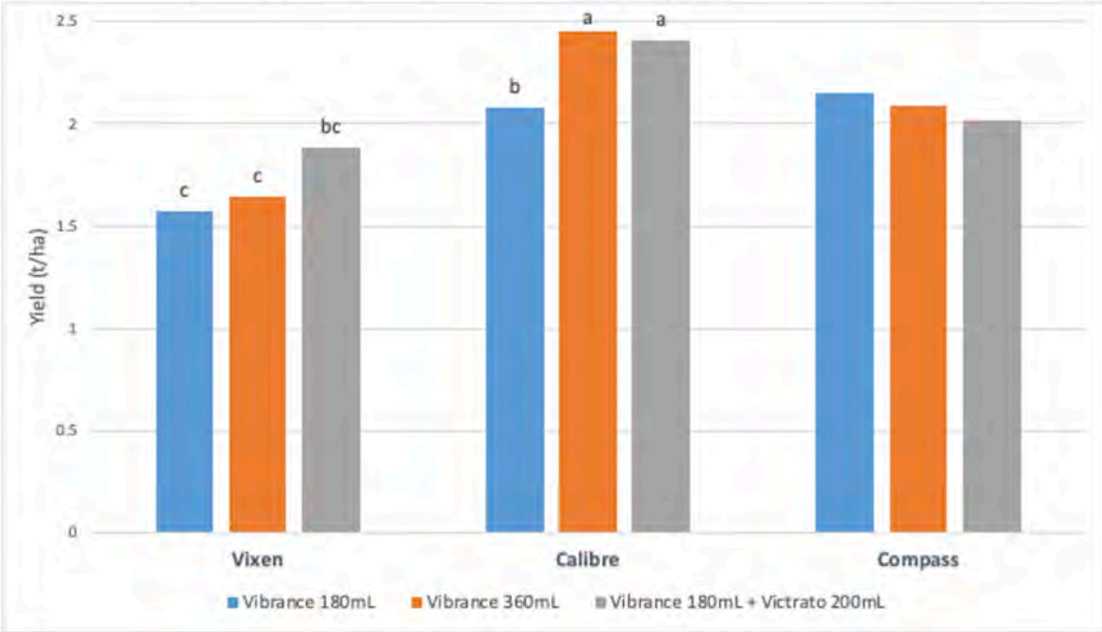

Figure 3. *Yield data from crown rot plot trial in wheat varieties Vixen and Calibre, and barley variety Compass with seed treatment applications in 2022.*

Yield data from 2022 demonstrated that in Vixen wheat, yield from the seed treatment combination of Vibrance at 180ml + VICTRATO® at 200ml was statistically ($P < 0.05$) higher than the sole applications of Vibrance at 180ml and Vibrance at 360ml (Figure 3). The yield in Calibre wheat was statistically ($P < 0.05$) higher in the combination application when compared to a sole application of Vibrance at 180ml, however, statistically equivalent to the sole application of Vibrance at 360ml. Yield of Compass barley indicated equivalent yield results for all treatments (Figure 3)

CONCLUSION

The farmer scale demo indicated no apparent affect on crop performance or crown rot inoculum by cultivating stubble prior to a two-year break at this site. However, inaccuracies of data collection indicate that more work may need to be done on this.

The replicated plot trial showcasing the new fungicide seed dressing for Crown rot control, VICTRATO®, indicates the application of this treatment may be having an increased effect on crop performance and production particularly in wheat. Results however do indicate carryover of crown rot inoculum is unaffected by the treatment application.

EXTENSION

1. Nelshaby Ag Bureau Sticky Beak Day (Bus Trip), Friday 2nd September 2022
2. Several small groups visited the site with Margaret Evans throughout 2022.

Approximately 30 people attended the annual Nelshaby Ag Bureau Sticky beak Day bus trip around the district. The Crown Rot demonstration trials on Jonno and Barry Mudge's farm were visited as the first stop of this trip. This trial aimed at evaluating the benefit of a two-year break from cereals in reducing crown rot inoculation levels. The small plot trial (Figure 1) was also visited which included the new seed treatment from Syngenta which targets nematodes and soil borne fungus diseases. Early indications were that the seed treatment was having a significant beneficial effect. Dr Margaret Evans was on site and presented on crown rot control and the trial.

Photos. *Nelshaby Ag Bureau Bus Trip, 2/9/22*

Acknowledgements

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UNFS Upper North Farming Systems
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SOIL & NUTRITION

DEMONSTRATING VETCH MIX OPTIONS TO REDUCE SOIL EROSION WHILST MAINTAINING GOOD NITROGEN FIXATION

Written by Beth Humphris, Elders Jamestown

Vetch pastures are a great legume feed option for growers across the Upper North Farming region, however, can leave paddocks vulnerable to soil erosion once grazed. This was one of the concerns outlined by local growers and agronomists alike from initial surveys undertaken as part of this project. In this case study a vetch, barley (kraken) and a vetch, brassica (canola) mix is considered as an alternative option to a sole vetch, in an attempt to improve ground covering over the summer period. Parameters including soil cover, nitrogen fixation for the following crop and weed control are considered throughout the document.

What is Wind Erosion?

Wind erosion is a process where fertile soil particles from the soils surface are moved from one location to another via wind events. This can have a devastating impact on the productivity of a soil resource, while also causing issues where soil particles are deposited. The occurrence of wind erosion events has dramatically reduced since the shift from cultivation to no-till. However, modern rotations including a vetch pasture can still lead to wind erosion events. The likelihood of a wind erosion event is increased when the following factors are met;

- The occurrence of erosive wind events that persist for hours or days. Winds are considered erosive once they reach speeds above 28 km/hr.
- Prolonged dry periods, for example where the break of season is late following minimal summer rainfall events.
- **A soils surface is left exposed, making soil particles vulnerable to movement. Stubbles need to have a minimum of 50% ground cover, with at least a third of this still anchored to avoid soil losses via wind erosion. A soil with 30% or less ground cover is considered a very high hazard, with more than 70% ground cover being considered a negligible hazard. Typically, watering points, gate ways and wheel / sheep tracks are the most prone to soil erosion.**
- Lastly, for soil particles to be prone to movement via wind, they need to be 'disturbed' or 'loose'. This is commonly found where sheep have been walking over paddocks for an extended period. Paddocks with gravelly or rocky surfaces are considered at less risk of erosion.

Whilst not all of the above factors can be controlled (i.e. wind events or timing and amount of rainfall) growers of the Upper North can ensure paddocks have adequate ground cover to reduce or completely avoid the effect of top soil erosion.

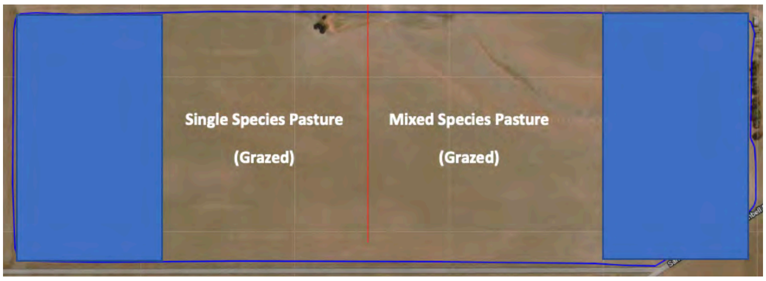
Above information taken from Agriculture Food and Wine, Diagnosing Wind Erosion Risk, 2022.

VETCH VERSUS A VETCH, BARLEY MIX DEMONSTRATION

Grower: Alison Henderson, Hendowie Poll Merinos

Location: Caltowie, SA
Rainfall: 370mm annually
History: 2022; Pasture
2021; Wheat
2020; Barley
2019; Wheat

This demonstration occurred throughout the 2022 season, sown on the 23rd of April, with opening rains falling closer to the 30th of May. One half of the paddock was sown to sole vetch (Rasina), with the other half of the paddock sown to a vetch, barley mix (Rasina, Kraken). The pastures were both grazed for a period of one month throughout winter and then green manured at the end of the season, before the pasture went reproductive.



Nitrogen Fixation

The site was sampled throughout January 2023 to assess the level of nitrogen fixation from each of the treatments, with key results shown below. pH (CaCl2) across the site ranged from 7.5 to 6.3, organic carbon (W&B) between 1.5 to 1.1 and phosphorous (Cowell) between 52 and 14. The site with a Cowell P of 14 was removed from the dataset as the data was heavily affected by phosphorous deficiency.

There was no significant difference in nitrogen fixation between the two treatments, with 4.8 kg more nitrogen fixed per hectare by the sole vetch treatment. Therefore, it is reasonable to conclude from these results, that there was not a significant impact on final nitrogen content by incorporating a barley in a mix with the vetch rotation.

Treatment	Total N (kg/ha)	Fixed N supplied Wheat (t/ha)
	0-60cm	0-60cm
Vetch, Barley	94.6	3.8
Sole Vetch	99.4	4.0

Biomass

Biomass cuts were taken throughout spring. The paddock had been grazed once throughout early spring for a period of one month, the pasture was then left to regenerate for one month before collecting the above biomass data. Again, there was not a significant difference between the treatments. The vetch, barley mix had 0.19 t/ha more dry matter in comparison to the sole vetch.

Treatment	Biomass (t/ha)
Vetch, Barley	3.35
Sole Vetch	3.16

Ground Cover

The site was visited throughout early Autumn, following the vetch and vetch/barley phase to assess ground cover. The vetch, barley showed 90% ground cover, with 20% of that cover anchored into the soil resource, making the treatment at very low risk of soil erosion.

The sole vetch treatment had 60% ground cover with only 5% of that ground cover anchored, meaning the treatment was considered a moderate risk for soil erosion.

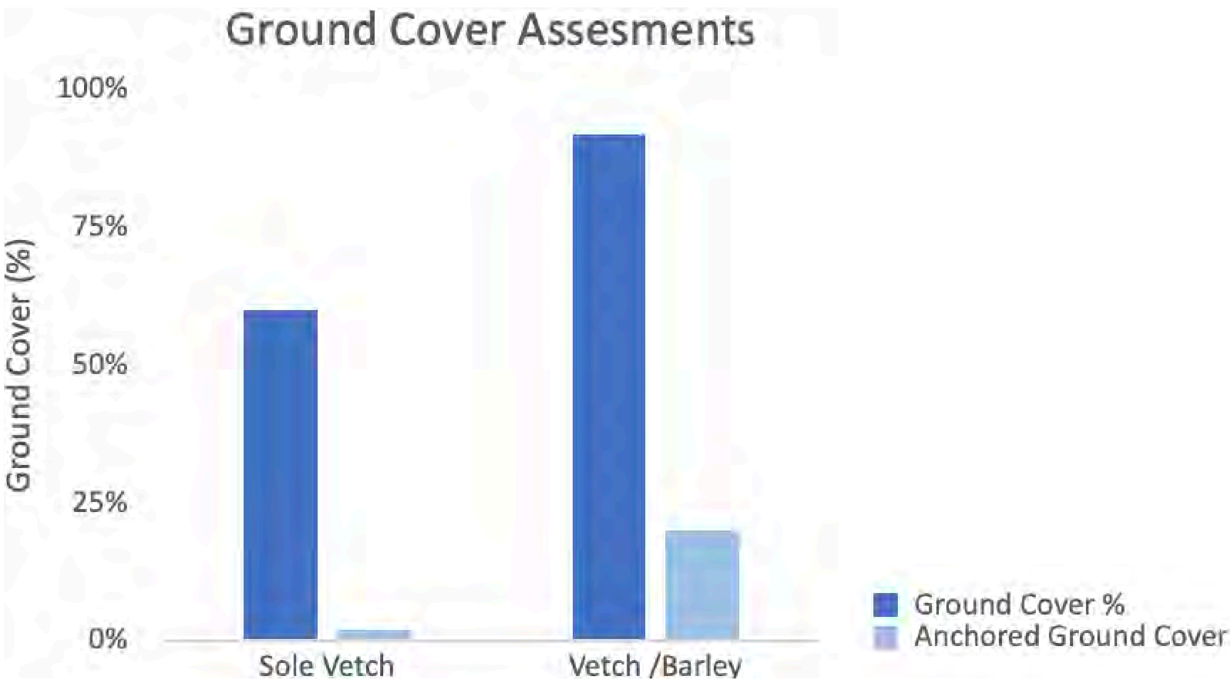


Figure 1.
Ground cover assessments taken throughout March, looking at overall ground cover and anchored ground cover.

Simulated Erosion

Soil erosion was simulated using a leaf blower, as shown in the below photos. A wind event was simulated using a leaf blower, with a wind speed of approximately 144 km/hr (determined using a kestrel). The leaf blower was held at a low angle, to simulate an erosion wind event. This was completed over a 30 second time frame.

The sole vetch treatment showed increased loss of ground cover resulting from the 'wind event'. This is likely a result of the low level of anchored biomass in this treatment, meaning biomass was free to move with winds. This in turn left the soil resource in a bare state, exposing topsoil to erosion for following wind events.

In contrast, there was minimal movement in the vetch, barley mix treatment. Therefore, with multiple erosive wind events the vetch, barley mix is less vulnerable to losses due to the higher percentage of anchored groundcover in contrast to the sole vetch treatment.

Another observation from the site was the consistency of ground cover across the trial site. The sole vetch treatment had patchy covering, with areas of accumulated vetch in some parts of the trial and other areas of bare, exposed soil. As a comparison, the vetch, barley treatment had consistent cover across the trial site, again linking back to the level of anchored biomass between treatments.

Sole Vetch

Vetch Barley Mix

VETCH VERSUS A VETCH, CANOLA MIX

Grower: Andrew Walter

Location: Melrose, SA
Rainfall: 280mm annually
History: 2022; Lentils
2021; Barley
2020; Barley
2019; Wheat

The replicated plot trial was sown at the beginning of 2022, looking at different mix options for vetch and canola. The vetch variety used at this trial site was Timok and the canola variety was Hi-Tec Trophy. The trial was sown with 40 kg N/ha. Below is a list of treatments considered in this case study;

Treatment Name	Description
Sole Vetch	Vetch alone, harvested for seed
Vetch, Canola - retained 1 graze	Canola and vetch sown together – Both mechanically grazed throughout winter once
Vetch, Canola - retained 2 graze	Canola and vetch sown together – mechanically grazed once in winter then again in spring
Vetch grazed	Vetch – mechanically grazed once in winter then again in spring
Vetch, Canola - retained	Canola and vetch sown together
Vetch, Canola - Early	Brown manured throughout early spring
Vetch, CAnola - Late	Brown manured throughout late spring

Nitrogen Fixation

The site was soil sampled throughout January 2023 to assess how much nitrogen each plot had fixed. Overall, the site had an organic carbon (W&B) of 0.7 to 0.6, a pH ($CaCl_2$) of 7.1 to 6.2 and a phosphorous (Cowell) of 40 to 31 mg P/kg. Therefore, it is reasonable to conclude the site was unconstrained.

Following the trial. Soil was sampled to a depth of 60 cm's and split into 0-10, 10-30 and 30-60 cm increments. The below table displays the total nitrogen throughout the 0-60 cm core and finally, as the potential wheat yield using fixed soil nitrogen. Results are displayed in order of the treatment that fixed the greatest soil nitrogen to the treatment which fixed the least.

The two treatments that fixed the greatest amount of soil nitrogen was the vetch, canola treatments where the vetch was sprayed out in early spring and late spring respectively, leaving the canola to set seed. The next highest level of nitrogen fixation was the sole vetch treatment, where the vetch was left to go reproductive and harvested for seed. If vetch was sprayed off before going reproductive it is reasonable to assume more nitrogen would have been fixed in the sole vetch treatment.

When considering the vetch treatment that was grazed throughout the season, less nitrogen was fixed compared to the vetch, canola retained, vetch, canola mix and the vetch, canola grazed once treatments. This suggests that if a paddock is sown to a vetch, canola mix and either left un-grazed or only grazed once throughout the growing season, the paddock would be left with more nitrogen than a sole vetch paddock that is grazed throughout the growing season twice.

Analyte	Total N (kg N/ha)	Fixed N supplied Wheat yield (f/ha)
Treatment	0-60cm	0-60cm
Vetch, Canola - Early	320.0	12.8
Vetch, Canola - Late	253.8	10.2
Sole Vetch	125.3	5.0
Vetch, Canola - retained 1 graze	117.3	4.7
Vetch grazed	97.4	3.9
Vetch, Canola - retained	95.8	3.8
Vetch, Canola - Retained 2 graze	68.9	2.7

Biomass

Biomass measurements were collected throughout spring to identify if there is a trade off to moving from a sole vetch to a multi-species pasture option. There is no significant difference between vetch biomass cuts at this site (Figure 2). Therefore, when considering the additional biomass the canola provides, it is reasonable to conclude that by adding canola to the mix, you are in fact increasing your overall feed on offer, rather than reducing it.

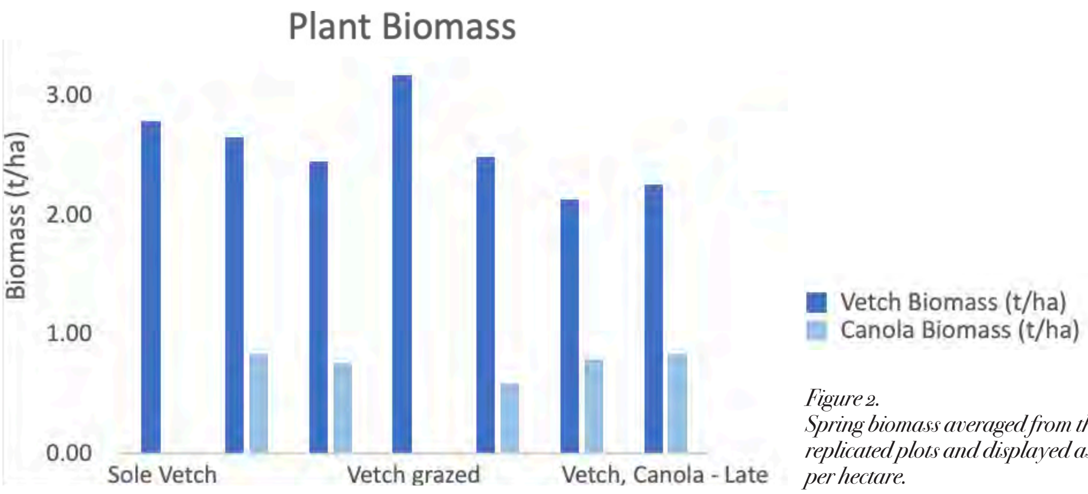


Figure 2.
Spring biomass averaged from the three replicated plots and displayed as tonnes biomass per hectare.

Ground Cover Assessments

Ground cover assessments were taken throughout early autumn 2023, following the trial phase in 2022, to assess how well plant biomass could persist over the dry period. Total biomass and anchored biomass was recorded in three locations of each treatment, with the below figure showing the averaged results (Figure 3). When looking at the mixed plots, the data indicates there are higher levels of anchored biomass and the ground cover is more consistent spatially across treatments, as shown by the error bars. Typically, treatments that were grazed throughout the season showed lower levels of ground cover in comparison to treatments that were not grazed or were grazed fewer times throughout the season. Overall, the vetch, canola treatment that was grazed twice showed the least amount of ground cover, followed by the vetch which was grazed twice, then the vetch, canola retained treatment. The treatments that resulted in the best ground cover was the vetch, canola treatments where the vetch was sprayed out early and late, then the vetch, canola grazed once, followed by the sole vetch treatment.

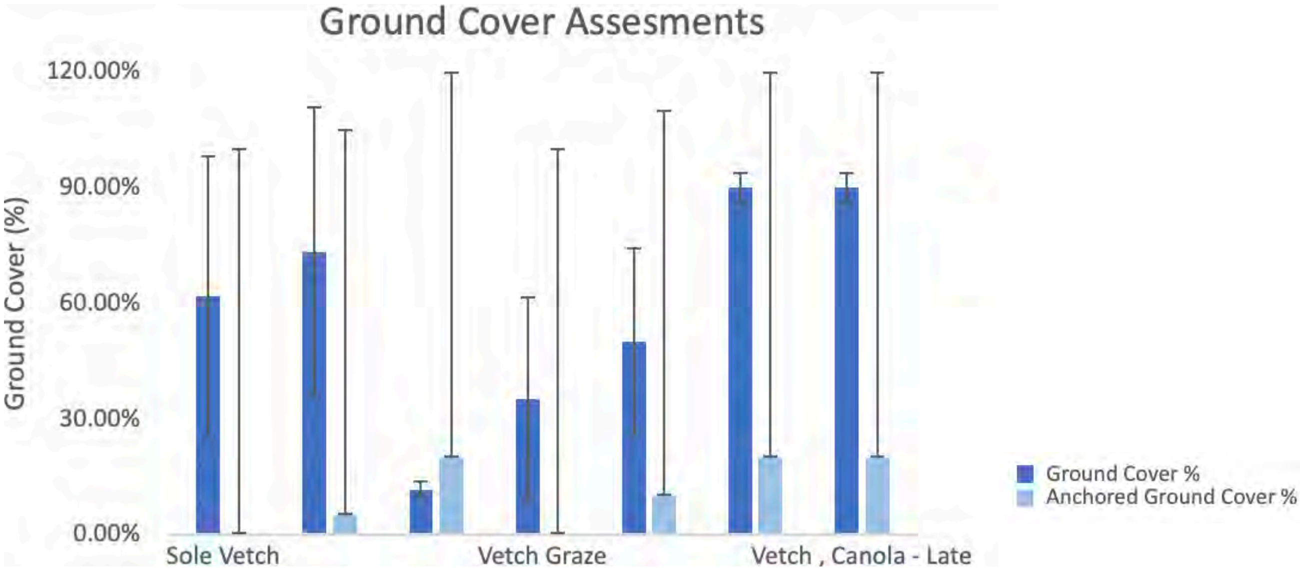


Figure 3..
Ground cover assessments taken throughout March 2023, looking at overall ground cover and anchored ground cover. These are averaged results using three measurements.

Simulated Erosion

In addition to the ground cover assessments, soil wind erosion was simulated using a leaf blower. Wind speed in this simulation was equivalent to 144~ km/hr winds (determined using a kestrel) and the results are shown in the below photos. Results highlight that numerous factors feed into the degree of soil loss during a wind event. Firstly, anchored biomass dictates how much ground cover is lost in initial wind events, with higher levels of anchored biomass inimising ground cover losses and leading to more consistent ground cover across plot areas. Lower levels of anchored biomass results in patchy ground cover and hence patches of exposed soil. Another big factor is if soil particles are dislodged and vulnerable to movement. This trial has not had sheep across it and so much of the soils surface had set hard, reducing the risk of erosion on a bare surface.

Overall, the sole vetch, grazed treatment showed the worst soil erosion, followed by the vetch, canola treatment that was grazed once. The best treatments were the vetch, canola, retained, early and late. In these treatments no movement of soil particles were observed.

Sole vetch

Vetch, Canola - 1 graze

Vetch, Canola - 2 graze

Vetch grazed

Vetch, Canola - retained, early, late

TRADE-OFFS TO A MIXED PASTURE

While the above demonstration sites attempted to consider a lot of the key factors for moving from a sole vetch pasture toward a mixed option, there are still a few considerations that could not be investigated throughout the lifespan of this project. These are listed below.

Reduced weed control options

This is particularly true for the vetch / cereal options. Group A herbicides that are typically used to control grass weeds in the pasture rotation are either taken off the table completely, or only used late in the season once the cereal has pushed out a head and the grower is happy to kill of the cereal. At this stage it can be difficult to get a good knock on grass weeds such as ryegrass, barley grass or wild oats. There are group A tolerant cereal options coming through breeding lines currently, which would make it possible to control grass weeds, while keeping the vetch, cereal mix for grazing. Alternatively, green manuring is an option, killing all plant species throughout late spring, before anything has set seed. This also has benefits for organic carbon levels within the soil resource. Alternatively, a mix of vetch and a forage brassica still allows the option of in season grass control using conventional herbicides in a timely fashion. Green manuring in this scenario also helps to control any grass weeds that may have germinated after the in-season control or escaped the in-season herbicide application. Chemical applications in season comes with the requirement of grazing with holding periods, as per label requirements.

Reduced root disease break

Typically, a legume rotation is used as a root disease break for other crop types within the rotation, for example cereals and brassicas. By incorporating these crop types into the legume phase, this reduces the ability for paddocks to have a good root disease break before re-planting crop types. For example, in a wheat, wheat, barley, legume rotation, if you were to add a cereal into the legume phase there would consistently be a cereal root in the soil resource increasing risk of root disease on cereals long term. Under this scenario a vetch, brassica option would be much better suited. Alternatively, a rotation following wheat, wheat, barley, vetch, canola, the vetch, brassica would present issues for the following canola. Seed treatments, appropriate nutrition and testing will help to manage this issue.

Other key methods to control erosion

- Managing other soil health aspects such as soil acidity, sodicity and compaction as unhealthy soil resources are unlikely to support good ground cover, therefore reducing organic carbon input and increasing wind erosion.
- Rotational grazing and good grazing management can minimises erosion and reduces compaction. Do not over graze paddocks as this can lead to poor ground cover and dislodged topsoil particles, leaving the resource highly prone to erosion.

CONCLUSIONS

Findings from this work have given confidence that moving from a sole vetch pasture rotation towards a mixed option such as vetch, barley or vetch, canola will benefit the overall system. Soil sampling work has highlighted little difference, in some cases benefits, to nitrogen fixation by incorporating a cereal or canola to a vetch pasture. Additionally, by using the inter-species method the paddock is left with a greater percentage of ground cover, particularly when considering anchored ground cover. Whilst there is concern around root disease breaks and weed control methods, there are options to combat these issues should growers across the upper north region choose to move toward an inter-species pasture phase.

ACKNOWLEDGEMENTS

This fact sheet is part of the 'Building soil knowledge and capacity to implement change in the farmers of the Upper North Agricultural zone of South Australia' project funded by the National Landcare Program: Smart Farms Small Grants Round 4.
The Vetch, Barley Mix Options soil sampling, wind erosion scoring and data analysis was completed by Beth Humphris, Elders Jamestown. Other data collection including spring plant biomass was collected by Morgan McCallum, Upper North Farming Systems. This Demonstration was as part of the project 'Improved Pasture Management Systems' made possible with the funding of SA Drought Hub.
The Vetch, Canola Mix Options project management and biomass data collection was completed by SARDI Clare, with soil sampling, wind erosion scoring and data analysis completed by Beth Humphris, Elders Jamestown. This project was as part of the 'Intercropping in Break Crops in the Upper North' funding by the SA Drought Hub.
A big thankyou to the landholders, Alison Henderson and Andrew Walter for facilitating the projects and being generous with data sharing.

References

1. Agriculture Food and Wine, Diagnosing Wind Erosion Risk, 2022

Report prepared for Upper North Farming Systems group by Beth Humphris, Elders Jamestown in 2023.

UNDERSTANDING WATER MOVEMENT THROUGHOUT DIFFERENT SOIL PROFILES ACROSS THE UPPER NORTH

Written by Beth Humphris, Elders Jamestown and Ed Scott, Soil and Water

This case study aims to exemplify how water movement through soil profiles in the region are impacted by various soil properties and how ameliorating / managing constraints can improve water use efficiency.

Water infiltration in soil profiles is a critical factor to ensure effective storage of moisture in a given soil profile. Infiltration and subsequent water extraction by crops can be influenced by numerous factors and ultimately will have the largest influence on yield potential of soil types in the region. The infiltration rate is a measure of the rate of a known volume of water penetrating into soil. The infil-tration rate is influenced by the interaction of water with the soil surface and subsequent porosity through the soil layers.

Factors to consider when assessing your soils ability to infiltrate water includes;

- **Soil cover**–soil cover reduces the energy of raindrop impact which can break apart the soil aggregates on the surface and block soil pores which are primary infiltration pathways. Soil cover also reduces the velocity of lateral water movement thereby allowing for greater infil-tration over time.
- **Soil Structure**–Soils in the Upper North region can be prone to surface crusting and hard setting. Surface crusting is caused by poor aggregate stability which results in slaking and or dispersion (potentially caused by low organic matter and or high sodium soil). This is often visualised with prolonged ponding of rainfall at the soil surface and crusting of the soil surface upon drying. Surface soil crusting can also impact crop germination.
- **Bulk density/Compaction**–Soils with high bulk density (compaction) have slower infiltration rates due to low pore connectivity and limited number of large pores for water to readily permeate.
- **Non-wetting/ Hydrophobic soils**–Sandy textured soils are prone to non-wetting. Due to the presence of waxes coating the sand particles (derived from organic matter) the water beads on the soil surface and is slow to infiltrate the soils.
- **Soil texture** and soil textural changes throughout the profile - Infiltration of water is a direct function of the porosity of soils. Sand texture soils will generally accept water more readily (unless non-wetting) compared to clay textured soils. However, sandy soil types will also leach water more readily compared to clay soil types.
- **Subsoil condition** will impact the wetting front of soil profiles. Once the water has infiltrated though the surface of the soil profile the movement of water is influenced by the rate at which it can continue to permeate through the profile (hydraulic conductivity). If there are subsoil constraints such as compaction or sodicity, water will not move throughout the soil profile evenly.

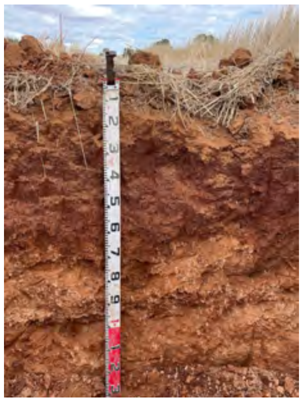
THIS CASE STUDY LOOKED AT THREE SOIL TYPES, COMMON TO THE UPPER NORTH FARMING REGION;

Site one

A Red Chromosol and a Dermosol South of Jamestown. The chromosol showed soil structural constraints while the dermosol is structurally less constrained.

Chromosols are a common soil type throughout the Upper North region of South Australia and typically are be classified as red or brown. They are characterised by a texture contrast with lower clay content in the topsoil, with clay increasing down the profile. Acidity is commonly observed in the topsoil. Chromosols are typically moderately fertile.
Dermosols are non-texture contrast, typically having similar tex-ture down through the profile and well structured subsoil (B horizon) .

Pit one

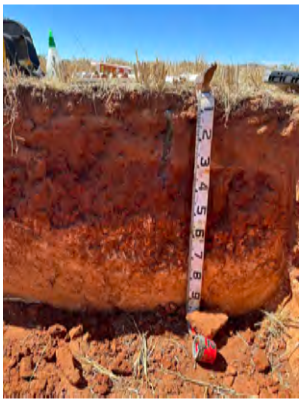


Pit two

Site two

A non-wetting Brown Chromosol soil (sand over clay) North, East of Booleroo.

Sandy non-wetting topsoil transitioning to clay topsoil with blocky structure. Presence of topsoil acidity and subsoil alkalinity due to the presence of carbonate.



Pit three

Site three

A deep sandy Tenosol compared to a Brown Chromosol with non-wetting topsoil in the Wandearah area.

A Tenosol is a profile where horizons are hard to identify due to little change throughout the profile. A defining feature is these soils gener-ally are sandy soil texture throughout.
Chromosols are texture contrast soils, often called duplex soils typically having a sand to loam topsoil over a clay textured subsoil. This Chromosols was dominated by the presence of free lime (carbonate) in the subsoil, resulting in alkaline subsoil conditions.

Pit four

Pit five

Words you will need to know:

Soil Horizon: A layer of soil that is chemically, physically or biologically different from the soil directly above and below. Soil pits are split into horizons, or layer to help classify soil type and therefore management of overall soil resources.

Sodic: This refers to a soil that has excess sodium content. Soils classified as sodic when Exchangeable Sodium Percentage >6%.

Dispersion: This refers to a process whereby a soil particle is broken into primary particles, destroying soil structure, when add-ed to distilled water. This is due to excess sodium cations bound to clay particles within the soil resource. This results in murky coloured water. Commonly a symptom of the soil being sodic (refer above).

Non-Wetting: This refers to when the topsoil of a profile does not absorb water, but actively repels it. This commonly occurs in sandy texture soil types and is a result of a wax coating (typically organic matter derived) over sand particles.

pH Stratification: This term is used when the pH of a soil changes abruptly down the profile, which can occur between or even-within soil horizons. For example, if pH changed from slightly acidic (pH6.5) in the 0-5 cm fraction, then shifts to strongly acid (pH 4.8) in the 5-10 cm fraction before then transitioning back to neutral-alkaline conditions below

Acidity: When the pH is below 7

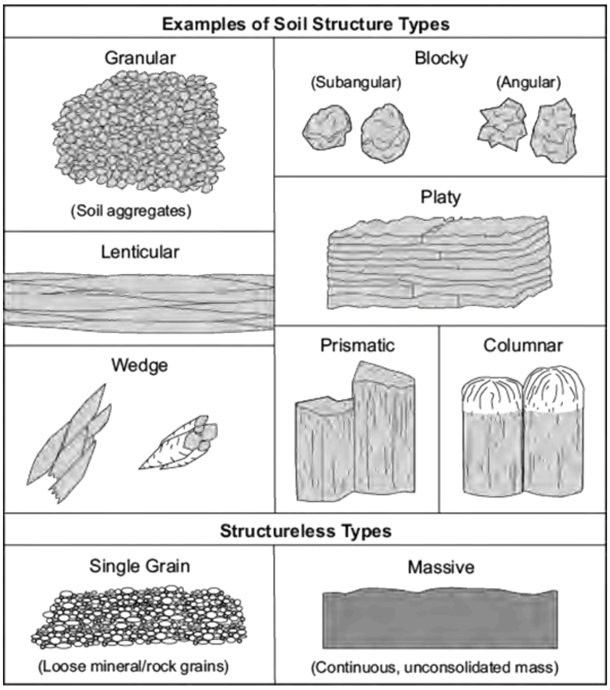
Alkalinity: When the pH is above 7

Compaction: Soil compaction occurs when soil particles are compressed together resulting in reduced soil pore space and a high soil mass relative to its volume, otherwise known as a soil with high bulk density. This can be caused by soil structural de-cline which can be exacerbated by external physical forces such as wheel traffic.

Plant Available Water: The component of water that is available for plants to take up from a soil profile. Different crop types can exude different pressures for extracting water from a soil profile, therefore the plant available water will differ between crop type. Likewise, water is held more tightly in a clay textured soil compared to a sand texture soil, therefore plant available water will differ between soil types.

Field capacity: The remaining water that is held in a soil profile once excess water has drained away / infiltration has reached a steady state.

Soil Structure: The way in which soil particles in a particular soil horizon are arranged around one another to form soil aggre-gates . These aggregates can vary dependant on the percentage of clay and organic matter present. There are 7 different for-mations of soil structure. Not all soils will have a defined soil structure, where soils are compacted there may be no structure present, making them structureless (massive) soil layers.



Infiltration: The movement of water into a soil profile. The time this takes is dependent on soil structure, soil texture and starting soil moisture. Below is a table showing the expected infiltration rate for the different soil textures, when the soil is at field capacity.

Soil Type	Basic infiltration rate (mm/hour)
Sand	<30
Sandy Loam	20-30
Loam	10-20
Clay loam	5-10
Clay	1-5

PROJECT DESIGN

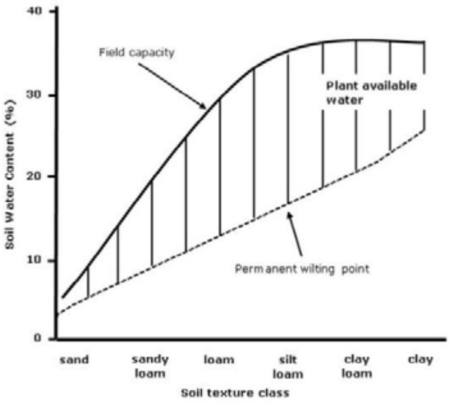
Soil pits were excavated at each site to compare water movement through a low productivity soil type and a highly productive soil type that yields consistently well. Infiltration ring assessments were completed at each site in addition to an infiltration simulation using soil dye to track water movement. The purpose of this investigation was to assess how soil constraints impact ability of soils to harvest water, translating into yield potential.

Infiltration Data

To test the ability of each soil type to infiltrate water, infiltration tests were completed. Metal infiltration rings were hit into the soils surface, creating a dam to add water. 800 ml of water was added to the rings and the time taken for water to infiltrate into the soil profile was measured. This was repeated until the infiltration time plateaued. At this point we consider the soil at field capacity or at steady state. Knowing the ability of a soil to infiltrate water will enable growers to better understand the water harvesting ability of soil types across a farm. This can then be related back to rainfall events and intensity to make calculated predictions on what percentage of rain-fall events has infiltrated into different soil types. This has major implications on yield potential of different soil types and overall management decisions.

Plant Available Water

Not all soil types store or release the same amount of water. Different soil types will release water at varying potentials depending on soil structure and soil texture. This needs to be considered in addition to crop type and total soil moisture. It is therefore important to link each soil profile throughout this project to the adjacent graph. This will help gain understanding of the total water accessibility and estimated yield potential for different growing season in addition to various soil types across paddocks and over whole farms.



Water Infiltration Simulation

Further visual assessments including blue dye tracer was used to exemplify how water moves throughout the soil profile in relation to structure type, soil horizons and soil constraints. Water containing dye was applied to the top of a dry soil resource and left for half an hour to move throughout the profile. The pit face was then cleaned to reveal water movement, using a blue dye to help visualise.
This shows how water is placed throughout a soil profile and how plant roots are required to move in order to intercept moisture.

Red Chromosol Soil Type

Grower: Scott & Luke Clark

Location: Jamestown, SA
Rainfall: 350mm annually

Background:

This case study focused on a paddock in the Belalie East region, approximately 20 km's south of Jamestown on the Clark's farm. Clark brothers have been following a controlled traffic farming (CTF) system in combination with running a disc since 2013 and a stripper front since 2019. The change from a knife point, press wheel system was prompted by the desire to build soil organic carbon and hence improve soil structure, among other reasons. The brothers follow a rotation of wheat, faba beans and canola, with the occasional barley. They no longer run livestock on the cropping land as a bid to further reduce compaction. Soil moisture probes were installed in 2015, providing another decision-making tool for the farm, particularly around in season urea applications. Antidotally, the Clark's believe that their water infiltration rates have improved since the adoption of their new system, with less compaction outside wheel tracks and increased biomass retention supplying larger amounts of organic carbon sources to the soil.

Soil Pit One – Constrained Due to Compaction

Fraction	Texture	Structure		Roots Score	pH ($CaCl_2$)	EC (sD/m)	Sodium %
		Grade	Type				
0-10cm	Silty Loam	Weak/Mod	Granular	3	4.58	0.086	1.0
10-45cm	Clay	Mod	Sub-blocky	3	6.56	0.067	1.1
45-65cm	Silty Clay Loam	Mod	Sub-blocky	2	7.67	0.16	1.2
65-90cm	Silty Loam	Weak	Poly	2	8.01	0.15	1.8
90-100cm	Rock	Weak	Massive	1	-	-	-
100-140cm	Clay Loam	Weak	Sub-blocky	1	8.23	0.23	5.9

Pit Classification: Red Chromosol with a silty loam surface texture abruptly overlying a red well-structured friable clay

Landscape Positioning: Lower Slope

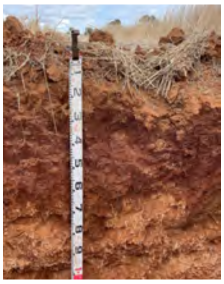
Structure: Soil structure in the 45-65cm region was subangular blocky, showing reduced ability of this soil area to infiltrate water throughout the season. Throughout this fraction there is clear evidence of the soils ability to shrink and swell with the wetting and drying cycle. This results in the soils ability to re-form soil structure long term.

Soil Chemistry: Beyond the 100 cm mark there is limestone (carbonate), resulting in an alkaline soil pH.

No salinity issues were identified at this site throughout the 0-100 cm fraction, further influencing good soil structure at this site. There is excess sodium in the 100-140 cm fraction. Topsoil is considered acid, requiring lime to correct this constraint.

Plant Roots: Roots are in high abundance in the 0-45cm zone. As clay content increases beyond the 45 cm point, the abundance of roots decreases. The reduction in root abundance is most evident at the 90cm mark, where the calcium carbonate content increases.

Soil Pit Two – Higher Productive



Fraction	Texture	Structure		Roots Score	pH ($CaCl_2$)	EC (sD/m)	Sodium %
		Grade	Type				
0-10	Silty Loam	Weak/mod	Granular	3	6.92	0.23	0.7
10-45	Silty Loam	Mod/strong	Sub-blocky	3	7.04	0.09	0.9
45-65	Sitly Loam	Mod	Sub-blocky	2	7.85	0.12	0.7
65-100	Silty Loam	Weak	Poly	2	7.93	0.11	0.8

Pit Classification: Brown Dermosol with a silty loam throughout and no major constraints.

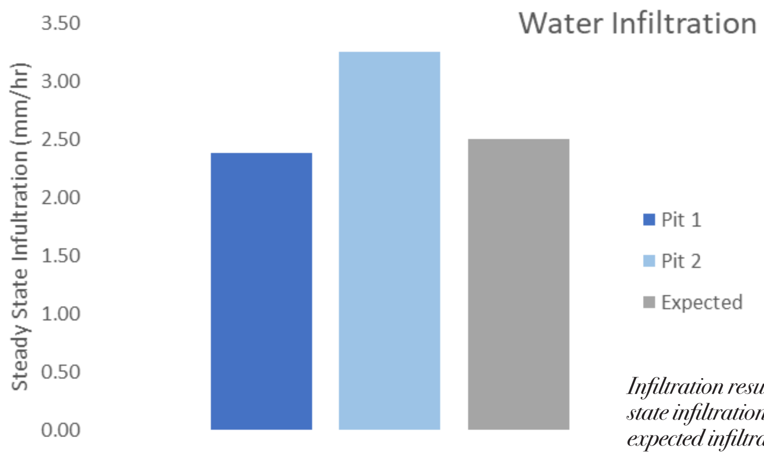
Landscape Positioning: Lower Slope

Structure: Good structure throughout with evidence of compaction, especially under when tracks.
Soil Chemistry: There is no major chemical constraints in the upper profile. There is an increase in calcium carbonate below 60cm

Plant Roots: Plant roots are concentrated evenly throughout the profile with no evidence of constraints to rooting depth at this site.

Infiltration Data

Infiltration results found that both soil pits were within the expected range of 1-5 mm/hr. Pit two, which showed fewer soil constraints when compared to pit one, had a greater ability to infiltrate water having an infiltration rate of 3.25 mm/hr. With both pits having the similar soil texture (silty loam) throughout the topsoil it is reasonable to conclude pit one showed a slower infiltration rate due to soil compaction. This reduced ability to harvest rainfall events will have negative repercussions on yield potential at the site. Both soil pits have capacity to infiltrate another ~0.5 mm/hr with improved soil structure.



Infiltration results averaged from three treatments, using the steady state infiltration from each site. This is compared to the average expected infiltration rate for the soil texture at this site.

Infiltration Simulation

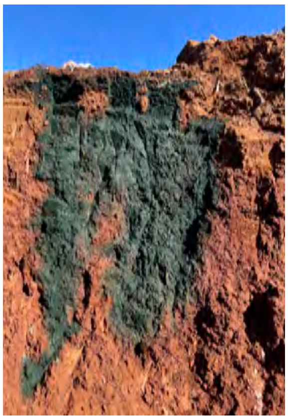
Pit one

From this simulation, the dye indicates that the water is moving down the profile via old root channels and vertical cracks down the soil profile. This is common to clay-based soil profiles where a subangular blocky soil structure is observed. You can expect infiltration to be slow in these soil types. Implications include increased likelihood of run off with heavy down pours of rain, when compared to a sandy soil type. Therefore, stubble retention is important at this site. Additionally, with smaller pore spaces between soil particles, more osmotic pressure is required for plants to extract water from this soil type. Therefore, in drier seasons, crops will become water stressed sooner compared to crops on lighter soil types—such as pit two.

Anecdotally it has been observed that the infiltration rate is improving at this site. Historically this site has been sodic, causing soil dispersion and hence loss of soil structure. To correct this constraint, the Clark's have spread numerous applications of gypsum to displace sodium particles, allowing them to leach beyond the plant root zone. The re-gaining of soil structure is observed at this site from evidence of the clay particles shrinking upon drying and swelling upon wetting, causing slickensides. Once soil structure has been corrected, it is expected that the wetting front at this site will be more horizontal, rather than spikes of water following old root channels.

Pit two

The wetting front at this site was uniform, showing that water didn't intercept any compaction layers. This site is considered less constrained and would take up water uniformly. Therefore, the yield potential at this site is greater than the yield potential of pit one. Additionally, having a lighter soil texture throughout the subsoil compared to pit one will result in moisture being more accessible to plants in tight season.



Pit one

Pit two

SAND OVER CLAY SOIL TYPE

Grower: Joe & Jess Koch
Breezey Hill Ag

Location: Wepowie/Morchard, SA
Rainfall: 300mm annually

Background:

This case study focused on a problematic soil type north east of Booleroo at Breezy Hill. This is a flip-flop soil type, performing quite well in drier years, but then poorer in good years compared to surrounding soil types.
Breezy Hill use RTK guidance which allows them to use the same wheel track from year to year, to reduce soil compaction. Whilst Breezy Hill do not follow full controlled traffic farming, they do ensure the same wheel tracks are used throughout the growing season when soil structure is at its most vulnerable.
They also moved away from a traditional knife point seeding system on 9-inch row spacing to a Conserver pack seeding set up on a 12-inch row spacing. This has minimised soil disturbance and allows Breezy Hill to better harvest moisture from rain-fall events in the furrow. This is particularly important when considering their growing environment, where crops need to germinate on minimal soil moisture.

Soil Pit Three—Constrained Due to Non-Wetting and Compaction

Fraction	Texture	Structure		Roots Score	pH ($CaCl_2$)	EC (sD/m)	Sodium %
		Grade	Type				
0-10	Sand	Weak	Granular	3	6.31	0.088	1.5
10-30	Loamy Sand	Weak	Blocky	1	5.82	0.021	0.8
30-60	Clay Loam	Moderate	Blocky	2	7.37	0.039	1.2
60-100	Clay Loam	Weak	Subangular Blocky	1	8.61	0.13	1.5

Pit Classification: Brown Chromosol with a sandy textured topsoil, moving to a clay loam subsoil.

Landscape Positioning: Mid Slope

Structure: Structure throughout the sandy topsoil was very weak, with the clay subsoil showing signs of compaction and blocky structure.

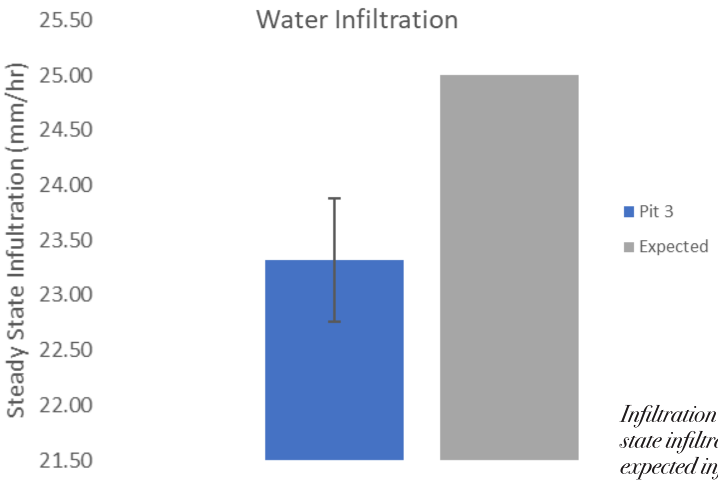
Plant Roots: It is evident that crops have limited access to resources such as water and nutrition from the sub-soil fraction of this site (60 cm+). This is highlighted by the limited rooting depth of previous crops, with 75% of roots concentrated to the top two layers of this site.

Soil Chemistry: The subsoil is dominated by calcium carbonate. This is a limitation that is not economically viable to correct. Management is around adjusting yield potential and therefore inputs accordingly.

Physical Soil Characteristics: The topsoil of this site is moderately non-wetting, impacting the ability of this site to infiltrate water. This is a constraint that could be corrected to potentially improve yield potential.

Infiltration Data

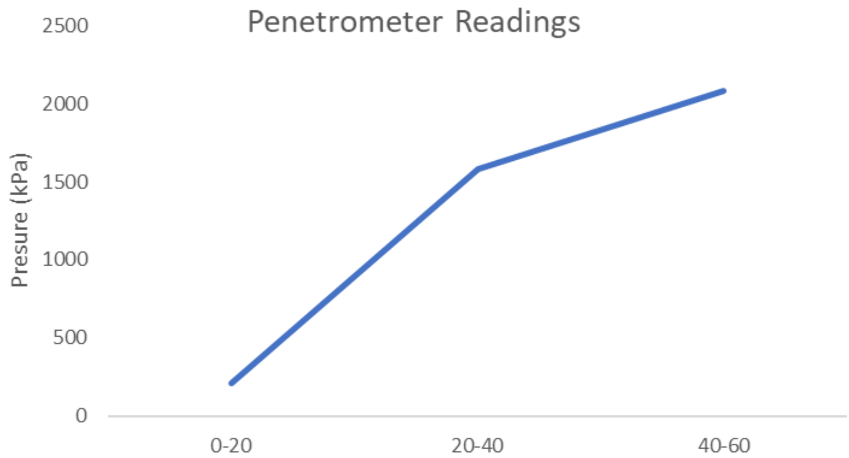
Infiltration at this site was inhibited by a moderately non-wetting top soil. Results varied dependent on where the infiltration rigs were placed in relation to the previous years crop row, as shown by the high standard deviation. Crop rows were found to significantly speed up infiltra-tion, with knife points separating surface soil particles, exposing new soil that did not have non-wetting properties. Overall, infiltration at this site was marginally below the average expected infiltration rate for a sandy loam textured topsoil. This could be moderately improved with clay spreading, increased organic carbon or the use of a soil wetting agent at sowing time.



Infiltration results averaged from three treatments, using the steady state infiltration from each site. This is compared to the average expected infiltration rate for the soil texture at this site.

Penetrometer Data

Penetrometer readings taken at this site found that the 0 to 20 cm fraction has little resistance. However, resistance increases down the profile, with a hard pan at the transition from sandy loam textured soil to clay loam at the 30 cm mark. The clay loam fraction shows signs of compaction, with a blocky soil structure and evidence of poor water movement. Plant root biomass reduces into this fraction of the profile, meaning crops have limited access to resources (water and nutrients) throughout this soil fraction.



Averaged penetrometer readings taken as replicates follow-ing an infiltration test, to ensure the soil resource was at field capacity.

Simulated Water Infiltration

Pit three

The blue dye was able to highlight that majority of water entering this profile was via historic crop rows, where non-wetting soil had been moved into the interrow. While this slows infiltration rates at this site, it is re-directing majority of moisture into the crop row. This maybe of benefit at the start of growing season, with this region commonly required to germinate crops on minimal rainfall events. Moving forward, a good strategy for this soil type is on row sowing, where the non-wetting soil has been displaced.

Pit three

SANDY SOIL TYPE

Grower: Chris Crouch, Crouch Agricultural Group

Location: Wandearah, SA
Rainfall: 330mm annually

Background:

This case study focused on two soil pits located South of Wandearah on the Crouch's family farm. These pits were approximately 100 m apart, highlighting how rapidly soil type can change west of the ranges. The eastern pit (pit four) was located on rising ground, with sand throughout and typically only achieving a 1 to 1.5 t/ha cereal yield. In contrast, the pit to the west (pit five) had a sandy top soil from 0-20 cm's, then transitioning to a loam textured soil dominated by free lime (carbonate). This site is capable of cereal yields between 3 and 3.5 t/ha, more than twice the yield of site one.

Crouch's use a knife point, press wheel seeding set-up, aiming to on-row sow where topsoil non-wetting is a major issue. As there is no good clay source close by, and delving is not an option due to subsoil toxicities, Chris has opted to spread manures instead. When necessary, sandhill paddocks will receive extra nitrogen throughout the season to address increased nitrogen leaching. Overall, Chris adopts to KISS mentality, focusing on the major pillars of broadacre crop production such as correct crop rotation, sowing time, cultivar choice and weed control.

Soil Pit One – Constrained Due to Compaction

Fraction	Texture	Structure		Roots Score	pH ($CaCl_2$)	EC (sD/m)	Sodium %
		Grade	Type				
0-10	Coarse Sand	Weak	Granular	4	7.53	0.11	0.7
10-20	Sand	Weak	Massive	3	8.1	0.083	0.4
20-40	Fine Sand	Weak	Massive	1	8.28	0.073	0.2
40-60	Fine Sand	Weak	Massive	1	8.23	0.066	<0.2

Pit Classification: Tenosol, the soil texture throughout this pit did not change significantly throughout, with no major chemical changes either.

Landscape Positioning: Rising ground, in a dune swale system

Structure: The structure was this site was weak throughout , with compaction found at 40 cm's.

Plant Roots: Majority of root activity was observed in the top 0-20 cm's at this site. The compaction from 40 cm's has prevent-ed historic crop roots from accessing resources (water / nutrient) beyond this point—ultimately limiting yield potential at this site.

Soil Chemistry: No major changes to soil chemistry throughout the profile.

Soil Physical Characteristics: Soil structure is weak throughout, with the subsoil showing little to no structure. When using the soil penetrometer, a hard pan was observed at the 30 cm mark.

Soil Pit Five – Higher Productivity

Fraction	Texture	Structure		Roots Score	pH ($CaCl_2$)	EC (sD/m)	Sodium %
		Grade	Type				
0-10	Sand	Weak	Granular	4	7.76	0.11	0.6
10-20	Sand	Weak	Granular	3	8.11	0.073	0.3
20-40	Loam	Moderate	Subangular Blocky	2	7.95	0.14	0.9
40-55	Loam	Moderate	Subangular Blocky	2	8.12	0.15	1.7
55-100	Clay Loam	Moderate	Subangular Blocky	2	8.53	0.36	9.7

Pit Classification: Calcarasol, this pit had carbonate (free lime) starting from 10 cm's, meaning the profile was dominated by carbonate.

Landscape Positioning: Depression

Structure: Soil structure from 0-20 cm at this site was weak, due to low levels of clay and organic carbon. Below 20 cm's structure improved due to increased presence of clay particle. Compaction, driven by the presence of sodium (causing dispersion) was observed throughout the 20 to 100 cm fraction of this site.

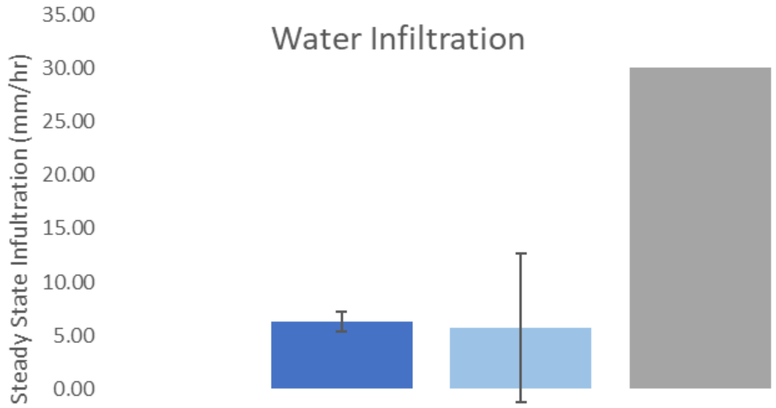
Soil Chemistry: The subsoil of this site is dominated by free lime (calcium carbonate). This has a strong influence on nutrient availability due to an alkaline pH.

Plant Roots: Roots were most prevalent from 0 to 20 cm's at this site, with the sudden increase in carbonate and salts limiting rooting depth at this site.

Infiltration Data

Infiltration at both sites was below the expected rates for a sandy textured soil, mainly due to non-wetting topsoil properties. Research shows that an unconstrainted sandy textured soil that is at field capacity, can take up an average of 30 mm rain-fall over a one hour time period. These soils are currently taking in closer to 5 mm/hr as shown by the infiltration data. Therefore, throughout the season once the profile has wet up, you can assume that these soil types will not be harvesting 100% of rainfall events greater than 5 mm across one hour.

The standard error at pit five was significantly greater when compared to pit four. Infiltration data was highly dependent on the placement of rings in relation to the previous crop rows. If a crop row was placed directly through the middle of the ring, infiltration rates increased to 22.4 mm/hr, much closer to the expected rate for a sand. In contrast, if the ring was placed directly on the inter-row, infiltration rates reduced to 3.3 mm/hr. The significantly higher on row infiltration at pit 5 is translating into higher yield compared to the poor infiltration across the whole soils surface at pit 4.

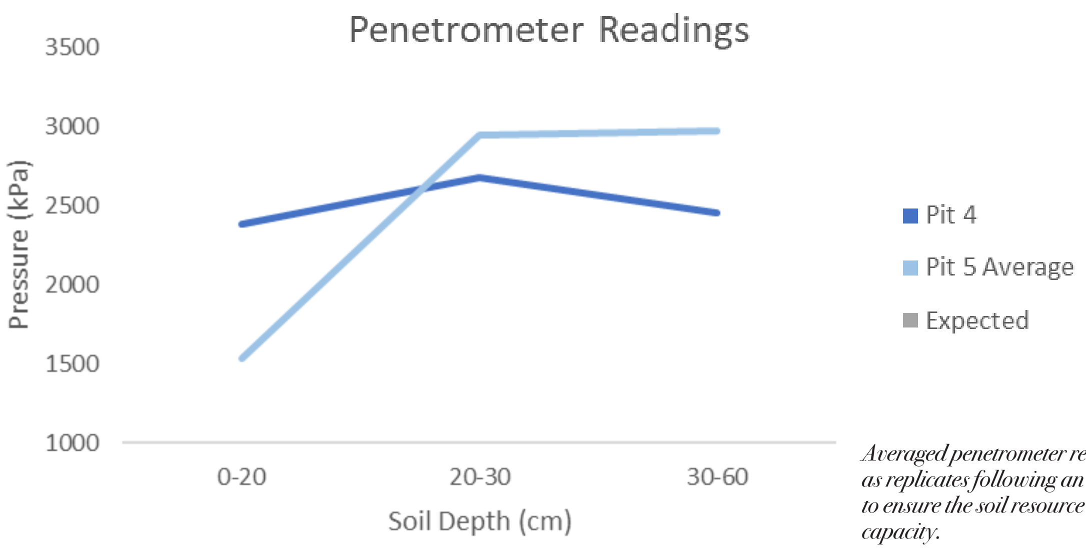


Infiltration results averaged from three treatments, using the steady state infiltration from each site. This is compared to the av-erage expected infiltration rate for the soil texture at this site.

Penetrometer Data

Soil structure at pit four was considered massive, meaning there was no defined soil structure at this site. A strong compaction layer was found at 35 cm's, at which point it was difficult to move the penetrometer through the profile. It was observed that there were less plant roots beyond the 35 cm point as a result. Therefore, crops would have limited access to resources (water and nutrients) be-yond the 35 cm point of this profile.

Pit five showed less resistance throughout the top-soil, with more organic matter helping to form structure throughout the 0-20 cm fraction of this site when compared to pit four. When transitioning into the clay loam textured soil, resistance in-creased. However, with increased clay particles throughout this fraction, soil structure also improved.

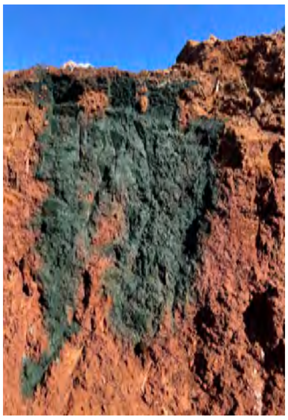


Averaged penetrometer readings taken as replicates following an infiltration test, to ensure the soil resource was at field capacity.

Simulated Water Infiltration

Pit four

Water moved into this profile in a vertical bulb shape. Movement slowed at the transition point between the coarse sand from 0-20 cm and the fine textured sand which is compacted from 20 cm's and beyond. Whilst water will readily move into this profile, it will also easily be lost via either evaporation or leaching beyond the plant root zone due to soil texture at the site.



Pit five

The wetting front at this site was determined by historical crop rows, where non-wetting topsoil had been thrown into the interrow. This slowed water infiltration rates significantly. Additionally, when moisture reached 20 cm's, it began to move laterally throughout the profile. This is due to the sudden textural change. As Sand particles have larger pore spaces in comparison to clay textured soils, it is easier for water to move into these pores, avoiding the small pore spaces throughout the clay. Water will only move into the clay fraction of this site once the 0-20 cm sandy fraction is saturated.

CONCLUSIONS

This case study aimed to exemplify how water harvesting and infiltration can differ between soils with different textures, structures and constraints. Soil types across paddocks and over whole farms have different yield potentials due to these factors and not all soils have the capacity to utilise 100% of each rainfall event. This is an important consideration when assigning inputs to soil types throughout the growing season. Additionally, understanding the current water harvesting ability of soils, verses the water harvesting potential can help to show the importance of soil amelioration. Water harvesting ability directly transfers into yield potential of soil profiles. Where soil constraints were observed throughout this case study (pits 1, 3 and 4) , infiltration was limited. Likewise, where historical soil constraints were corrected (pit 2 and 5), infiltration rates were improved.

Methods used throughout this project can be easily replicated by growers, should they want to gain a better understanding of different soils types and the associated ability to harvest water. Considerations include starting soil moisture, soil texture and soil constraints at the site. Results can be compared to the expected infiltration rate for different soil textures on page 3 and the graph on page 4.

ACKNOWLEDGEMENTS

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A big thankyou to the landholders, Luke and Scott Clark, Joe and Jess Koch and Chris Crouch for being generous with data sharing and providing areas for soil pits to be dug.

References

1. University of Florida, Examples of soil structure types, 2023
2. University of Cape Coast, Basic Infiltration Rates, 2009

Report prepared for Upper North Farming Systems group by Beth Humphris, Elders Jamestown in 2023.

MANAGING DRY SALINE SOILS IN THE UPPER NORTH AND YP

Written by Stefan Schmitt, Ag Consulting and Research

This case study aims to outline the issue of dryland salinity in the Upper North Region. With a summary of key findings from current research exploring improved management practices.

What is dryland salinity?

Dryland salinity is an issue that limits agricultural production in the lower Broughton region. Soil types in this region consist of ancient flood plains, characterised as alluvial soils with moderate to high salt content and poor soil structure. Accumulation of salts in the surface soil, limits crop establishment, unless flushed from the surface with rainfall. Improving ground cover decreases salt accumulation in the topsoil, by reducing the capillary rise of salt to the surface as water evaporates.

Why does it occur?

Soils in this region have inherently high salt levels at depth, with the depth and concentration of salts varying across paddocks. Visually, salt affected areas appear as a mosaic pattern across the landscape, with patches of good and poor plant growth. Within a small area, establishment and crop performance can vary from a viable plant stand to nothing as shown in the photo above. The effect of salinity is more evident during seasons of low rainfall, as rainfall dilutes salts in the surface soil by washing them into the profile.

Figure 1. Variation in the growth of barley on a paddock in the lower Broughton region as a result of varying salt concentrations in surface soil.

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There are two ways in which salinity occurs, either through ground-water driven salinity or dry saline land.

Dry saline land, often referred to as 'magnesia patches', occur due to the presence of natural salts in the upper part of the soil profile and are not associated with a water table. Salts moves up and down the soil profile via two pathways, rainfall (leaching salts down) and evaporation (pulling salts up via capillary rise). For this reason, managing ground cover is so important as it impacts evaporation rates, which drives salt accumulation in the surface soil.

The other way in which salinity occurs in this region is through rising ground water tables this is known as **'ground water driven salinity'.** This occurs when deep rooted perennial plants such as shrubs, saltbush and trees are removed in favour of annual crops such as cereals, pasture and legumes. The change from perennial to annual plants, results in rising groundwater tables as they remove less water from the system. This is because, they do not grow year-round, have a lower tolerance to salinity and are shallow rooted. When the water table is within a metre of the surface, water can be drawn up through capillary rise. As this saline water evaporates, salts accumulate at the soil surface. In extreme situations, this results in the formation of a white scald or crust.

Salinity in this region has been extensively mapped and is best described as non-water table salinity higher in the landscape and groundwater driven in the valleys. Most saline land occurs near the coast, where the distinction between ground water driven and non-water table salinity becomes blurred.

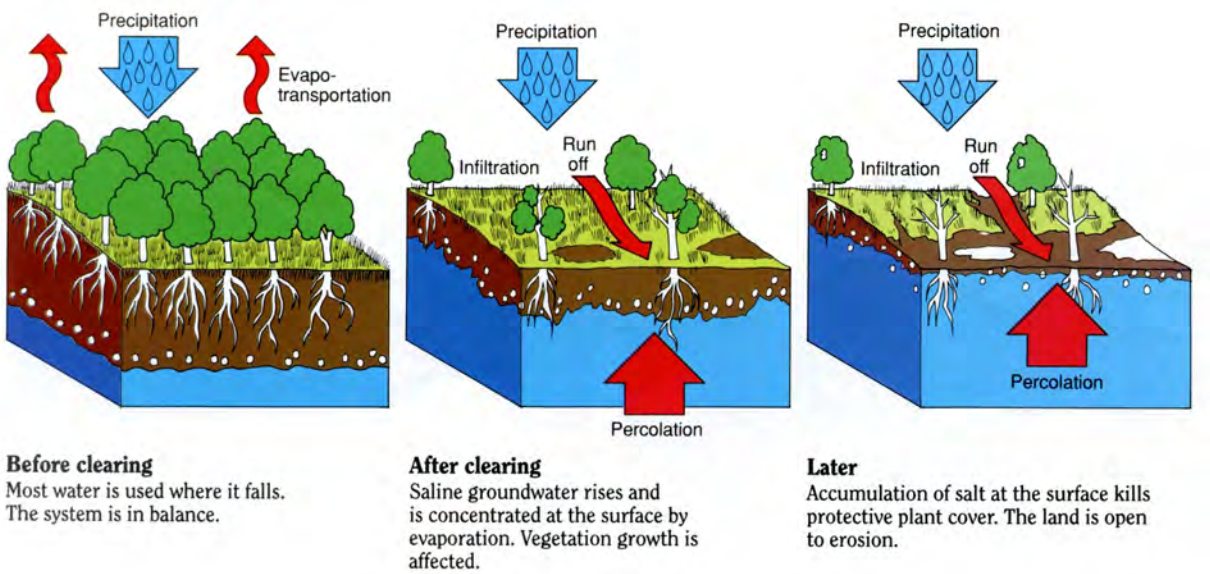

Figure 1. Example of how groundwater driven dryland salinity occurs.

Why is it an issue?

Salinity reduces the ability of plants to access water and nutrients. Symptoms of high salinity include stunted plant growth and bare areas. Annual plants on saline land experience very high salinity as the soil first wets up, with increasing moisture the impact of salinity decreases as water fills the soils pores and salts leach down the profile. As the season finishes and the soil dries, salinity levels increase. Salt bush and some native shrubs are tolerant to high salinity levels, whilst most annual crops are not.

How can it be measured?

Salinity is a measure of the soluble salts in soil or water. Sodium chloride (NaCl) is the most common salt in groundwater in SA. When measuring salt levels within a paddock, soil sampling methods are different if assessing soils for the suitability of establishing annuals or perennials. For annuals and if establishing perennials from seed, soil tests should be taken from the topsoil (0-10cm). Whilst if seeking to understand the impact salinity may have on established perennials, a subsoil sample should be taken.

There are three main measures of salinity, they include.

- The electrical conductivity (EC) of a solution or soil and water mix in the field or laboratory.
- The apparent electrical conductivity using an electromagnetic induction (EM) device.
- Chemical analysis of total dissolved salts (TDS) of water or soil in a laboratory to identify and measure ion concentrations.

Table 1.
Salinity classes in electrical conductivity as EC1:5 or ECe for different soil textures.

Salinitiy Class (dS/m)	Sands (EC1:5)	Loams (EC1:5)	Clays (EC 1:5)	ECe Range
Non-Saline	0-0.14	0-0.18	0-0.25	0-2
Slightly Saline	0.15-0.28	0.19-0.36	0.26-0.5	2-4
Moderatley Saline	0.29-0.57	0.37-0.72	0.51-1	4-8
Highly Saline	0.58-1.14	0.73-1.45	1.01-2	8-16
Severly Saline	1.15-2.28	1.46-2.9	2.04-4	16-32
Extemely Saline	>2.28	>2.9	>4	>32

EC 1:5 can be converted to ECe which corrects the value for soil type. This is achieved by multiplying the EC value by the associated conversion factor based on soil texture, in the table below. **ECe is generally considered the preferred measure of soil salinity.**

Table 2. Texture conversion factors (soil salinity)

Soil texture	Conversion Factor
Sand to clayey sand	14.0
Sandy loam to clay loam	9.5
Clay	6.5

How can we manage dryland salinity?

Management is difficult in areas where scalds occur as mosaic patterns (eg in the Lower Broughton region). Incorporating deep rooted perennial plants is the best option, but is not necessarily the most profitable in the short term. Other options include:

- Keep saline areas covered with stubble by retaining as much stubble as possible
- Apply mulch (sand or straw) if economically viable
- Revegetation of saline areas with fodder shrubs such as salt bush
- Grow species with greater salt tolerance (e.g., barley, canola, oats)
- Reduce or eliminate stock grazing on these areas

What crops are most tolerant to salinity?

The table below demonstrates the expected tolerance of various crop types to salinity measured as (ECe).

Table 3. Yield decrease (%) from selected crops to soil salinity (Source: Maschmedt, 2004a)

Crop	Yeild decrease expected				
	0%	10%	25%	50%	Maximum
	Soil ECe (dS/m)				
Barley	8.0	10.0	13.0	18.0	28.0
Wheat	6.0	7.7	9.5	13.0	20.0
Beans	1.0	1.5	2.3	3.6	6.5
Lucerne	2.0	3.4	5.4	8.8	15.5
Strawberry Clover	1.5	2.3	3.6	5.7	10.0

Recently, research work has been undertaken in the lower Broughton and Tickera region investigating opportunities to improve crop yield and ground cover on soils impacted by salinity. This work was made possible through the Future Drought Fund Drought Resilient Soils and Landscapes Project "Building resilience to drought with landscape scale remediation of saline land". The key findings to date from this work are presented below.

TRIAL 1: EXPLORING THE TOLERANCE OF DIFFERENT CROP SPECIES TO SALINE SOIL

The image below is of a replicated mixed species trial comprising the crop types listed in Table 4 above. The trial was sown on a saline soil near Tickera SA in 2022 by Trengove Consulting. The ECe across this site varied from 5.4-37 in the top 10 cm with chloride levels ranging from 520 - 4,800 mg/kg in the surface and subsurface. The critical level for chloride for annual crops is 300 mg/kg. In this year, oats were the highest yielding species at .9 t/ha followed by safflower, barley and field peas. Wheat, triticale, lentils and vetch were the lowest yielding species trialled.

TRIAL 2: EXPLORING THE USE OF AMENDMENTS SUCH AS SAND, STRAW AND GYPSUM ON THE GROWTH AND ESTABLISHMENT OF BARLEY ON SALINE SOILS.

Both sand and straw act like a mulch when spread on the soil surface, reducing evaporation and decreasing the accumulation of salts in the topsoil, this helps to improve crop establishment and growth. Gypsum whilst not acting like a mulch, can improve soil structure by increasing water availability on sodic soils. Depending on the source of gypsum, salt levels in the product can be high and may exacerbate the issue. A trial was conducted in the lower Broughton region in 2022 to explore the effect of these amendments on barley establishment and grain yield on a saline soil (Figure 3).

The topsoil (0-10cm) at this trial site returned an average ECe value of 9.9 indicating a high level of salinity. ECe levels increased to 20 in the 40-60cm zone indicating levels were severe in the subsoil.

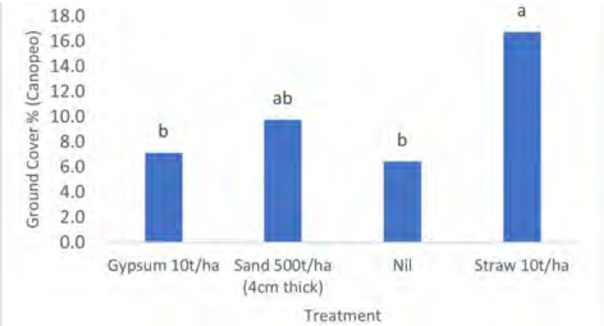

Figure 3. Ground cover (%) at GS30 of barley and impact of sand, straw and gypsum compared to control (no amendment) near Port Pirie in 2022. Means that share letters in common do not significantly differ from one another.

Image: Replicated small plot trial prior to sowing near Port Pirie in April 2022, note straw treatments were applied post sowing.

TRIAL 3: EXPLORING THE USE OF AMENDMENTS SUCH AS SAND AND STRAW ON THE PERFORMANCE OF LENTILS ON A SALINE SOIL AT TICKERA SA

Application of sand and straw improved lentil growth and grain yield in the first year of trial work. Sand rates above 650 t/ha and straw rates above 6.6 t/ha resulted in lentil grain yields of 0.45 t/ha – 0.57 t/ha compared to the control which yielded 0.12 t/ha (Figure 4).

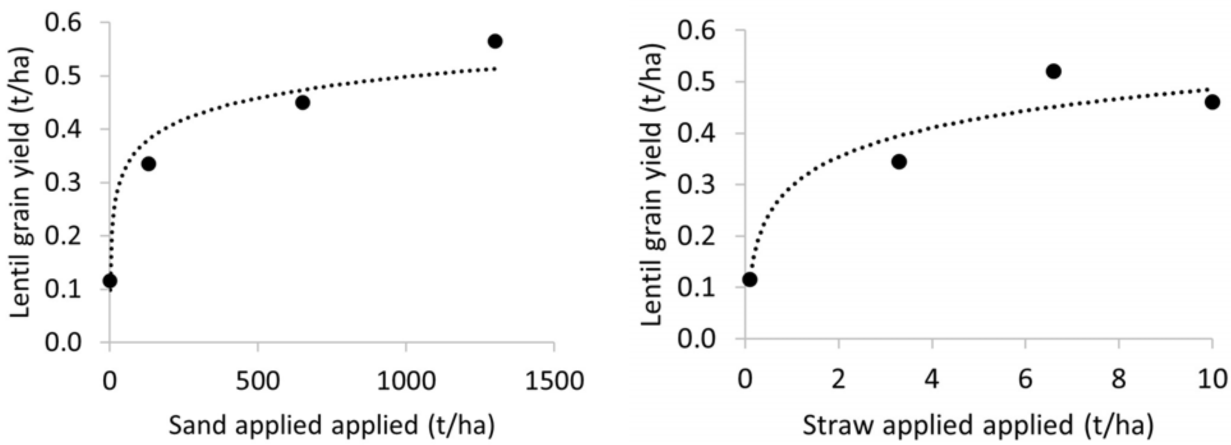

Figure 4. Straw (left) and sand (right) applications (t/ha) impact on the grain yield (t/ha) of lentils sown on a salt scald near Tickera SA, courtesy of Trengove Consulting.

CONCLUSIONS

The logistics of spreading sand on areas of high salinity is difficult unless the source is in close proximity or within the paddock. Spreading straw is more practical as a means to ameliorate saline patches. However, the longevity of response is key if such practices are to achieve positive economic benefits in the long term. Further investigation is needed to determine this, before such a practice should be implemented on a wide scale. With respect to crop selection, one year of trials has suggested that oats, safflower and canola are worth exploring further on saline soils.

ACKNOWLEDGEMENTS

This fact sheet is part of the Building Soil Knowledge and capacity to implement change in the farmers of the Upper North Agricultural zone of South Australia project funded by the National Landcare Program: Smart Farms Small Grants Round 4.

This project received funding from the Australian Governments Future Drought Fund

Stefan Schmitt, Agricultural Consulting and Research completed trial work for Trial 1. Sam Trengove, Trengove Consulting also completed trial work for Trial 2.

Thankyou to the landholders Leighton, Byron and Philip Johns and Michael Barker.

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Report prepared for Upper North Farming Systems group,
Stefan Schmitt, Ag Consulting and Research

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REGENERATING GOYDERS LINE

Re-establishing productive and profitable grasslands and shrublands in the highly degraded, once cropped landscapes of Goyder's Line.

Author: Ruth Sommerville

Funded By: *Australian Government National Landcare Program – Smart Farms Grants (Round 4), Upper North Farming Systems Commercial Paddock, Northern and Yorke Landscape Board and In-Kind.* ***Project Title:*** *Regenerating Goyders Line - Re-establishing productive and profitable grasslands and scrublands in the highly degraded, once cropped landscapes of Goyders Line. (Smart Farms Project Number 4-EEHQ7GO)* | ***Project Duration:*** *2020 - 2023* |
Project Delivery Organisations: *UNFS and Rufous and Co, with delivery partners Anne Brown Consulting, Succession Ecology, Seeding Natives Inc and Greening Australia.*

Key Points

- **Soils** in the vicinity of Goyders Line are highly variable on a temporal and spatial scale. Soil testing at an appropriate scale and within 1 year of implementation may significantly increase the success of grassland and shrubland pasture remediation activities.
- **Vegetation diversity** is key to a resilient landscape in this highly variable climatic zone. Acknowledging that it may take a process of succession to achieve the final desired vegetation community and using robust and readily available plant species such as barley and brassicas to improve soil function including water infiltration, and provide shelter for more perennial species to establish could be key to improving these vegetation communities as both functional ecosystems and productive pastures.
- **Legislation** covers the activities that can be undertaken on paddocks that have not been sown in over 5 years. Understanding the SA Native Vegetation Act is important for any land manager that has remnant or regenerated native vegetation, of any quality or condition, on their property. A template for working within this legislation to improve these once cropped degraded landscapes is available on our website. More information on the legislation and the regulations relating to these activities can be found here: https://www.environment.sa.gov.au/topics/native-vegetation/legislation-administration.
- **Seeding and Soil Management** options are vast. This demonstration showed 5 seeding systems using native and non-native seed. The outcome from the demonstration sites showed that there is no silver bullet. Clear objectives for the outcome for the site and a good understanding of the limitations of the location and the current climate should guide the decisions. Cost varies significantly between the machines and the seed selected, more expensive options often result in faster outcomes, but can limit uptake. Seeding utilising readily available machinery may be a more viable option for many.

Background

The region 50km either side of Goyder's Line has long been known as a low rainfall zone with the opportunity for cropping and pastoral operations to be highly profitable in better rainfall years and marginal in low rainfall periods and as such managed in response to climatic conditions. Significant areas of this region have been cropped historically but due to extended dry and drought conditions have not been cropped within the preceding 5 years, as required under the SA Native Vegetation Act 1991 to be considered continuation of land use. As such, this land is now considered grazing land and not arable under this legislation. To undertake any mechanical removal of plants, or modification to the plant communities now requires either notification of or approval from the Native Vegetation Council, depending on the length of time since the land was last cropped. This action is termed "land clearance" under the legislation, regardless of the purpose of the action. The target areas for this project are those that have become scalded, bare, or low-quality grasslands and shrublands with limited biodiversity or ecological function, and marginal production capacity that are no longer considered arable under the SA Native Vegetation Act 1991 but have been sown in the past 20 years. There are soil types and higher rainfall areas within this region where a return to cropping may be sought, but that is not the focus of this project.

Recurring drought conditions have increased the awareness of the Goyders Line farming community on the value of increased resilience in the landscape through supporting perennial vegetation and maintenance of soil cover. There is a focus on developing production systems that rehabilitate the landscape, rehydrate the soil profile, and facilitate vegetation succession within a production enterprise. Farmers along Goyders Line are looking to improve the resilience of their landscape and ensure the long-term viability of their farming enterprise.

Project Aims

This project had 3 main aims.

1. To demonstrate and evaluate methods of restoring ecological function and productive pastures to once cropped, now degraded landscapes along Goyders Line in the Mid-Upper North of South Australia.
2. To increase the awareness and knowledge of farmers in the region to the limitations and opportunities to improve these soils and vegetation communities within the bounds of the South Australian Native Vegetation Legislation 2017.
3. To work with the SA Native Vegetation Council to enable farmers along Goyders Line to improve their landscape function within the bounds of the SA Native Vegetation Legislation in a practical, productive, and profitable manner.

Methodology

To achieve project aims, three demonstration sites were established and a range of extension activities were run.

Demonstration Site Overview

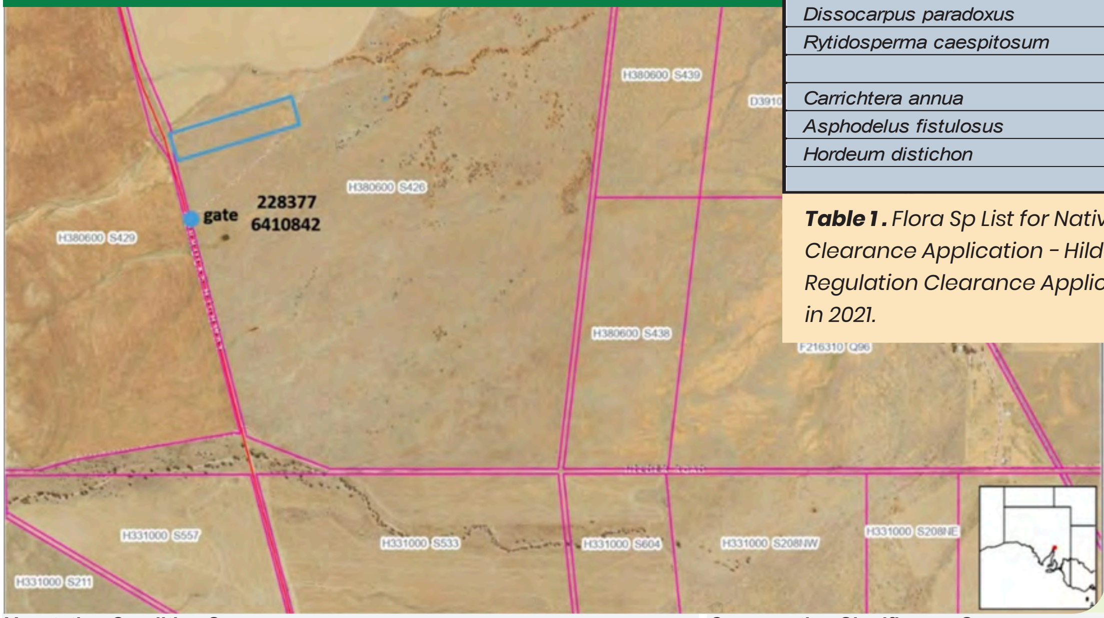
The demonstration sites aimed to utilise a combination of seeding set-ups and seed mixes to improve ecological function in both the soil profile and the vegetation communities, and by doing so improve the production capacity and resilience of the paddocks. The demonstrated treatments combined traditional revegetation seeding techniques with novel native seeding techniques and modern cropping seeding systems and utilised both native and non-native seed. The aim is not to re-create a pristine native ecological community, but to restore ecological functions such as vegetation succession, water infiltration, soil carbon accumulation, and to do so in a resilient and productive manner using cost effective methodology which can improve production capacity, farm profitability and whole of enterprise and ecosystem resilience.

Sown in 2023 after seasonal and approval delays, three demonstration sites were established from a shortlisted five sites. One site at Orroroo was deemed unsuitable for this project due to the higher level of regenerated vegetation on the site. This site was passed to another project and has been revegetated using Greening Australia's Frankenpitter. The second unsuitable site met the project needs but was unable to be left out of grazing rotation for the required 3-5 years to enable soil stabilisation and effective vegetation community succession to occur post treatment. The final selected three sites are located near Quorn, Bruce and Peterborough, SA. Full details for each site are below:

HILDERS – QUORN

Location: Horrocks Highway, between Wilmington and Quorn, 10kms south of Quorn. **Soil Type**: Clay – Clay Loam, neutral to low level alkaline. Evidence of significant wind drift, slumping and scalding present across the site.

Map 1. *Hilders Demonstration Site Paddock Location.*



Plant Species Recorded (Native and Introduced)	
Species	**Common Name**
Atriplex holocarpa	Pop Saltbush
Austrostipa scabra ssp.	Rough Spear-grass
Maireana brevifolia	Short-leaf Bluebush
Calotis sp.	Burr-daisy
Sida intricata	Twiggy Sida
Enneapogon avenaceus	Common Bottle-washers
Salsola australis	Buckbush
Maireana pyramidata	Black Bluebush
Dissocarpus paradoxus	Ball Bindyi
Rytidosperma caespitosum	Common Wallaby-grass
Carrichtera annua	Ward's Weed
Asphodelus fistulosus	Onion Weed
Hordeum distichon	

Table 1 . *Flora Sp List for Native Vegetation Regulation Clearance Application - Hilders. Completed in 2021. Regulation Clearance Application - Hilders. Completed in 2021.*

Vegetation Association/ BCM Community: EP 9.2 Chenopod Open Shrublands, low species diversity due to historic cropping and grazing practices.

Vegetation Condition Scores

SITE:	Hilder trial
BCM COMMUNITY	EP 9.2 Chenopod Open Shrublands
VEGETATION ASSOCIATION DESCRIPTION	Chenopod low shrubland with low species mix due to past cropping
SIZE OF SITE (Ha)	5

Benchmarked attributes
(Scores determined by comparing to a Benchmark community)

Number of Native Species (Minus herbaceous annuals for spring Surveys)	10
Native Plant Species Diversity Score (max 30) from benchmark score *weighted by a factor of 2*	**18.0**
Number of regenerating native species	0
Regeneration Score (max 12) from benchmark community weighted by a factor of 1.5	**0**

Weed species (Top 5 Cover x Invasiveness)	Cover (max 6)	Weed Threat Rating (max 5)	C x I
Carrichtera annua	3	2	6
Asphodelus fistulosus	2	2	4
Hordeum sp.	3	1	3
			0
			0
	Cover x Threat		13
Weed Score (max 15) from benchmark community			**10**

Native Plant Life Forms	**Cover rating**
Trees > 15m	
Trees 5 - 15 m	
Trees < 5m	
Mallee > 5m	
Mallee < 5m	
Shrubs > 2m	
Shrubs 0.5 - 2m	
Shrubs < 0.5	
Forbs	
Mat Plants	
Grasses > 0.2m	
Grasses < 0.2m	
Sedges > 1m	
Sedges < 1m	
Hummock grasses	
Vines, scramblers	
Mistletoe	
Ferns	
Grass-tree	
Total	0
Native Plant Life Forms (max 20) from benchmark score *weighted by a factor of 2*	**0.0**

Conservation Significance Score

Is the vegetation association considered a Threatened Ecological community or Ecosystem?	**Yes/No**
State (Provisional List of Threatened Ecosystems of SA) **Rare** community (0.1 pt)	☐
State (Provisional List of Threatened Ecosystems of SA) **Vulnerable** community (0.2 pts)	☐
State (Provisional List of Threatened Ecosystems of SA) **Endangered** community (0.3 pts)	☐
Nationally (EPBC Act) V**ulnerable** community (0.35 pts)	☐
Nationally (EPBC Act) **Endangered** or **Critically Endangered** community (0.4 pts)	☐
Note; all sites will score a minimum Conservation Significance Score of 1 **Threatened Community Score**	1

Number of Threatened Flora Species recorded for the site (within the site)	**Number**
**If a species has both a State (NP&W Act) and National (EPBC Act) rating, it's only recorded for its National rating.*	
State **Rare** species recorded (1 pt each)	0
State **Vulnerable** species recorded (2.5 pt each)	0
State **Endangered** recorded (5 pts each)	0
Nationally **Vulnerable** species recorded (10 pts each)	0
Nationally **Endangered** or **Critically endangered** species recorded (20 pts each)	0
0 = 0 pts; <2 = 0.04 pts; 2 - <5 = 0.08 pts; 5 - <10 = 0.12 pts; 10 - <20 = 0.16 pts; 20 or > = 0.2 pts	**0**
Threatened Flora Score	0

Potential habitat for Threatened Fauna Species (number observed or previously recorded)	**Number**
**If a species has both a State (NP&W Act) and National (EPBC Act) rating, it's only recorded for its National rating.*	
State **Rare** species observed or locally recorded (1 pt each)	0
State **Vulnerable** species observed or locally recorded (2.5 pt each)	0
State **Endangered** species observed or locally recorded (5 pt each)	0
Nationally **Vulnerable** species observed or locally recorded (10 pts each)	0
Nationally **Endangered** or **Critically endangered** species observed or locally recorded (20 pts each)	0
0 = 0 pts; <2 = 0.02 pts; 2 - <5 = 0.04 pts; 5 - <10 = 0.06 pts; 10 - <20 = 0.08pts; 20 or > = 0.1 pts	**0**
Threatened Fauna Score	0
CONSERVATION SIGNIFICANCE SCORE	**1**

Non-Benchmarked Attributes
(Scores determined from direct field observations)

Native:exotic Understorey biomass Score (max 5)	
Is the community naturally treeless?	☐
Tree attributes not scored for treeless communities or communities with only emergent trees	

Total Scores for the Site

	Score
LANDSCAPE CONTEXT SCORE	**1.14**
VEGETATION CONDITION SCORE	**7.26**
CONSERVATION SIGNIFICANCE SCORE	**1.00**

Vegetation Condition x Landscape Context x Conservation Significance =	
UNIT BIODIVERSITY SCORE	8.27
Total Biodiversity Score (Biodiversity Score x hectares)	41.36

Vegetation Condition Score calculation

Positive Vegetation Attributes Score = Native species diversity + Regeneration + Native Plant Life Forms Fallen timber/debris + Hollow-bearing trees *- If the community Score is Not Benchmarked (SNB) for regeneration this score is multiplied 1.24* *- If the community is naturally treeless this score is multiplied by 1.29*	23.22
Negative Vegetation Attributes Score = (15 - Weeds) + ((10 - (Biomass score x 2))exp2/2)	55.00
VEGETATION CONDITION SCORE (Positive veg attributes x ((80 - Negative vegetation attributes) / 80))	**7.26**

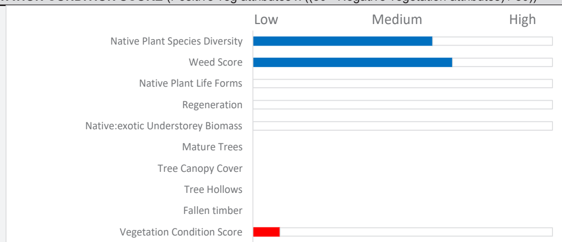


Photo Point and Vegetation Survey Location	**Direction of the Photo**
	GPS Reference
	Datum
	Zone (52, 53 or 54)
	Easting (6 digits)
	Northing (7 digits)
	Description

What is the purpose of Assessment? Clearance SEB Area Other

Assessment for Clearance

Loss Factor	1.0
Loadings for clearance of protected areas	
Reductions for rehabilitation of impact site	0.5
SEB Points required	**21.71**

Approximate hectares required	2.71
Economies of Scale Factor	0.5
Mean Annual rainfall for the site (mm)	302
Payment into the fund (GST Exclusive)	**$8,649.64**
Administration fee (GST Inclusive)	**$475.73**

Table 2 . *Site Condition Score for Native Vegetation Regulation Clearance Application - Hilders. Completed in 2021.*

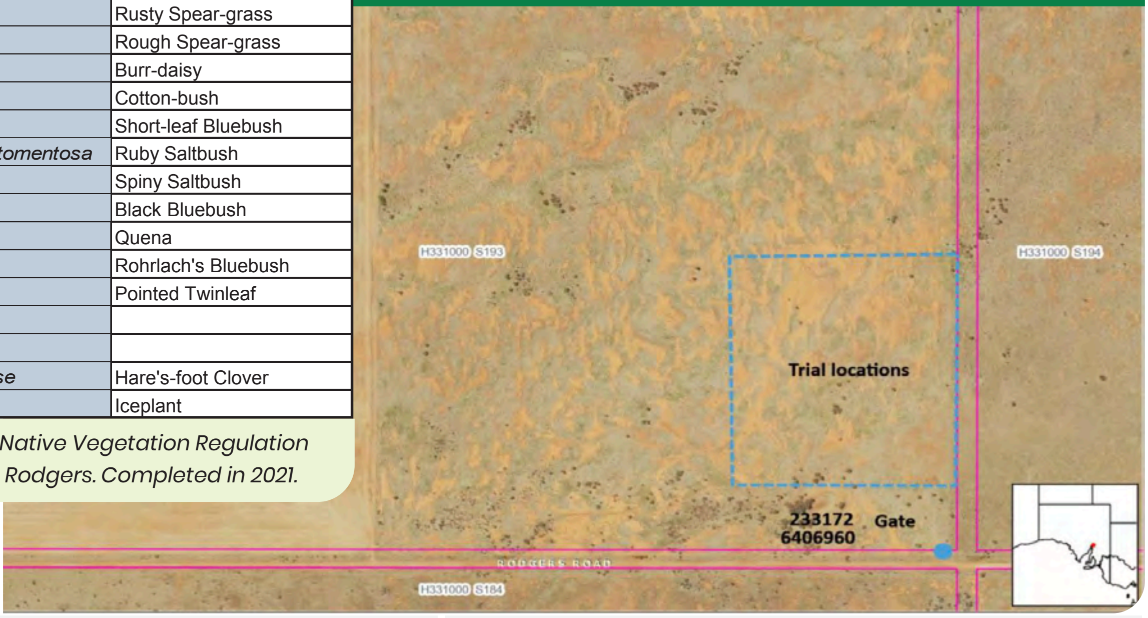
RODGERS – BRUCE

Located: Rodgers Road, near Bruce, 25kms north of Wilmington. **Soil Type**: Loam – Sandy Loam, neutral to low level alkaline. Evidence of significant wind drift, slumping and scalding present across the site.

Plant Species Recorded (Native and Introduced)	
Species	**Common Name**
Sclerolaena patenticuspis	Spear-fruit Bindyi
Goodenia pusilliflora	Small-flower Goodenia
Minuria leptophylla	Minnie Daisy
Acacia victoriae ssp.	Elegant Wattle
Sida intricata	Twiggy Sida
Rytidosperma caespitosum	Common Wallaby-grass
Rhodanthe pygmaea	Pigmy Daisy
Convolvulus angustissimus	Narrow-leaf Bindweed
Austrostipa eremophila	Rusty Spear-grass
Austrostipa scabra ssp.	Rough Spear-grass
Calotis sp.	Burr-daisy
Maireana aphylla	Cotton-bush
Maireana brevifolia	Short-leaf Bluebush
Enchylaena tomentosa var. tomentosa	Ruby Saltbush
Rhagodia spinescens	Spiny Saltbush
Maireana pyramidata	Black Bluebush
Solanum esuriale	Quena
Maireana rohrlachii	Rohrlach's Bluebush
Roepera apiculata	Pointed Twinleaf
Hordeum distichon	
Trifolium arvense var. arvense	Hare's-foot Clover
Mesembryanthemum sp.	Iceplant

Table 3 . *Flora Sp List for Native Vegetation Regulation Clearance Application - Rodgers. Completed in 2021.*

Map 2. *Rodgers Demonstration Site Paddock Location.*



Vegetation Condition Scores

SITE:	Rogers trial
BCM COMMUNITY	EP 9.2 Chenopod Open Shrublands
VEGETATION ASSOCIATION DESCRIPTION	Area recovering Maireana shrubland with emergent Acacia victoriae
SIZE OF SITE (Ha)	5

Benchmarked attributes
(Scores determined by comparing to a Benchmark community)

Number of Native Species (Minus herbaceous annuals for spring Surveys)	17
Native Plant Species Diversity Score (max 30) from benchmark score *weighted by a factor of 2*	28.0
Number of regenerating native species	0
Regeneration Score (max 12) from benchmark community weighted by a factor of 1.5	**0**

Weed species (Top 5 Cover x Invasiveness)	Cover (max 6)	Weed Threat Rating (max 5)	C x I
Hordeum sp.	2	1	2
Trifolium spp.	1	2	2
Mesembryanthemum crystallinum	1	2	2
Carrichtera annua	1	2	2
			0
	Cover x Threat		8
Weed Score (max 15) from benchmark community			**13**

Native Plant Life Forms	**Cover rating**
Trees > 15m	
Trees 5 - 15 m	
Trees < 5m	
Mallee > 5m	
Mallee < 5m	
Shrubs > 2m	1
Shrubs 0.5 - 2m	1
Shrubs < 0.5	2
Forbs	2
Mat Plants	1
Grasses > 0.2m	
Grasses < 0.2m	
Sedges > 1m	
Sedges < 1m	
Hummock grasses	
Vines, scramblers	1
Mistletoe	
Ferns	
Grass-tree	
Total	8

Native Plant Life Forms (max 20) from benchmark score *weighted by a factor of 2*: **12.0**

Conservation Significance Score

Is the vegetation association considered a Threatened Ecological community or Ecosystem?	**Yes/No**
State (Provisional List of Threatened Ecosystems of SA) **Rare** community (0.1 pt)	☐
State (Provisional List of Threatened Ecosystems of SA) **Vulnerable** community (0.2 pts)	☐
State (Provisional List of Threatened Ecosystems of SA) **Endangered** community (0.3 pts)	☐
Nationally (EPBC Act) V**ulnerable** community (0.35 pts)	☐
Nationally (EPBC Act) **Endangered** or **Critically Endangered** community (0.4 pts)	☐
Note; all sites will score a minimum Conservation Significance Score of 1 **Threatened Community Score**	1

Number of Threatened Flora Species recorded for the site (within the site)	**Number**
**If a species has both a State (NP&W Act) and National (EPBC Act) rating, it's only recorded for its National rating.*	
State **Rare** species recorded (1 pt each)	1
State **Vulnerable** species recorded (2.5 pt each)	0
State **Endangered** recorded (5 pts each)	0
Nationally **Vulnerable** species recorded (10 pts each)	0
Nationally **Endangered** or **Critically endangered** species recorded (20 pts each)	0
0 = 0 pts; <2 = 0.04 pts; 2 - <5 = 0.08 pts; 5 - <10 = 0.12 pts; 10 - <20 = 0.16 pts; 20 or > = 0.2 pts	**1**
Threatened Flora Score	0.04

Potential habitat for Threatened Fauna Species (number observed or previously recorded)	**Number**
**If a species has both a State (NP&W Act) and National (EPBC Act) rating, it's only recorded for its National rating.*	
State **Rare** species observed or locally recorded (1 pt each)	0
State **Vulnerable** species observed or locally recorded (2.5 pt each)	0
State **Endangered** species observed or locally recorded (5 pt each)	0
Nationally **Vulnerable** species observed or locally recorded (10 pts each)	0
Nationally **Endangered** or **Critically endangered** species observed or locally recorded (20 pts each)	0
0 = 0 pts; <2 = 0.02 pts; 2 - <5 = 0.04 pts; 5 - <10 = 0.06 pts; 10 - <20 = 0.08pts; 20 or > = 0.1 pts	**0**
Threatened Fauna Score	0
CONSERVATION SIGNIFICANCE SCORE	**1.04**

Non-Benchmarked Attributes
(Scores determined from direct field observations)

Native:exotic Understorey biomass Score (max 5)	3
Is the community naturally treeless?	☐
Tree attributes not scored for treeless communities or communities with only emergent trees	

Total Scores for the Site

	Score
LANDSCAPE CONTEXT SCORE	**1.14**
VEGETATION CONDITION SCORE	**45.15**
CONSERVATION SIGNIFICANCE SCORE	**1.04**

Vegetation Condition x Landscape Context x Conservation Significance =	
UNIT BIODIVERSITY SCORE	53.53
Total Biodiversity Score (Biodiversity Score x hectares)	267.65

Vegetation Condition Score calculation

Positive Vegetation Attributes Score = Native species diversity + Regeneration + Native Plant Life Forms Fallen timber/debris + Hollow-bearing trees *- If the community Score is Not Benchmarked (SNB) for regeneration this score is multiplied 1.24* *- If the community is naturally treeless this score is multiplied by 1.29*	51.60
Negative Vegetation Attributes Score = (15 - Weeds) + ((10 - (Biomass score x 2))exp2/2)	10.00
VEGETATION CONDITION SCORE (Positive veg attributes x ((80 - Negative vegetation attributes) / 80))	**45.15**

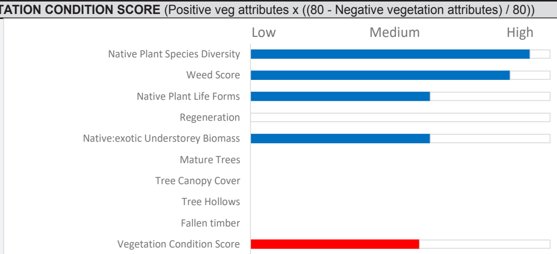


Photo Point and Vegetation Survey Location	**Direction of the Photo**
	GPS Reference
	Datum
	Zone (52, 53 or 54)
	Easting (6 digits)
	Northing (7 digits)
	Description

What is the purpose of Assessment? Clearance SEB Area Other

Assessment for Clearance

Loss Factor	1.0
Loadings for clearance of protected areas	
Reductions for rehabilitation of impact site	0.5
SEB Points required	**140.52**

Approximate hectares required	17.56
Economies of Scale Factor	0.35
Mean Annual rainfall for the site (mm)	302
Payment into the fund (GST Exclusive)	**$39,180.96**
Administration fee (GST Inclusive)	**$2,154.95**

Table 4 . *Site Condition Score for Native Vegetation Regulation Clearance Application – Rodgers. Completed in 2021.*

LUDGATES – PETERBOROUGH - GUMBOWIE

Located: Cleary Road, 10kms South of Peterborough.

Soil Type: Loam – Sandy Loam, acidic. Well maintained and managed grassland paddock with low productivity. Improved pasture in the past 5 years, continuous management therefore not requiring Native Vegetation Clearance approval.

Map 3. *Ludgate Demonstration Site Paddock Location.*

Site Establishment Process

To meet the project requirements the sites needed to meet a number of criteria; including having been cropped historically but not cropped in the past 5 years, used for grazing in the past 10 years and be of a low species diversity, degraded ecological function and low productivity.

The sites were assessed by native vegetation consultant Anne Brown and in consultation with the Native Vegetation Council (NVC), a management plan developed under the Native Vegetation Regulations 2017. The two northern sites required management plans, whilst the southern did not as it had been sown to improve the pasture in the past 5 years.

The project started in July 2020, however the seeding planned for May 2021 was delayed until June 2022 due to seasonal conditions and delays in the NVC Management Plan approval process.

Soil Testing

Conducted prior to seeding in 2022 with repeat testing in January 2024, approximately 18 months post treatments were implemented. The following tests were conducted at 0-10cm:

Colwell P	pH CaCl
Colwell K	EC
N	Water Infiltration
Organic Carbon	

Figure 1 . *Rogers Site initial vegetation assessment with Anne Brown and Paul and Ian Rogers.*

Treatments

13 treatments were developed with assistance from the project advisory committee to demonstrate and evaluate a combination of commercially used rehabilitation and ecological restoration methods and readily available farm machinery and a mix of native and agricultural seed. The sites aimed to compare the effectiveness, cost benefits and limitations of each treatment as seed reintroduction and soil property amending treatments. Treatment 5 was removed from the trial after seeding due to a lack of summer rainfall the following season preventing post-em seed distribution to occur.

Table 5: Treatments Sown Autumn Winter 2022		**Seeder**	**Seed**
1	Unsown		
2	Sown: Every row	Tyne	no seed
3	Sown: seed skip rows	Tyne	cereal
4	Sown: seed 2 rows, 2 skipped rows	Tyne	cereal
6	Sown – Every row	Tyne	cereal
7	Sown –– Every row	Tyne	cereal + legume
8	Sown – Every row	Tyne	mixed species
9	Sown: Every row	Disc	no seed
10	Sown: Every row	Disc	mixed species
11	Work & Spread	Succession Ecology	Native Seed
12	Worked, seed and drum roll	Seeding Natives Inc	Native Seed
13	Deep rip and roll strips: Frankenpitter	Greening Australia	Native Seed

Seeding System Descriptions

5 seeding systems were demonstrated, each with different soil impact and method of seed distribution.

1. **Tyned Seeder** – Agrow Drill at 2.5m width, 10 inch spacings. Creating soil disturbance and small furrows for water retention and wind protection.

Figure 2 . *Rogers Family and Broom Hilder after seeding the Rogers Site.*

Figure 3 . *Ian and Paul Rogers seeding the Ludgate Site.*

2. **Disc Seeder** – John Sheerer disc with 20 inch spacings. Minimal soil disturbance and shallow seed placement.
3. **Work and Spread System** – Tillage using a pass with harrows or a tyned machine, then spread using either a commercial fertiliser spreader or manually spread depending on the scale of the project. Full, shallow soil disturbance with uneven soil bed and surface seed placement.
4. **Work, seed, drum roll System** - Seeding Natives Incorporated's primary direct seeding machines are our innovative and in-house developed "Blue Devil Multi Mix Seeder". The ground operation is a First Products Aera-Vator that utilises offset barrel tynes that break up the soil without turning it over, then drops a curtain of seed over the disturbed ground and finally rolls it flat, all in one pass, ensuring exceptional seed-to-soil contact. Full shallow soil disturbance creating a fine seed bed.

5. **Deep Rip and Roll Strips: FrankenPitter** – a modified, ute towed machine that creates both a continuous furrow and along side this a series of pits, 5-10cm in depth and approximately 25cm long.

Seed Species Selections

Seed Description	Species Used	Objective
no seed	nil	
cereal	Rodgers – Kracken Barley Ludgate – Brusher Oats Hilders – Winteroo Oats	Biomass production and soil activation
cereal + legume	Rodgers – Barley + Morava Vetch Ludgate – Brusher Oats + Studenica Vetch Hilders – Winteroo Oats + Lupin/Bean/Vetch Mix	Biomass plus nitrogen production
mixed species	Rodgers – Barley + Morava Vetch + Garnet Canola, Sub zero forage Brassica + Smart Radish Ludgate – Brusher Oats + Studenica Vetch + Garnet Canola, Sub zero forage Brassica + Smart Radish Hilders – Winteroo Oats + Lupin/Bean/Vetch Mix + Garnet Canola, Sub zero forage Brassica + Smart Radish	Biomass plus nitrogen production plus tap root soil penetration
Native seed mix	See Below	Landscape restoration and increase in diversity to improve resilience

Native Seed Mix Composition

Species:	Total Weight (grams)	Species:	Total Weight (grams)
Rytidospermum caespitosum	3000	Atriplex holocarpa	5350
Rytidosperma setaceum	2000	Atriplex lindleyi	5350
Rhagodia spinescens	500	Atriplex semibaccata	350
Einadia nutans	500	Atriplex suberecta	5000
Enneapogon avenceus	500	Atriplex stipitata	2350
Enneapogon nigricans	4000	Atriplex vesicaria	5350
Austrostipa elegantissima	1000	Atriplex paludosa	200
Austrostipa nodosa	1000	Austrostipa blackii	250
Austrostipa scabra	1000	Austrostipa eremophila	250
Austrostipa sp	2000	Austrostipa nitida	250
Enteropogon acicularis	1000	Enneapogon avenaceus	250
Enchylaena tomentosa	2000	Maireana brevifolia	1250
Chloris truncata	2500	Maireana erioclada	250
Dichanthium sericeum	500	Maireana pentatropis	250
Anthosachne scabra	500	Maireana pyramidata	2250
Digitaria brownii	500	Rytidosperma racemosum	250
Enchylaena tomentosa	500	Setaria jubiflora	250
Rytidospermum auriculatum	500	Vittadinia sp.	250
Rytidosperma sp	2000	Themeda triandra	500
Aristida behriana	400	Zygophyllum aurantiacum	100
Einadia nutans	250		

Extension Events

A series of pre-seeding field days were held at the demonstration sites in 2021. Presentations from soil researchers, seeder experts, regeneration and vegetation specialists educated and engaged land managers and industry in the complexity of restoring degraded landscapes in the highly variable climate along Goyder's Line.

In June 2023 a bus toured from Burra to Bird Lake at Port Augusta, visiting 2 of the demonstration sites and 2 additional sites which were sown 1 year and 3 years prior to show progress of these grassland/shrublands after regeneration activities have been implemented.

These sites included Ulooloo at Hallett, Gumbowie (Ludgate's) at Peterborough, Rodgers property near Willmington and at the reclaimed Port Augusta Power Station Site. It was inspiring to see the progress of the sites, and to collect a group of passionate land managers and project specialists together to learn from each other on how we can we can implement future projects with the similar aim of restoring landscape function.

Figure 4 . *Iron Grass at Ulooloo*

Figure 6 . *The Rodgers Site with comparison of the tyned vs no-treatment plots.*

Native Vegetation Legislation Landholder Engagement

The Native Vegetation Legislation in SA is designed to protect remnant vegetation communities across the state. Changes to this legislation in the past 15 years has resulted in many farmers unaware of their requirements and disenfranchised with the process. This project aimed to address this through;

1. Awareness raising of the legislation.
2. Demonstration of the process.
3. Development of a template for farmers to use to make the process simpler (Appendix B and available on our website)
4. Working with the Native Vegetation Council of SA to increase awareness of the region and the objectives of work like this to improve the timeliness and outcomes of future applications by land holders seeking to improve their landscape resilience whilst retaining their production capacity.

Figure 5 . *Port Augusta Power Station Restored Chenopod Shrubland*

RESULTS AND DISCUSSION

Plant Diversity:

Due to the high soil variability at each site and between sites, and the variability in the existing vegetation it is extremely difficult to interpret the results from the plots. All sites were demonstrations, not replicated and therefore unable to be analysed statistically. Plant counts were conducted using 1m quadrats and an overall plot presence/absence. There are some trends that were observed.

1. Oats and Wild Oats are highly competitive.
   At Hilders Paddock, the sown oats proved to be highly competitive and out-competed the native grasses. At this site we didn't do the skipped rows due to space at the site, it would have been good to see if this would have enabled to native grasses to remain. At Ludgates Paddock the wild oats, at high numbers in the unsown, and through-out all treatments, resulted in very high soil cover and high levels of competition for the other sown species and natives. The sown oats were also highly competitive, where they had not been decimated by the guinea fowl. Barley at Rodgers did not over-compete to the same extent and provided good shelter for germinating native seedlings.
2. Legumes were in-effective in this project
   At all three sites lugumes were included in selected treatments, Stedenica vetch at Ludgates, lupin mix (incl. faba beans) at Hilders and Timoc vetch at Rodgers. At each site it was possible to find individuals of the sown legume species, however the rates of germination and the vigor of the individual plants were un-competitive and unlikely to result in significant soil N production or palatable biomass.

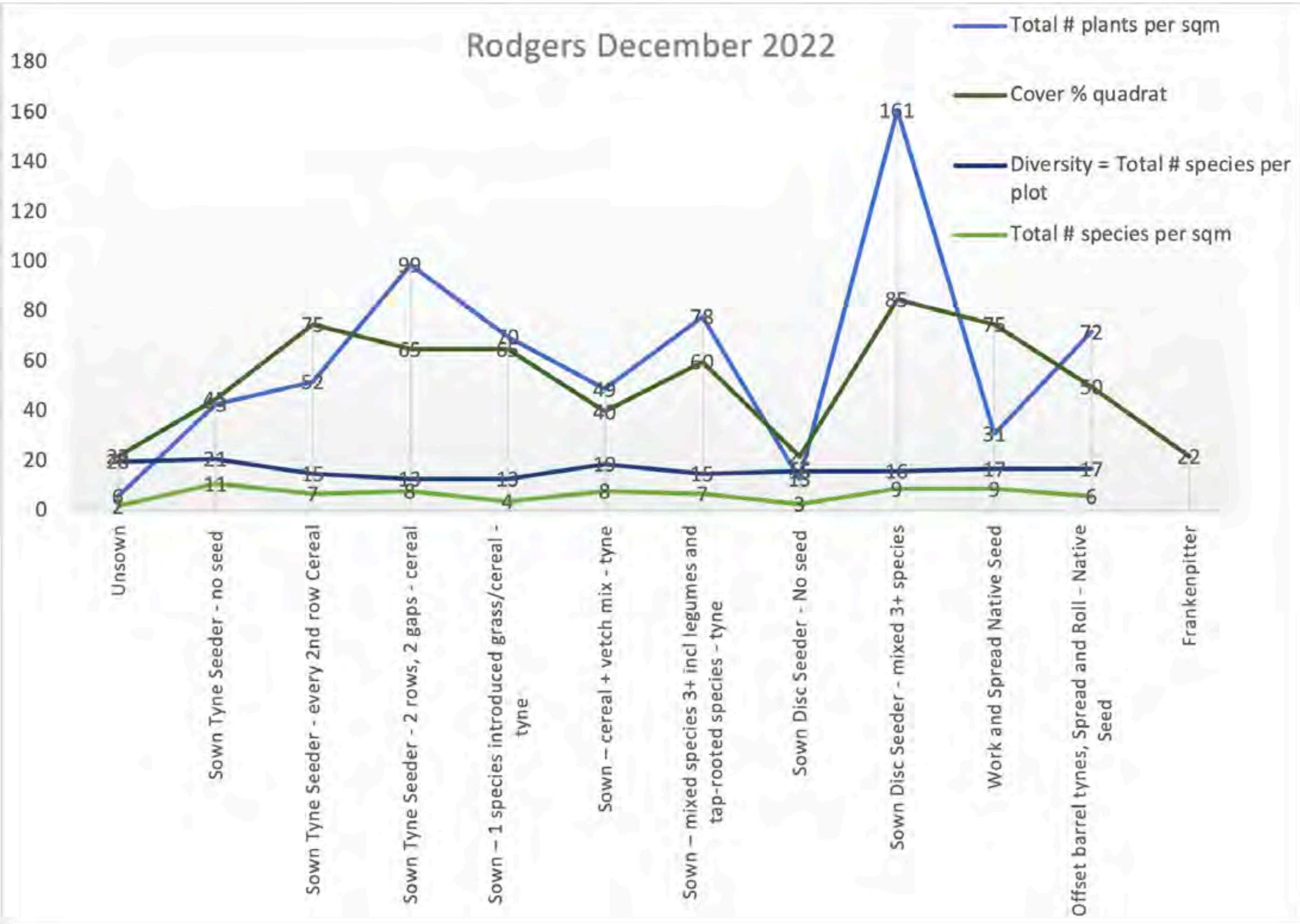


Figure 1 . *Rogers Site, Plant Diversity in December 2022*

3. The Frankenpitter is not suited to this approach of improving pasture function and production. A unique seeding system designed for re-introducing diversity and increasing cover to areas with established vegetation, it was ineffective in the really hostile soils as it removed the small layer of topsoil. It did however in the less hostile soils create effective catch-holes for seed and moisture and with time may have a significant outcome for these sites. Due to the low footprint in comparison to the other treatments it was not assessed in the same way as the other treatments.
4. An uneven soil surface/soil disturbance improved establishment across most sites. These soils have become crusted, resulting in poor water infiltration rates, high wind shear and no shelter for germinating seeds. The furrow impact of the tynes improved infiltration and appeared to improve seed germination / survival rates. The rough surface of the work and spread method also assisted with germination. The disc seeder did not leave noticeable furrows and had lower levels of germination at Rodgers, the more hostile soil. At Hilders the disc seeder did out perform the tyne seeder, showing that more work to understand this is required.
5. Too much disturbance and lack of early competition can result in significant weed establishment using the no-kill cropping approach. Wards Weed, Ice Plant and Wild Oats all dominated in plots with high levels of disturbance, and lower levels of early competition.

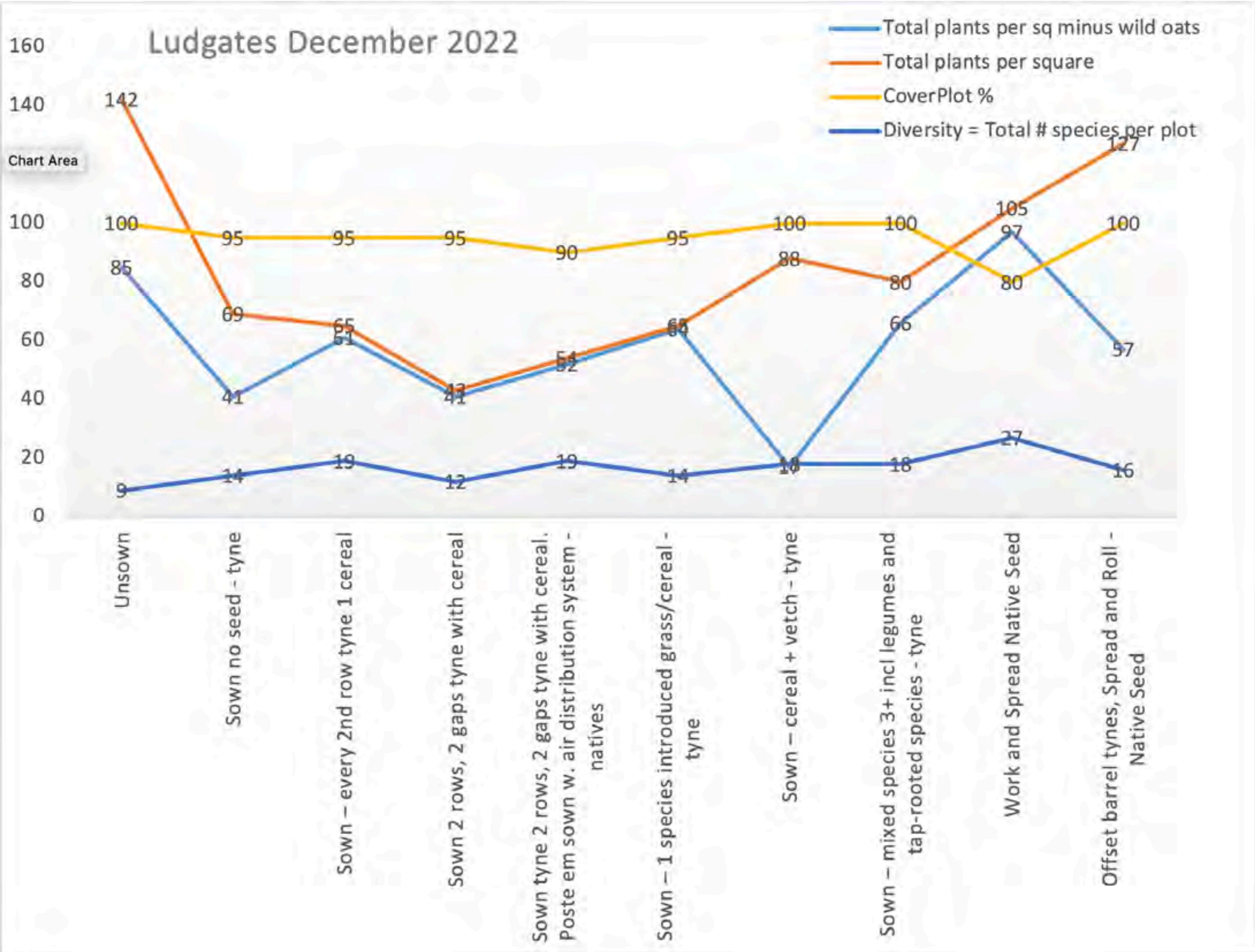


***Figure 2 .** Ludgate Site, Plant Diversity in December 2022*

6. Different methods and species combinations have different outcomes in different soil types and with different background seed stock. The same treatment did not have the same effect twice across the sites, this is likely due to the high level of variability at the sites in soil conditions, background seedbank and pest and weed pressure. It highlights the need to understand the site when selecting treatment methods. It also highlights that more work needs to be done in this space to identify which treatments may suit which soil types best.
7. The non-native seed worked well at early establishment and providing biomass production and shelter to the native seedlings at the site. The sown native seed germinated differently with the different methodologies. The work and spread method worked well for the larger broadleaf species, whilst the offset barrel tynes, spread and roll method worked well for native grasses. This resulted in differences in their assessments (cover % higher in the first method but # plants and species higher in the second).

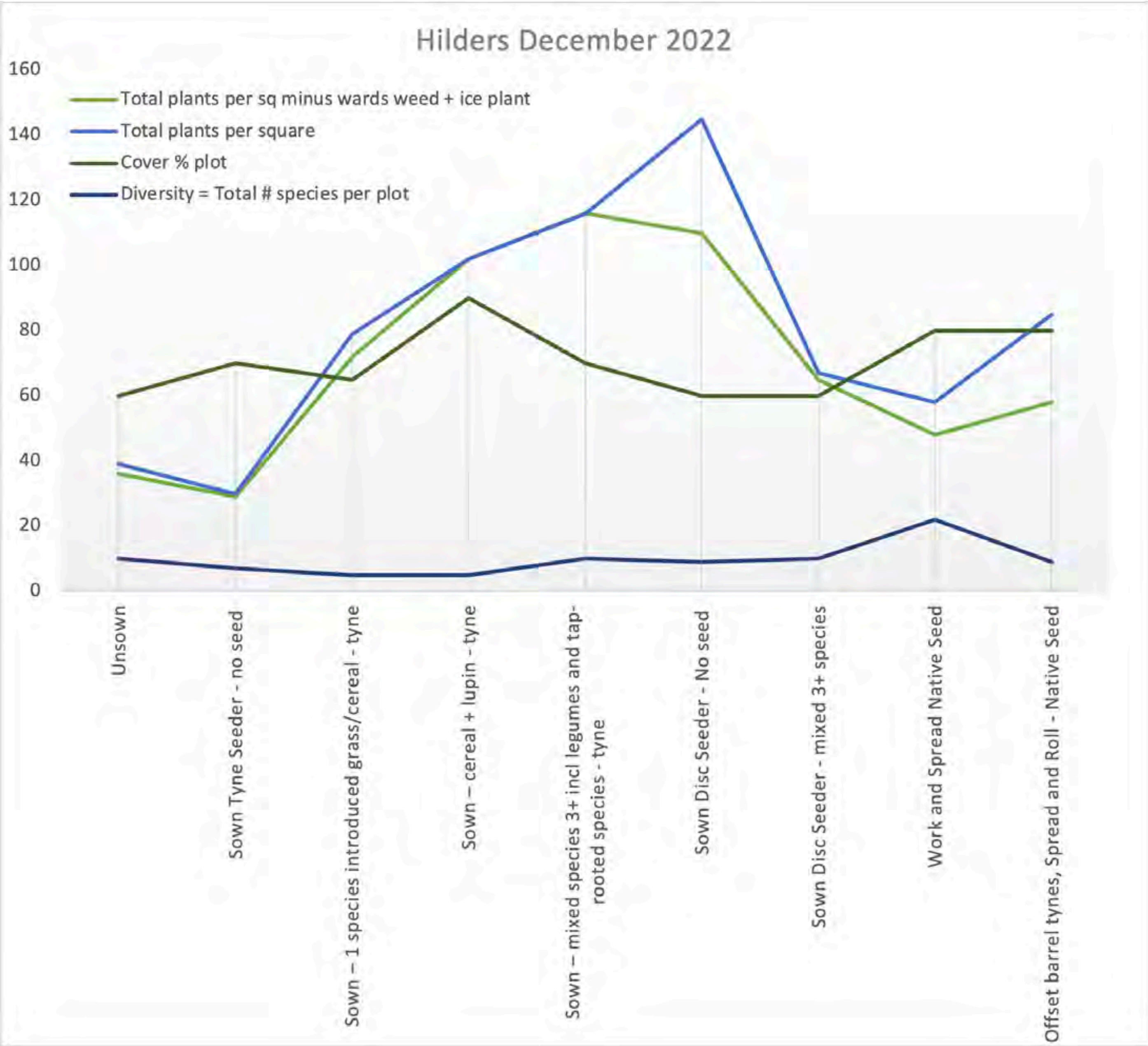


Figure 3 . *Hilders Site, Plant Diversity in December 2022*

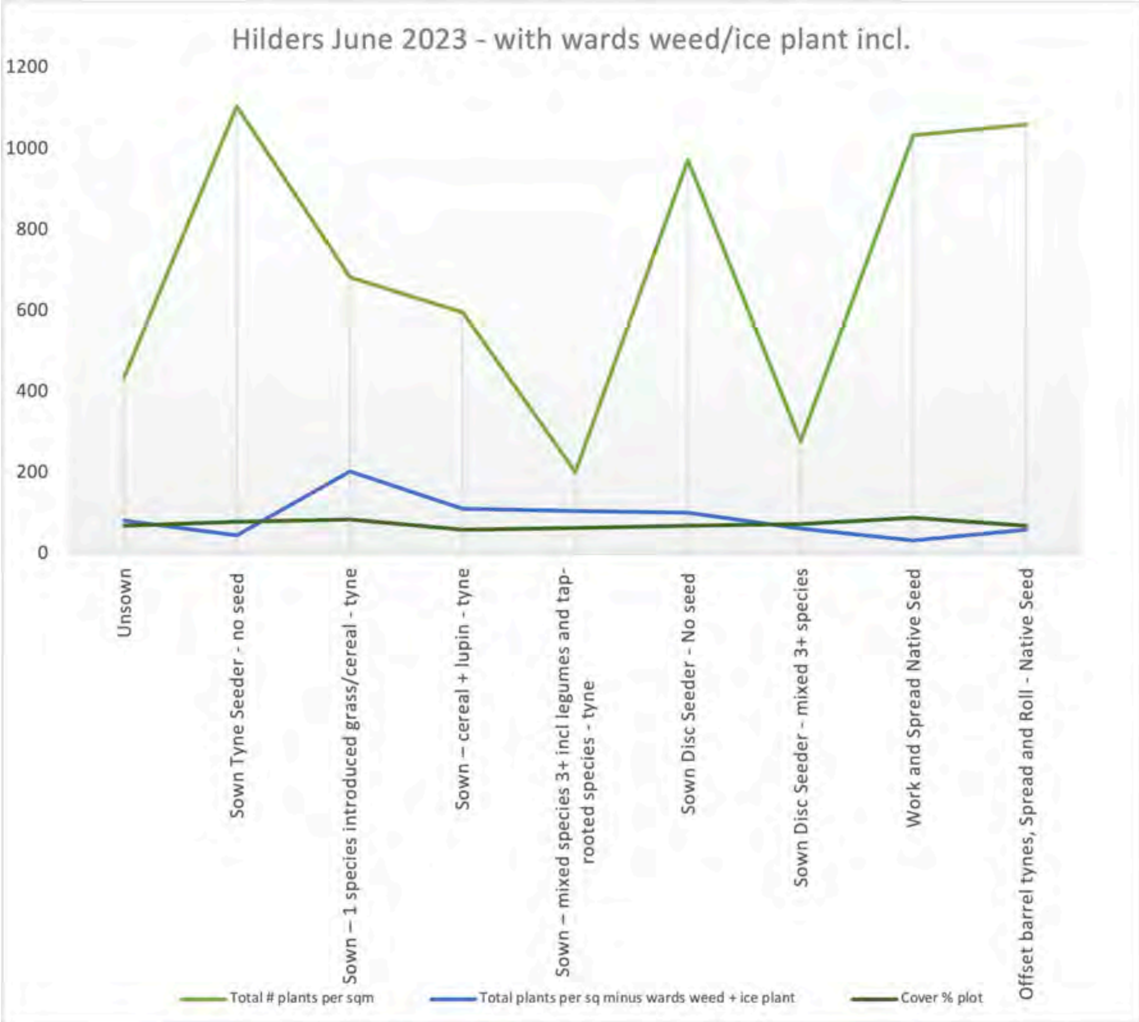
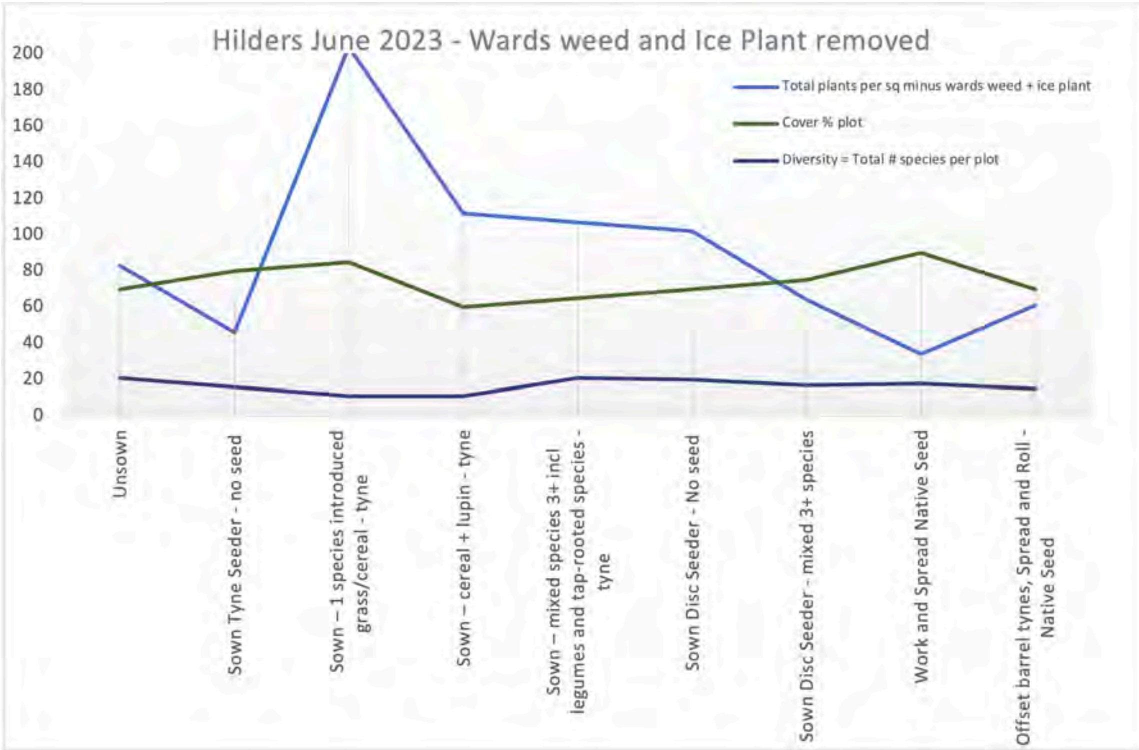


Figure 4 & 5 . *Hilders Site, Impact of Weeds & Disturbance on Plant Diversity in June 2023*



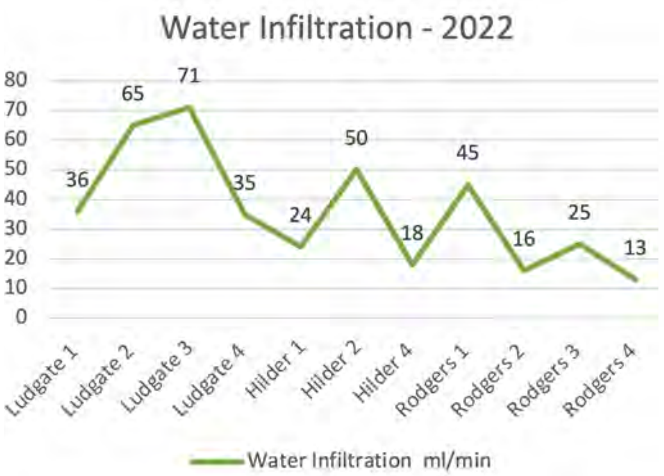
Soil Function:

In 2022, soil tests were taken across each demonstration site, aiming to provide a good representation of the soil types in the treatment areas. In 2024 the tests were repeated, and in addition to re-sampling the original sites the following 7 treatments were tested: 1. Untreated, 3. Tyne Seeder – cereal skipped row, 6. Tyne seeder - cereal every row, 8. Tyne seeder – mixed species, 11. Work and spread and 12. offset barrel tynes, spread and roll method. As shown in the figures below, the sites were highly variable both between the sites and within the sites, making clear statements unable to be generated. Unfortunately, the replication of the original soil testing sites was not successfully taken and as such limited data without a clear statement of environmentally generated change is presented below. What is presented below is a collection of observations made by the project team.

Note: The data has not been collated onto one graph for the 2 sampling events as the sampling locations do not corelate.

Water infiltration varied across the sites, from 13ml/min at Rodgers 4 through to 71ml/min at Ludgate 3 in 2022. But by 2024 at all sites the water infiltration rates had increased in all the active treatments by a

greater amount than that increase seen in the unsown treatment. The exception to this was Ludgate Treatment 6, oats sown with tyne, which was closest to the Ludgate 3 sample site of 2022, however treatment 6 was closer to the fence and high traffic area of the paddock and likely to have had a higher soil tension prior to the treatment being implemented. Even with this anomaly, the increase in water infiltration rates across the treatments is of significant interest for improving production capacity and ecological function in these low rainfall zones.



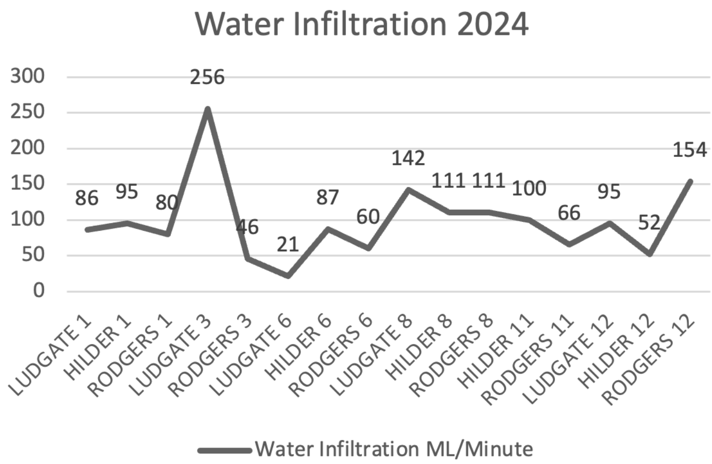
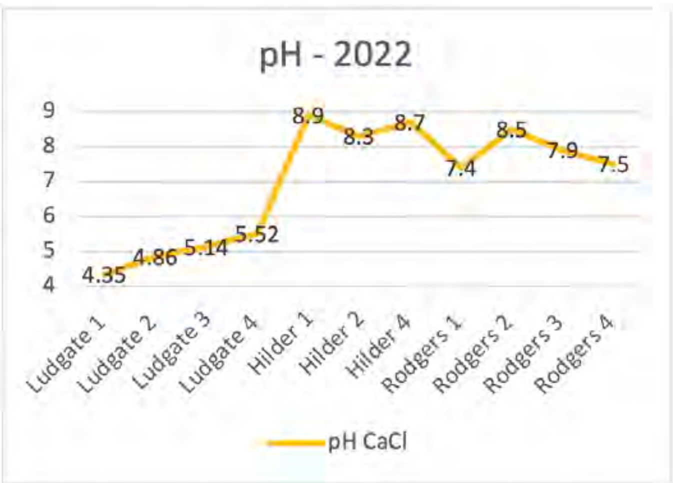


Figure 6 & 7 . *Water Infiltration rates (ml/min) in 2022 at 4 representative sites across the demonstration paddocks and in 2024 at 16 selected treatments at the 3 demonstration sites.*

pH and Nitrate Levels both declined across the sites in the treatment period. pH in 2022 was acid at Ludgate's, but neutral to low level alkalinity at Rodgers and Hilders, this remained the case in 2024. There are many theories as to this change, including leaching due to the high rainfall events that did occur in the treatment window, but no clear statement can be ascertained. The low remaining levels of N suggest a successful legume or added N would be required to ensure biomass production into the future.



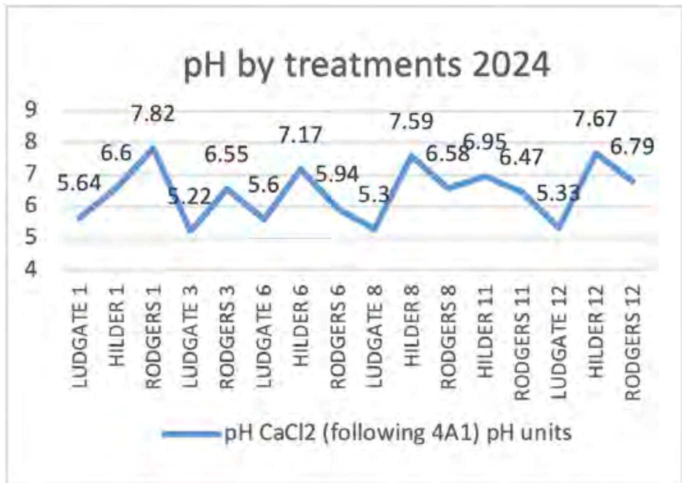
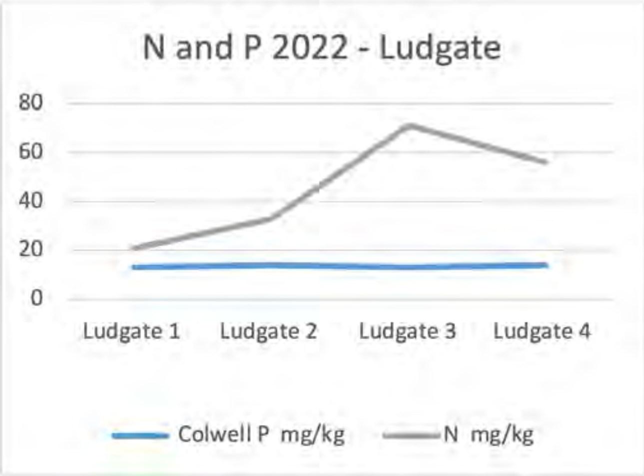


Figure 8 & 9 . *pH CaCl in 2022 at 4 representative sites across the demonstration paddocks and in 2024 at 16 selected treatments at the 3 demonstration sites.*



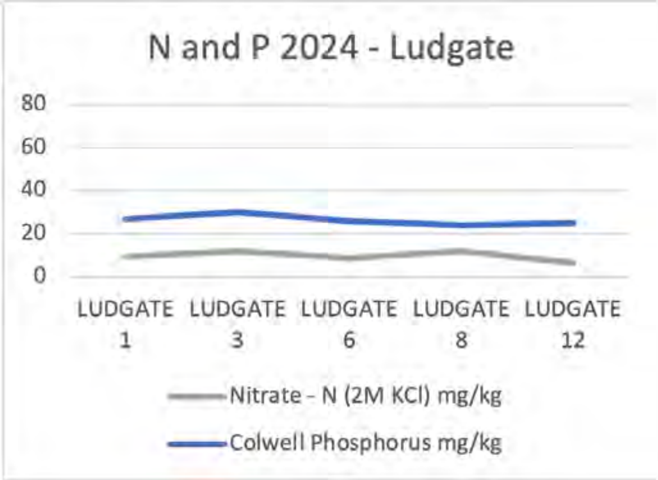
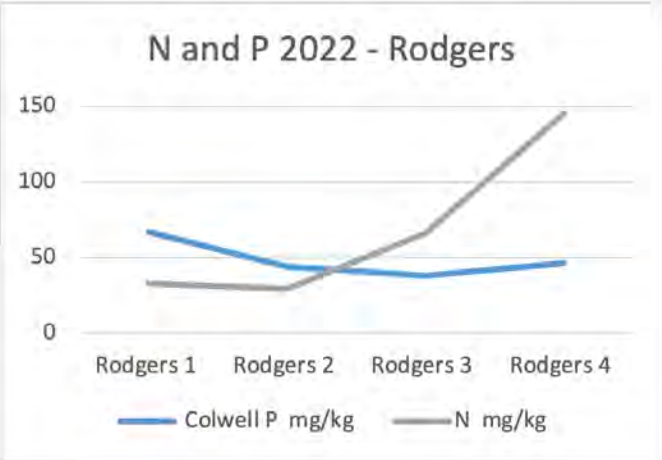


Figure 10 & 11 . *Nitrogen (Nitrate) mg/kg in 2022 at 4 representative sites and in 2024 at 5 selected treatments at the Ludgates Demonstration Site near Peterborough, SA.*



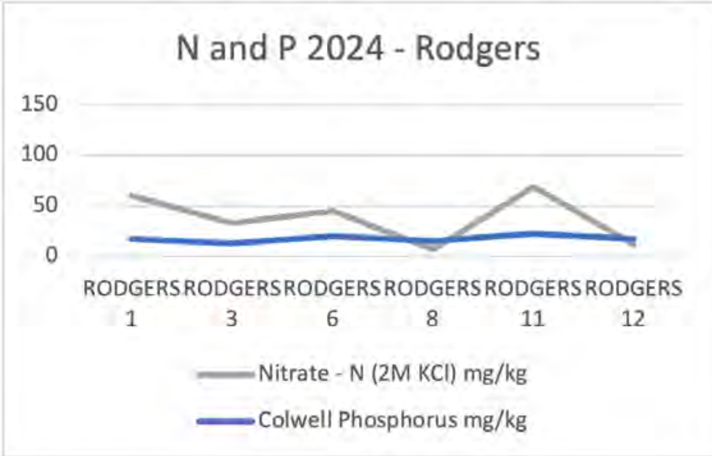
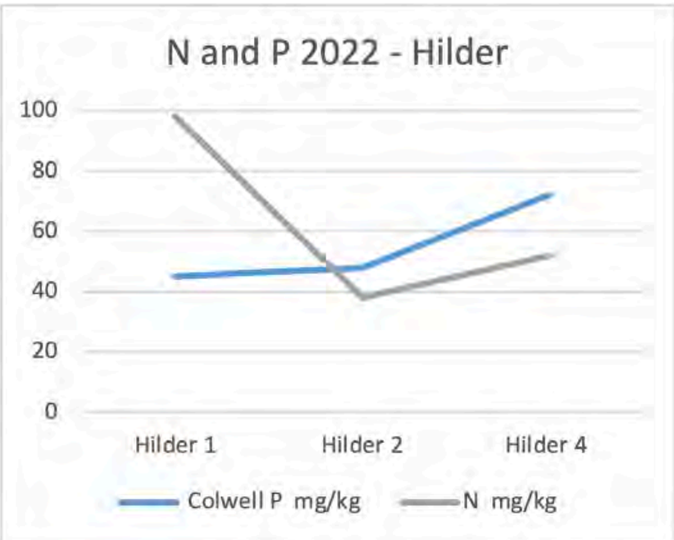


Figure 12 & 13 . *Nitrogen (Nitrate) mg/kg in 2022 at 4 representative sites and in 2024 at 6 selected treatments at the Rodgers Demonstration Site near Bruce, SA.*



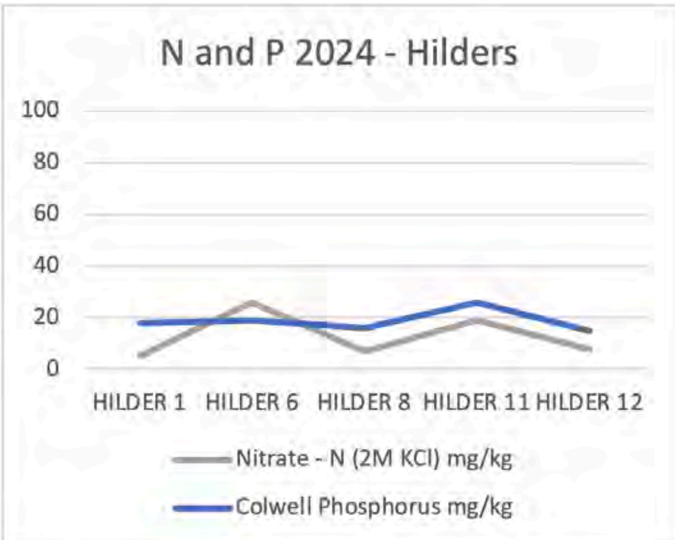


Figure 14 & 15 . *Nitrogen (Nitrate) mg/kg in 2022 at 3 representative sites and in 2024 at 5 selected treatments at the Hilders Demonstration Site near Quorn, SA.*

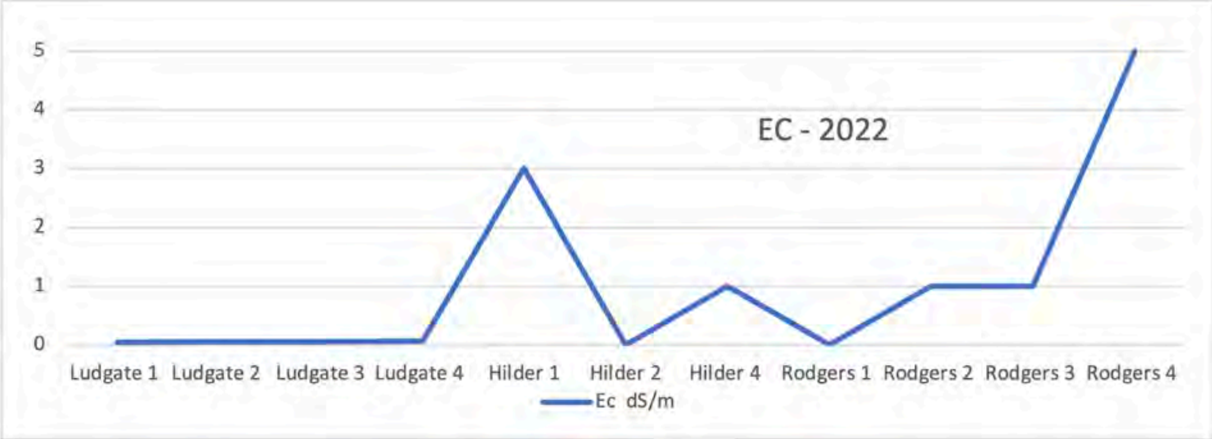
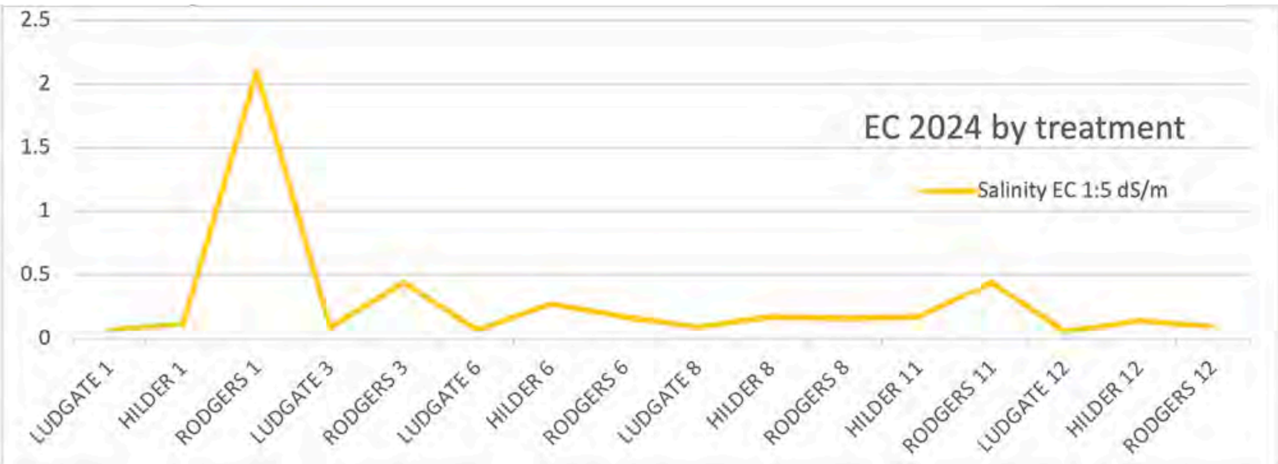


Figure 16 & 17 (above & below) . *Salinity (EC 1:5) dS/m in 2022 at 4 representative sites across the demonstration paddocks and in 2024 at 16 selected treatments at the 3 demonstration sites.*



What is clear is the high level of soil variability that occurs in these highly degraded paddocks and landscape both in a spatial and temporal scale. The methodology used to revegetate or restore function must consider recent soil tests designed to the scale of the project and site. Work to increase biological activity and increase water infiltration capacity will improve overall soil health and resilience.

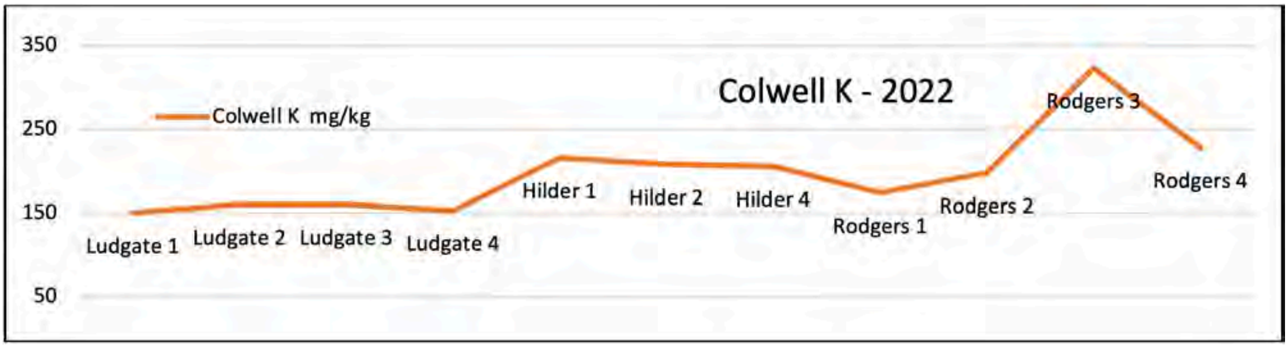
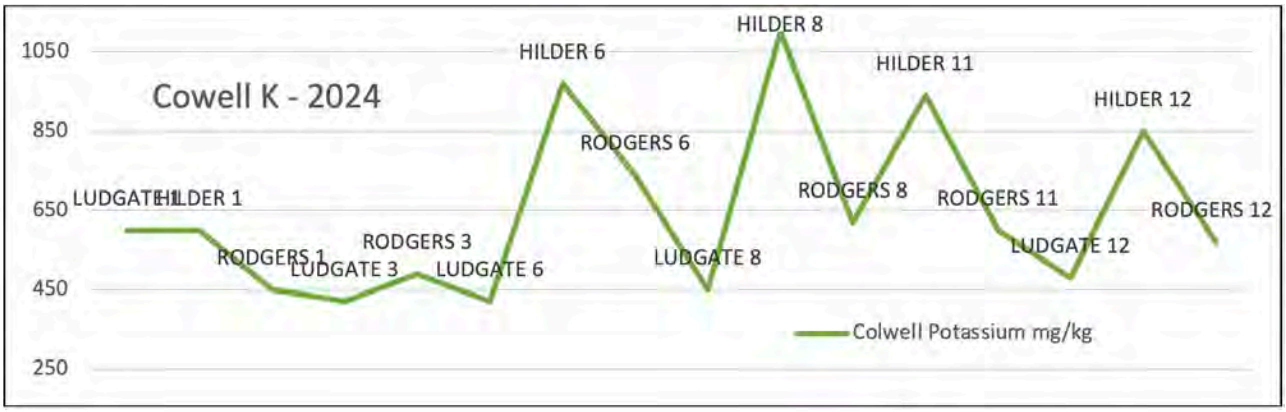


Figure 17 & 18 (above & below) . *Colwell Potassium mg/kg in 2022 at 4 representative sites across the demonstration paddocks and in 2024 at 16 selected treatments at the 3 demonstration sites. Increase due to cause unknown.*



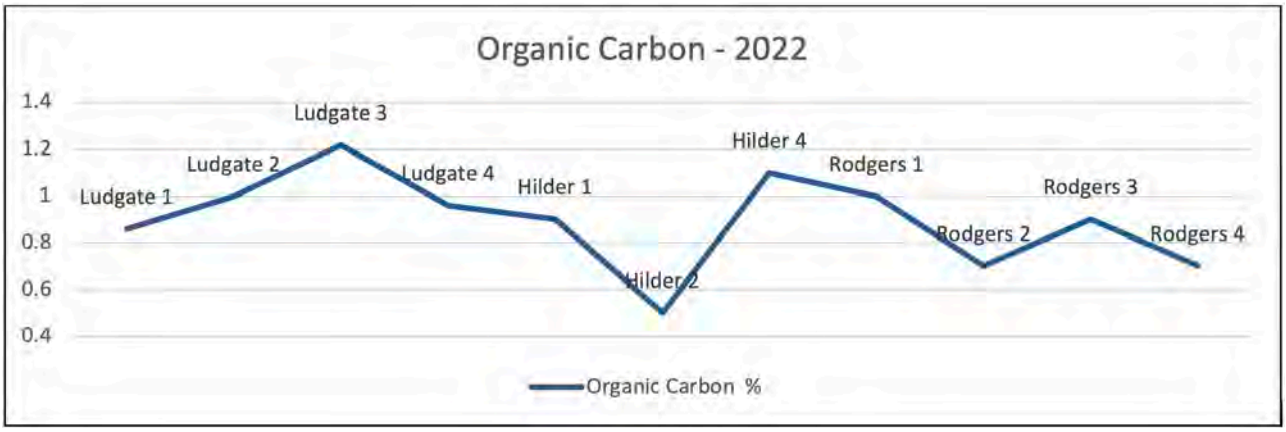


Figure 19. *Organic Carbon % in 2022 at 4 representative sites across the demonstration paddocks.*

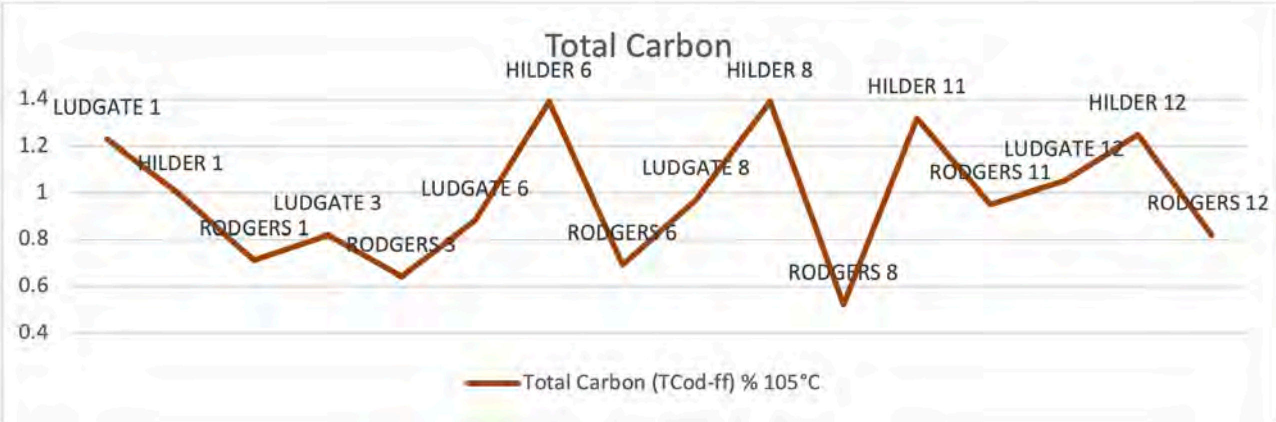


Figure 20. *Total Carbon (TCod-ff) %105oC in 2024 at 16 selected treatments at the 3 demonstration sites.*

Productivity and Farm Resilience:

It is clear the "do nothing" approach is not improving biomass production, water infiltration or farm resilience to climatic shock, however, there were components of the demonstrations that were.

By using a low tillage machine (not a no-tillage) to work the soil, with or without seed, we saw improved water infiltration rates. This means less water is running off and more is available for plants once germinated. The tyned system left a more prominent furrow and is anticipated to have a longer lasting effect. The 3 native seeding systems had very different levels of soil disturbance and left different seed beds/rainfall harvest conditions. The frankenpitter did not work well in the short review period of this project, but left large furrows and pits for rainfall and seed capture and showed signs of this occurring on the final site visit. The work and spread method will leave a different seed bed depending on the machine used to work the soil prior to spreading of the seed. In this case it left an un-even seed bed with small clods 3-5cm in diameter and was highly effective at rainfall harvest and germination of the chenopods and other large seeded native species. The offset barrel tynes, spread and roll method worked the top 5 cm into a fine seed bed, proving highly effective for the native grass seeds to become established in, however it did show signs of crusting and run-off and may not be as suitable for the sodic and saline soil types.

By incorporating low cost, readily available barley at low seeding rates and even at skip-rows we were able to speed up the biological activity in the soil in a manner that did not seem to have a negative impact on the already present species, or the germinating native annuals. This was not the case with oats. The legumes, though good in theory, did not perform. This may be due to delays from seeding to germinating rainfall or soil toxicity rendering the inoculum in-active. The forage brassica, tillage radish and canola all established at the 3 sites and should be investigated further for inclusion in this type of work.

In Conclusion

There are many factors to consider when attempting to restore function to a degraded landscape. Firstly, is the cause of the degradation a one off or an ongoing issue? Action without land management change will result in further degradation. If the impact is no longer occurring or can be reduced, then many factors impact the scope and timeline of restoration activities. In a production landscape that is also covered by the SA Native Vegetation Legislation this is more complex. Below are some of the factors highlighted by this project to consider:

- ***Seasonality*** – Without rain, it won't grow. It is unwise to implement an activity of this nature during extended dry periods, but the process to gain approval with the Native Vegetation Council is not short, and as such it becomes a good job to plan for during a dry period in anticipation of the next wetter season.
- ***Seed source*** – Without a doubt locally native species will result in a more resilient landscape and a diverse mix of grasses and shrubs will result in a productive pasture if managed well. The cost of this seed in large volumes is often prohibitive and seeding into bare paddocks has often failed due to wind damage and erosion. The use of feed barley, sown at a low seeding rate and if possible, on skipped rows may improve the success of sown native seed establishment. These sites have also suggested that it may assist with recruitment of native seed from on the wind or remaining in the soil due to shading and improved water infiltration from the furrows and roots. A combination approach of using both commercially available cereal seed and native seed should also be investigated further. This was intended for this project but a lack of follow up rain made the second seeding unviable.
- ***Optimum machine for the job*** – the best machine for the job of restoring landscape and pasture function in these circumstances may not be the most effective grassland restoration machine available, or the one that is used for restoring high value landscapes, but a readily available tyned seeder, set on wide row spacings and if it has the ability to seed skip rows then all the better. As these sites have not been able to be analysed statistically further research into this as an effective technique for restoring degraded, once cropped, pastures along Goyders Line is recommended.
- ***Know the soils*** – this approach to landscape restoration is expensive and climate sensitive, but the soils add a level of spatial and temporal complexity that is often underestimated. Timely, appropriately scaled soil tests can assist with planning any pre-seeding amelioration (pH or nutritional), and will assist with seed selection. It can also highlight issues relating to slumping or toxic layers that need to be avoided.
- ***Understand the limitations*** – Pests and weeds had a significant impact on this project.
  Each site was impacted by different pests, Hilders and Rodgers were targeted by Kangaroos and Emus at significantly higher areas than the surrounding paddocks, whilst Ludgates was impacted by Peacocks and Guinea Fowl...an un-expected yet impactful pest of freshly sown oats and plot trial pegs.
  Wild Oats, Wards Weed and Ice Plant were dominant weed species, and had a negative impact on the successful germination of other species and the resulting longer-term diversity of the site. Implementing a no-kill seeding system has resulted in high weed pressure, effecting germination success. Long term review of this is necessary. Awareness of the site dominant weeds and action to reduce seed set in the prior years through grazing or chemical control may improve seeding success, but will also increase the cost of the activity and the risk of bare paddocks in a highly variable climate.

Future Research:

This project highlighted that there is still a great deal to work through in order to have effective and impactful pasture restoration activities in these paddocks that are no longer arable under the SA Native Vegetation Legislation. Some of these topics for further research may include;

- Combination tyned seeder with non-native seed and broad cast native seed effectiveness for landscape and pasture restoration in degraded once cropped soils of Goyders Line.
- Temporal variation in the soils of the region and it's impact on re-establishing pastures and biodiversity.
- Are oats, wheat or barley allelopathic to native plant species at different plant densities?

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EXPLORING SURFACE SPREAD AMENDMENTS *to* IMPROVE CROP ESTABLISHMENT *on* SALINE SOIL

Author: *Stefan Schmitt, Agricultural Consulting and Research*

Funding *provided by the Future Drought Fund Drought Resilient Soils and Landscapes Project* ***"Building resilience to drought with landscape scale remediation of saline land"***

Key Points

- 10t/ha of straw applied in year one increased barley yield by .8t/ha over the untreated in year two.
- There was no significant difference in yield between the untreated control and Gypsum applied at 10t/ha or Sand applied at 500t/ha in year one.
- Sand treatments looked promising but a yield benefit was not realised in the second year of this project.
- The straw treatment has retuned ~17% of its initial estimated cost of $1500/hectare to spread the 10t/ha.

Background

Dryland salinity is an issue limiting agricultural production in the lower Broughton River catchment region. This region consists of ancient flood plain characterised by alluvial soils with moderate to high salt content and poor soil structure. Accumulation of salts in the surface soil, limits crop establishment, unless flushed from the surface with rainfall. Improving ground cover decreases salt accumulation in the topsoil, by reducing the capillary rise of salt to the surface as water evaporates.

The aim of this trial is to quantify the impact of surface spread amendments such as straw, gypsum and sand on barley establishment, groundcover and yield on land impacted by dryland salinity. Innovative farmers in this region have experimented with these amendments in the past on a small non replicated scale. This trial aimed to produce replicated data to support farmer decision making on the use of these amendments. Both sand and straw act like a mulch when spread on the soil surface decreasing the accumulation of salts which favours crop establishment. Gypsum whilst not acting like a mulch, improves soil structure (decreasing slaking) and has the ability to help flush magnesium salts from the surface.

It is hoped that use of these amendments will give provide long lasting improvement to ground cover and subsequently crop yield.

Methodology

Sowing Date	5th May 2023
Soil Type	Hard clay loam over dispersive red clay, hard sodic clay restricts root growth. High boron, high ESP and moderate – high salinity at depth
Fertiliser	MAP @ 60 kg/ha
Crop Type	Commodus Barley
Growing Season Rainfall (Apr-Oct)	193.4mm
Condition Post Sowing	7.8mm received 21st May, 17.8mm received 26th May.
Pre-Emergent Chemicals	Mateno Complete .75L/ha

Treatments

Treatment Number	Treatment	Application Rate
1	Straw	10 t/ha
2	Sand	500t/ha
3	Gypsum	10t/ha
4	Nil	

Paddock Zone Tested	Sample depth cm	pH 1:5 water	Chloride	Salinity EC1:5 (soil:water)	ECe (estimated)	Boron
			mg/kg	dS/m	dS/m	mg/kg
Trial Site	0-10	9.41	1100	1.1	9.9	
	10-20	7.82	2300	2.2	13	7.9
	20-40	8.47	2600	2.8	16	13
	40-60	8.54	3300	3.5	20	18
High Production Zone Surrounding Paddock	0-10	8.02	840	.87	7.8	
	10-20	9.09	530	.62	4.7	4.7
	20-40	9.07	1100	1.1	8.4	8.4
	40-60	9.01	1800	1.6	15	15

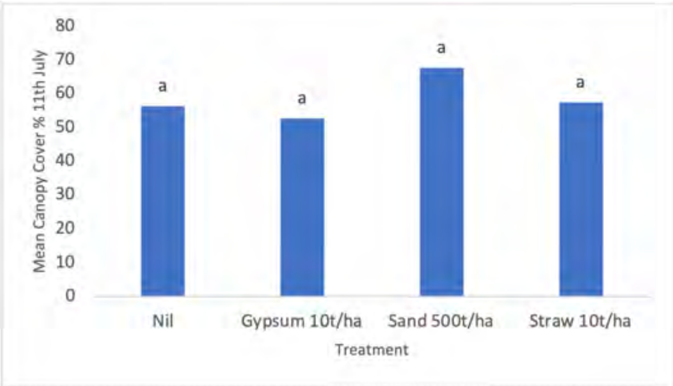

Figure 1. *Mean ground cover percentage by treatment measured using Canopeo app. An analysis of variance (ANOVA) was conducted on the data using R statistical software. Treatments means with letters in common are not significantly different from one another.*

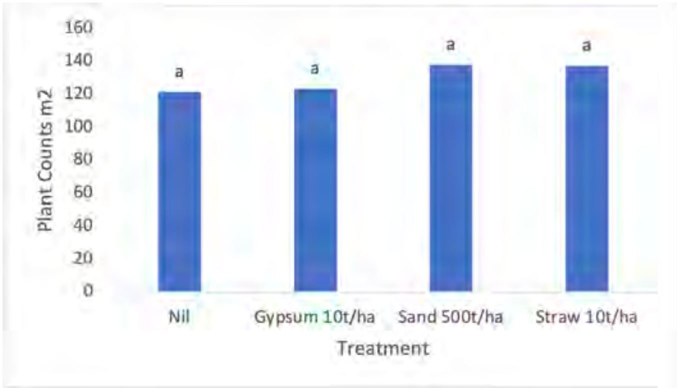

Figure 2. *Mean plant count per treatment. An analysis of variance (ANOVA) was conducted on the data using R statistical software. Treatments means with letters in common are not significantly different from one another.*

Discussion

The start to the season was favourable in this region with 7.8mm and 17.8mm received within a seven-day period two weeks after sowing the site. This provided the ideal conditions for germination and establishment. As a result, there was no significant difference in the establishment, or canopy cover percentage at GS30, between any of the treatments. At harvest the highest yielding treatment was the straw treatment at 3.2t/ha which was significantly different to the untreated control. There was no significant difference in yield between the untreated control and the sand and gypsum treatments yielding 2.4t/ha, 2.7t/ha, 2.8t/ha respectively.

In the second year of this trial the straw treatment outyielded the untreated control by .8t/ha. The cost to cart and spread the straw is estimated to cost $1500/ha*. In year two we have returned an estimated $264/ha* on this initial investment. At this rate we will need to realise this yield gain at this price point for a minimum of 6 years before the initial investment has paid off.

- *Estimate cost to spread straw at 10t/ha = $1500/ha: 10t/ha straw at $130/tonne + $10/tonne spreading cost + $10/tonne cartage cost.

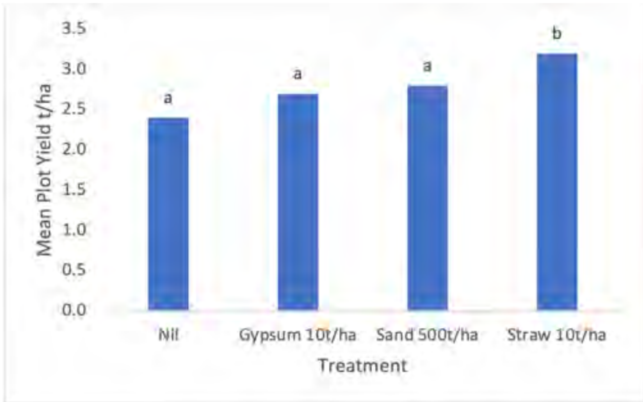

Figure 3. *Mean plot yield per treatment. An analysis of variance (ANOVA) was conducted on the data using R statistical software. Treatment means were separated using Tukey's HSD Post Hoc at the 95% level of probability. Treatments means with letters in common are not significantly different from one another.*

- *PGM calculated by .8t/ha barley x $330/tonne (2023 avg price).

THE PERFORMANCE *of* RESIDUAL *and* CUMULATIVE P APPLICATIONS *on* SOILS *in the* MID NORTH *of* SA

Authors: *Sam Trengove [1] , Stuart Sherriff [1], Jordan Bruce [1] and Sean Mason [2]*
Project Delivery: *[1]Trengove Consulting, [2]Agronomy Solutions*

Keywords

- Phosphorus Availability, Phosphorus Economics, Replacement Phosphorus

Key Points

- Residual P (from a one-off application of a high rate in year one) provided a grain yield response in the second and third year at two of the three sites.
- The method for applying a high rate (90 kg P/ha) of P fertiliser was not important in these trials. High rates of P applied by either deep banding, spreading MAP or chicken litter spread in front of the seeder, all produced the same yield response at each site and year.
- At Hart and Crystal Brook repeated applications of P fertiliser rates showed the crop P requirements were not satisfied by lower rates in the second and third season. The highest repeated P rates (50 and 90 kg P/ha) were still increasing yields in year three at these sites.
- Partial gross margin analysis showed within the range of MAP prices of $500-$1500/t the district practice strategy was never the highest PGM on these P responsive sites.
- When MAP reached $1500/t the chicken litter treatment became the highest PGM at Crystal Brook and one of the highest at Hart, despite freight and spreading costs.

Background

High fertiliser prices have increased grower interest in phosphorus (P) responses on variable soil types and improving returns from P fertiliser inputs. Recently, two SAGIT funded projects (TC219 and TC221) have examined P fertiliser response on a range of soil types with varying soil P availability. The trial locations were determined using soil pH maps and satellite NDVI imagery. To date 49 P response trials have been established across the Mid and Upper North and Northern Yorke Peninsula (NYP) to validate the P sufficiency index (pHnNDVI) methodology (refer to method section) of predicting P response based on these data layers.

Included in the 49 P response trials were three long term (3 year) trials established in 2021 at Spalding, Crystal Brook and Hart. These three sites are highly P responsive alkaline soil types. The project aims to address the following questions.

- What is the residual value of high rates of P from year 1 in following years?
- What is the effect of repeated high-rate P application vs district practice?
- What alternative application strategies can be implemented at high response sites in lieu of variable rate P application through the seeder?

Methodology

In SAGIT project TC219 a methodology for estimating crop P responsiveness, the P sufficiency index, was developed. The P sufficiency index combines soil pH maps and historical satellite NDVI to estimate how responsive a given site will be to applied P fertiliser. The P sufficiency index has been given the acronym pHnNDVI as it is the pH value divided by NDVI normalised to the paddock average using the formula below.

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

Areas of a paddock with high soil pH (>7) and low relative NDVI (<0.9) result in a high pHnNDVI value and are likely to be highly responsive to applied P. Areas with low pH (<6.5) and high relative NDVI (>1.1) result in a low pHnNDVI value and are likely to be unresponsive to applied P in the paddocks tested. This methodology has proven useful in determining the optimal site-specific P rate in paddocks tested across the Mid and Upper North and Northern Yorke Peninsula.

At the beginning of 2021 three highly P responsive sites were identified using the P sufficiency index methodology (Table 1). These sites were soil sampled (0-10 cm) pre-seeding in 2021. Soil pH levels ranged from 7.7 – 7.9 pH CaCl2 which is categorised as moderately alkaline. The DGT-P values were low ranging from 18-23 µg/L (critical limit 60 µg/L). Full comprehensive soil test analysis was conducted for each site and no other nutritional constraints were identified (data not presented)

The crop sown at each location/year were chosen based on the hosting growers' rotation (Table 1).

Location	Soil pH $CaCl_2$	DGT P µg/L	Colwell P mg/kg	PBI	P sufficiency index	2021 crop	2022 crop	2023 crop
Crystal Brook Ave GSR 289mm	7.8	23	29	88	11.9	Compass barley	PBA High-land XT lentil	Calibre wheat
Spalding Ave GSR 268mm	7.7	18	20	77	11.7	Scepter wheat	Spartacus CL barley	Commodus CL barley
Hart Ave GSR 291mm	7.9	17	40	110	10.0	Scepter wheat	PBA Jumbo 2 lentil	Calibre wheat

Table 1. *Average growing season rainfall (GSR = April – October), soil properties and crop sown for long term P response sites.*

Treatment number	Management strategy	2021 P rate (kg P/ha)	Equivalent MAP (kg/ha)	2022 P rate (kg P/ha)	Equivalent MAP (kg/ha)	2023 P rate (kg P/ha)	Equivalent MAP (kg/ha)	Cumulative P rate (kg P/ha)
1	Residual value of high P rates applied in year one	0	0	15	68	15	68	30
2		7.5	34	15	68	15	68	37.5
3		15	68	15	68	15	68	45
4		22.5	102	15	68	15	68	52.5
5		30	136	15	68	15	68	60
6		50	227	15	68	15	68	80
7		90	409	15	68	15	68	120
8	Alternative P management strategies	Spread MAP (90)*	341 fb 68	15	68	15	68	120
9		Chicken litter (93)**	CL fb 68	15	68	15	68	123
10	Value of repeated P rates over three years	0	0	0	0	0	0	0
11		7.5	34	7.5	34	7.5	34	22.5
12		22.5	102	22.5	102	22.5	102	67.5
13		30	136	30	136	30	136	90
14		50	227	50	227	50	227	150
15		90	409	90	409	90	409	270
16	Compare strategies above to high P rates in year three only	15	68	15	68	0	0	30
17		15	68	15	68	7.5	34	37.5
18		15	68	15	68	22.5	102	52.5
19		15	68	15	68	30	136	60
20		15	68	15	68	50	227	80
21		15	68	15	68	90	409	120

* 75 kg P/ha spread prior to sowing as MAP + 15 kg P/ha banded as MAP **78 kg P/ha spread as chicken litter prior to sowing + 15 kg P/ha banded as MAP

Table 2. *Treatment list showing units of P (kg P/ha) applied, the equivalent rate applied as MAP fertiliser (kg/ha) and cumulative P rate for the long-term P response trials in the Mid-North, SA.*

The long-term P fertiliser trials sown at all three sites can be divided into four main management strategies (Table 2) which were used to answer specific questions throughout the project. Phosphorus fertiliser was applied as MAP and nitrogen was balanced at seeding with urea, to match the amount of nitrogen in the 90 kg P/ha treatment. In the main treatments, the fertiliser was applied below the seed using a knife point press wheel system on 250 mm row spacing.

The chicken litter sourced for these trials had a total P concentration of 1.48%, total nitrogen concentration of 4.14% and moisture content of 15.4%. This treatment had a target of 75 kg P/ha broadcast as chicken litter (equivalent to 6250 kg/ha chicken litter) prior to seeding plus 15 kg P/ha as MAP applied below the seed, resulting in a total of 90 kg P/ha. The actual total P applied in the chicken litter treatment was 93 kg P/ha in the first year (Table 2). As the nitrogen in all other treatments was balanced to the 90 kg P/ha treatment it is important to note that the chicken litter treatment received an additional 178 kg N/ha compared to all other treatments.

Grain yield data was analysed using ASREML in R. Partial gross margin was calculated as cumulative income minus cumulative fertiliser cost.

Results and discussion

The long-term trials aimed to address three key research areas and the discussion has been structured around responding to these topics.

What is the residual value of high rates of P from year 1 in following years?

Banded MAP

The residual effect of P fertiliser rates (ranging from 0 – 90 kg P/ha) were assessed in year two and three in treatments where district practice applications (15 kg P/ha) followed the range of rates in the first season. The results from year three show at two of the sites, Hart and Crystal Brook, there was still evidence of residual P from high application rates in the first season (Figure 1 and 2). In contrast, at the Spalding site in the third season there was no grain yield response to the range of P rates (0-90 kg P/ha) applied in year one (Figure 3).

At Hart in year one, grain yields reached 137% of the untreated where rates of 50 kg P/ha or more were applied. High rates of P continued to produce higher grain yields in year two and three (Figure 1). These results show at Hart residual effects of high P rates in year one, were still being observed in year three.

Crystal Brook was the most responsive site in season one, where grain yields reached 170% of the untreated at a rate of 90 kg P/ha. In the second season the grain yield response to increasing P remained significant with maximum grain yields coming from the year one 90 kg P/ha application. In the third season the response to high rates of P in year one was not consistent (Figure 2). The 50 kg P/ha applied in the first year remained higher yielding compared to 0 kg P/ha however, the 90 kg P/ha was not different to the untreated.

Similarly, the Spalding site was highly responsive to P rates in year one, reaching 149% of the untreated with 90 kg P/ha. The chicken litter treatment produced higher grain yields than the comparable 90 kg P/ha MAP in all three seasons indicating other yield limitations (Figure 3). Protein data (not presented) showed nitrogen was limiting in year two which may have masked the P response in that season. Higher rates of nitrogen and foliar trace elements were applied in the third season to address any possible nutrient limitations. However, no response to high P rates applied in year one were recorded in year three (Figure 3). This indicates there was no legacy effect of the higher P rates carrying into the third season.

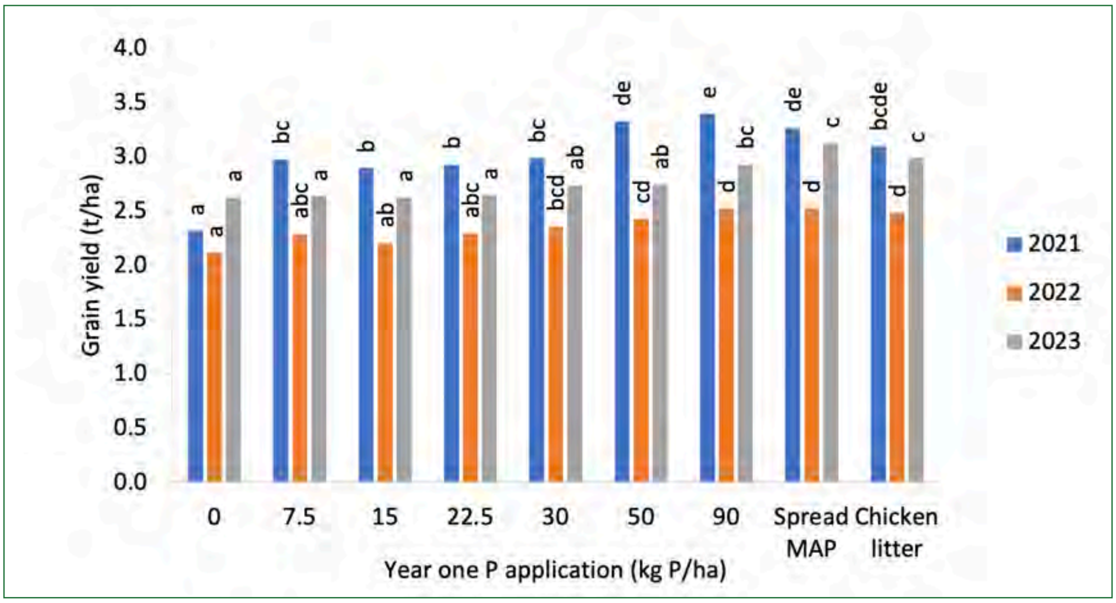

Figure 1. *Grain yield (t/ha) over three seasons for P rates applied in year one at Hart, SA from 2021-2023. (P value for all 21 treatments; 2021 <0.001, 2022 <0.001 and 2023 <0.001). Bars within a year level that share a common letter are statistically similar.*

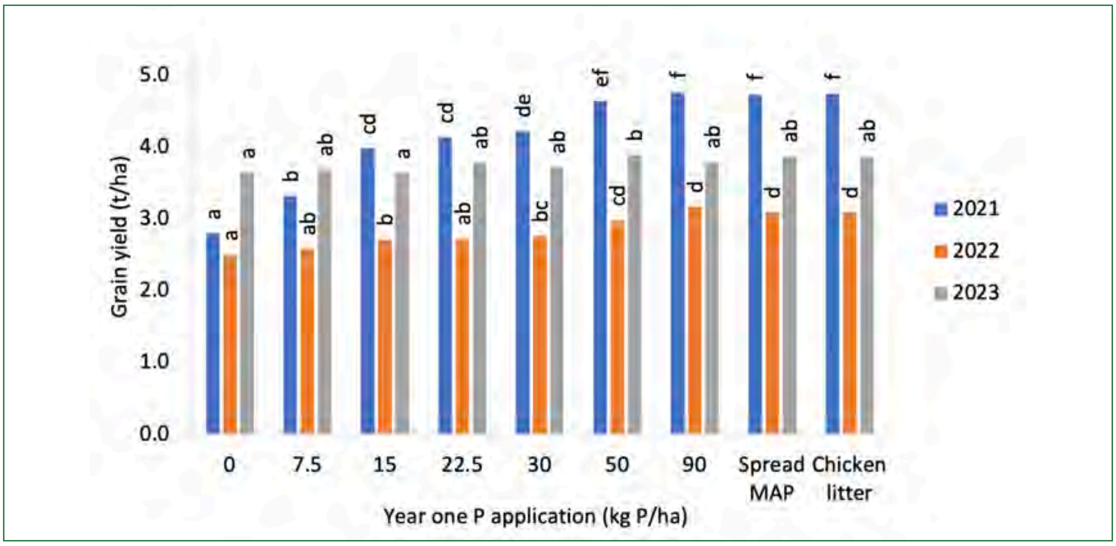

Figure 2. *Grain yield (t/ha) over three seasons for P rates applied in year at Crystal Brook, SA from 2021-2023 (P value for all 21 treatments; 2021 <0.001, 2022 <0.001 and 2023 <0.001Bars within a year level that share a common letter are statistically similar.*

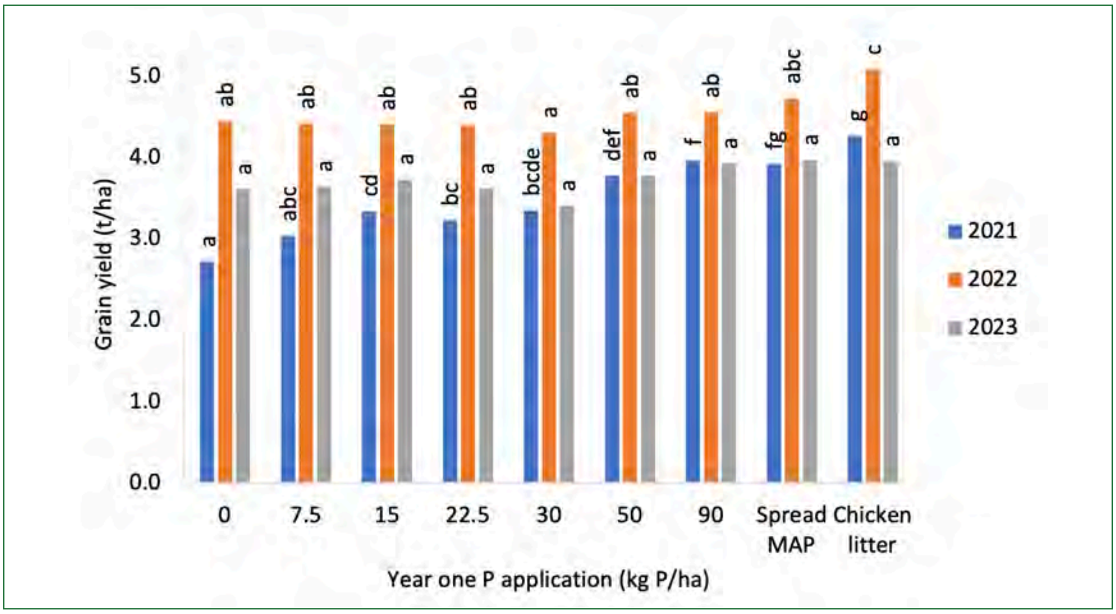

Figure 3. *Grain yield (t/ha) over three seasons for P rates applied in year one at Spalding, SA from 2021-2023. (P value for all 21 treatments; 2021 <0.001, 2022 <0.001 and 2023 <0.001). Bars within a year level that share a common letter are statistically similar.*

What alternative strategies can be implemented at high response sites in lieu of variable rate P application through the seeder?

Spread MAP and chicken litter application

At all three sites and in all seasons, the spread MAP treatment (75 kg P/ha spread in front of the seeder plus 15 kg P/ha MAP deep banded in year one) produced similar grain yields to the equivalent treatment of 90 kg P/ha MAP deep banded (Figures 1-3). The chicken litter treatment (78 kg P/ha of chicken litter spread in front of the seeder plus 15 kg P/ha MAP deep banded in year one) also produced similar grain yields to the equivalent treatment of 90 kg P/ha MAP deep banded at Hart and Crystal Brook in all three seasons. At these highly P responsive sites this result indicates the P fertiliser efficiency was similar regardless of application method.

At Spalding, grain yields from the chicken litter treatment were higher compared to the 90 kg P/ha deep banded in the first and second season. The chicken litter treatment received an additional 173 kg N/ha compared to other treatments. Grain protein data (not presented) indicated that the additional N likely contributed to the grain yield response in the first two seasons. In the third season there was no difference between the chicken litter treatments and the equivalent deep banded MAP treatment.

What is the effect of repeated high-rate P application vs district practice?

The district practice treatment refers to the repeated application of 15 kg P/ha (Table 2). This treatment is representative of the P management strategy used by all three trial cooperators in previous years.

The Crystal Brook and Hart sites showed similar responses with highest grain yields coming from repeated P rates of 50 and 90 kg P/ha in the trials in year two and three (Figure 4 and 5). At Hart, repeated applications of 30 kg P/ha were enough to outyield the district practice in years two and three (Figure 4). The same treatment increased yields above district practice in year two at Crystal Brook but no yield advantage was seen in year three. Repeated applications of 22.5 kg P/ha yielded the same as district practice for the three years at both Crystal Brook and Hart.

It was anticipated that with repeated applications of high rates, the crop P requirements would be satisfied by smaller applications in the second and third season. This was not observed with the highest repeated P rates still increasing yield into the third year at these sites. Further investigation is required to understand if higher yields continue from the highest P rates or if a point of P saturation occurs allowing lower P rates to satisfy crop requirements.

At Spalding, the application of P rates of 50 and 90 kg P/ha resulted in increased yields compared to the district practice in year one (Figure 6). Individual year analysis indicates a small grain yield response above 15 kg P/ha in year two and three. However, the cumulative grain yield analysis shows significant grain yield increases above district practice P rates with repeated applications of 50 and 90 kg P/ha. As discussed above, it is likely that nitrogen was a limiting factor at this site and confounds the grain yield results. The chicken litter treatment was the highest yielding at this site in year two.

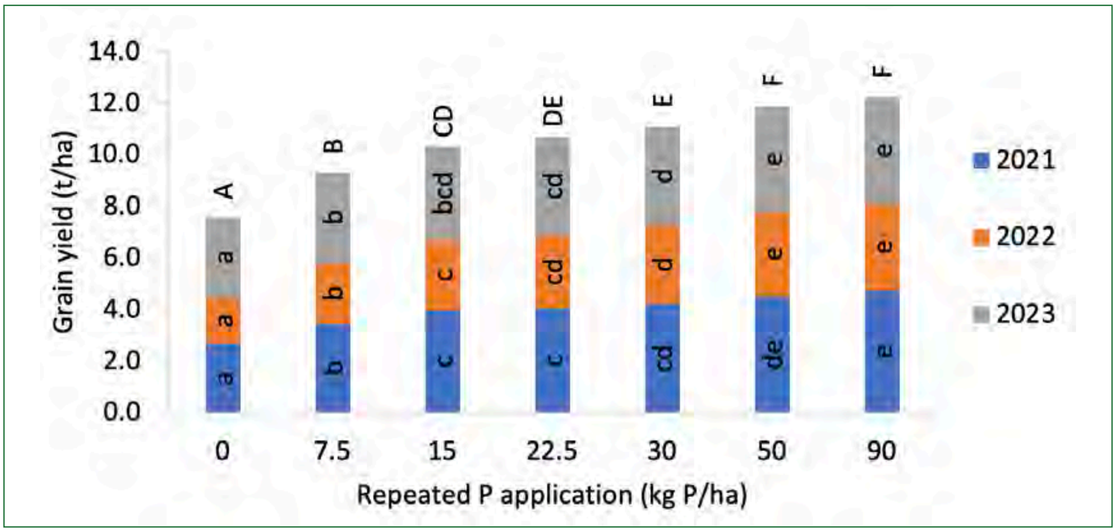

Figure 4. *Hart cumulative grain yield for repeated applications of P fertiliser, P values = 2021 <0.001, 2022 <0.001, 2023 <0.001 and cumulative <0.001. Bars within a year level that share a common letter are statistically similar, capital letters refer cumulative yield analysis.*

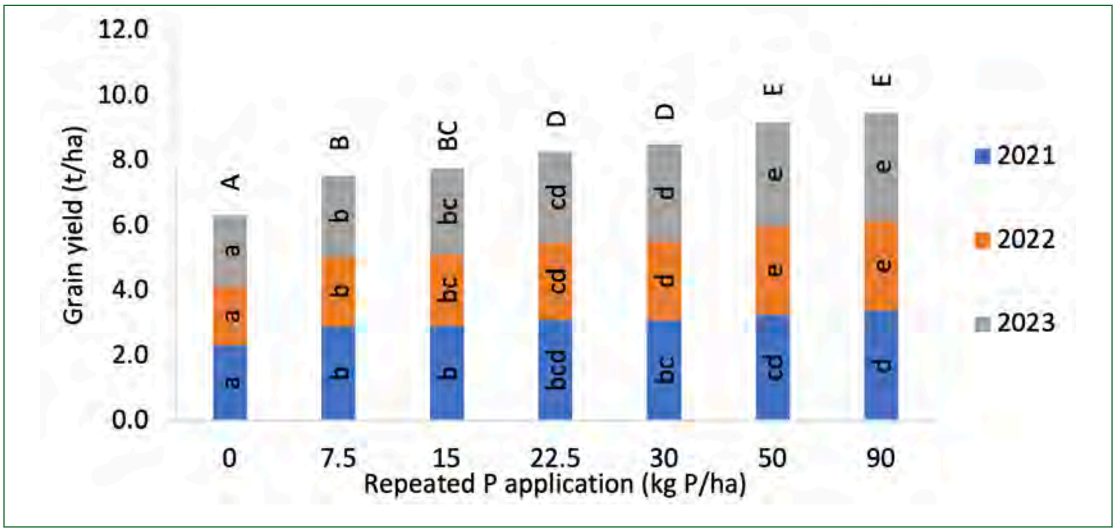

Figure 5. *Crystal Brook cumulative grain yield for repeated applications of P fertiliser, P values = 2021 <0.001, 2022 <0.001, 2023 <0.001 and cumulative <0.001. Bars within a year level that share a common letter are statistically similar, capital letters refer cumulative yield analysis.*

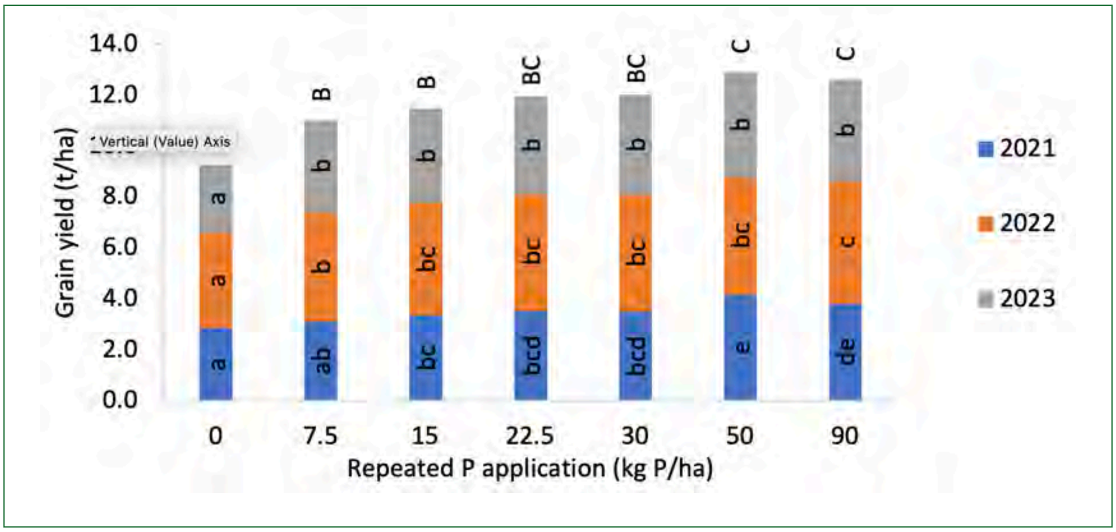

Figure 6. *Spalding cumulative grain yield for repeated applications of P fertiliser, P values = 2021 <0.001, 2022 <0.001, 2023 <0.001 and cumulative <0.001. Bars within a year level that share a common letter are statistically similar, capital letters refer cumulative yield analysis.*

Economic analysis of the different P management strategies

Whilst the repeated application of high P fertiliser rates has resulted in the largest cumulative grain yields, the cost of fertiliser also needs to be considered. The partial gross margin (PGM) has been calculated on the cumulative grain yield for all sites and presented with variable MAP pricing scenarios (Table 3).

The Spalding PGM values have been impacted by the variability of the site and due to the N limitation in year one and two, which affected grain yields in all treatments except for chicken litter (Table 3).

The Hart and Crystal Brook sites behaved similarly in terms of grain yields over the three years and therefore the PGMs are similar (Table 3). Firstly, within the range of MAP prices of $500-$1500/t the district practice treatment is never the highest PGM on these responsive sites. Therefore, the alternative P management strategies tested have potential to improve profitability. Secondly, when fertiliser prices are low (MAP $500/t) there is an economic advantage of achieving consistently higher yields with repeated P rates of 50 kg P/ha, which produces the highest PGM for these sites. As fertiliser prices increase, the optimum P rate for repeat applications declines, ultimately resulting in a lower PGM. This is where the value of residual P becomes important. Under high fertiliser prices (MAP $1500/t) the one-off high P rates in year one of 50 - 90 kg P/ha has a greater PGM than the repeat high applications. However, we would expect that the repeated applications of higher rates will have higher reserves to support ongoing productivity in the near future compared with the one-off high application rates. Soil testing planned for these trials will explore this.

Treatment 5-7 show the value of addressing P deficiency immediately, rather than putting it off for two seasons as in treatment 19-21. On average, at Hart and Crystal Brook there is a $272/ha advantage for addressing deficiency in year one with 30-90 kg P/ha, compared with year three (Table 3).

Under high MAP fertiliser prices ($1500/t) the chicken litter treatment provided the greatest PGM at Crystal Brook and one of the highest at Hart (Table 3). This alternative source of P becomes important under high MAP prices assuming the price does not increase from demand because of high synthetic P fertiliser prices. Not only is the chicken litter supplying P to the crop, but it is also supplying other nutrients which can potentially reduce the total synthetic fertiliser inputs, such as urea, to further decrease input costs whilst maintaining grain yields which ultimately increase PGM further.

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SAGIT

Table 3. *Predicted cumulative yield and partial gross margin (PGM) for the three seasons at differing MAP fertiliser prices.*

Treatment	2021 P rate (kg/ha)	2022 P rate (kg/ha)	2023 P rate (kg/ha)	Predicted cumulative yield (t/ha)			MAP $500/t			MAP $1000/t			MAP $1500/t		
				Crystal Brook	Hart	Spalding	Crystal Brook	Hart	Spalding	Crystal Brook	Hart	Spalding	Crystal Brook	Hart	Spalding
1	0	15	15	8.95	7.07	10.78	$3,477	$2,901	$2,763	$3,409	$2,833	$2,695	$3,340	$2,764	$2,626
2	7.5	15	15	9.58	7.91	11.11	$3,655	$3,204	$2,844	$3,570	$3,119	$2,759	$3,484	$3,033	$2,674
3	15	15	15	10.33	7.74	11.48	$3,882	$3,104	$2,935	$3,779	$3,001	$2,832	$3,677	$2,899	$2,730
4	22.5	15	15	10.64	7.88	11.25	$3,954	$3,165	$2,855	$3,834	$3,045	$2,735	$3,715	$2,926	$2,616
5	30	15	15	10.70	8.09	11.07	$3,967	$3,235	$2,799	$3,830	$3,098	$2,662	$3,694	$2,962	$2,526
6	50	15	15	11.51	8.51	12.11	$4,231	$3,343	$3,035	$4,049	$3,161	$2,853	$3,868	$2,980	$2,671
7	90	15	15	11.72	8.86	12.46	$4,273	$3,397	$3,041	$4,001	$3,125	$2,768	$3,728	$2,852	$2,495
8	Spread MAP	15	15	11.68	8.93	12.62	$4,215	$3,418	$3,078	$3,942	$3,146	$2,806	$3,669	$2,873	$2,533
9	Chicken litter	15	15	11.70	8.58	13.32	$4,065	$3,126	$3,099	$3,963	$3,024	$2,997	$3,860	$2,921	$2,895
10	0	0	0	7.60	6.32	9.26	$2,862	$2,620	$2,458	$2,862	$2,620	$2,458	$2,862	$2,620	$2,458
11	7.5	7.5	7.5	9.32	7.53	11.02	$3,511	$3,064	$2,859	$3,460	$3,013	$2,808	$3,409	$2,962	$2,757
12	22.5	22.5	22.5	10.70	8.27	11.95	$3,994	$3,280	$3,011	$3,841	$3,126	$2,857	$3,687	$2,973	$2,704
13	30	30	30	11.10	8.49	12.02	$4,117	$3,318	$2,975	$3,913	$3,114	$2,770	$3,708	$2,909	$2,566
14	50	50	50	11.89	9.17	12.62	$4,312	$3,490	$3,006	$3,971	$3,149	$2,665	$3,630	$2,808	$2,324
15	90	90	90	12.23	9.46	12.92	$4,158	$3,328	$2,824	$3,544	$2,715	$2,211	$2,931	$2,101	$1,597
16	15	15	0	10.08	7.57	10.48	$3,854	$3,087	$2,708	$3,786	$3,019	$2,640	$3,718	$2,950	$2,571
17	15	15	7.5	10.04	7.69	11.12	$3,800	$3,106	$2,856	$3,715	$3,021	$2,771	$3,629	$2,935	$2,685
18	15	15	22.5	10.30	7.90	11.78	$3,857	$3,147	$2,991	$3,737	$3,027	$2,871	$3,618	$2,908	$2,752
19	15	15	30	10.21	7.98	11.84	$3,807	$3,162	$2,994	$3,671	$3,025	$2,857	$3,534	$2,889	$2,721
20	15	15	50	10.46	8.09	11.91	$3,797	$3,149	$2,959	$3,615	$2,967	$2,777	$3,433	$2,786	$2,595
21	15	15	90	10.51	8.40	12.37	$3,750	$3,147	$2,991	$3,477	$2,875	$2,719	$3,204	$2,602	$2,446

Assumed grain pricing wheat $300/t, barley $250/t, lentil $700/t.

Chicken litter $54.70/t which includes cost of product, spreading and transport (averaged across the three sites).

White cells = grain yields at Spalding which were not nitrogen limited.

USING GRAIN PROTEIN MAPS *to* OPTIMISE NITROGEN FERTILISER *to* PADDOCK SCALE NITROGEN VARIABILITY

Authors: *Sam Trengove, Stuart Sherriff, Jordan Bruce, Declan Anderson and Sarah Noack*
Project Delivery: *Trengove Consulting*

Key Points

- 2022 wheat grain protein showed a moderate correlation with soil available N pre-seeding in the following season at Bute and Redhill.
- The 2022 grain protein was able to predict the in-paddock variability in fertiliser N requirement in the following crop at both experimental paddocks. However, there was a large variation between the paddocks despite having similar yield potentials. At 10% protein in 2022 the N fertiliser rate required to maximise PGM at Redhill was 125 kg N/ha compared to 61 kg N/ha at Bute.
- Crop N removal (combination of yield and protein) in 2022 had a strong relationship with N rate to optimise PGM in 2023 both Redhill and Bute.

Background

In paddocks with significant spatial variation there is an opportunity to utilise data layers that can provide information at the site-specific level and aid nitrogen (N) decision making. The use of on combine protein analysers is becoming more common among grain growers. At harvest this technology allows growers to blend and segregate different grades of grain based on protein. However, the resulting grain protein maps also have the potential to assist N decision making by showing the spatial variation in protein (and therefore N) across a paddock. This variation can be used to assign zones and produce variable rate fertiliser maps.

The aims of this project are to increase the profitability derived from N fertiliser applications by:

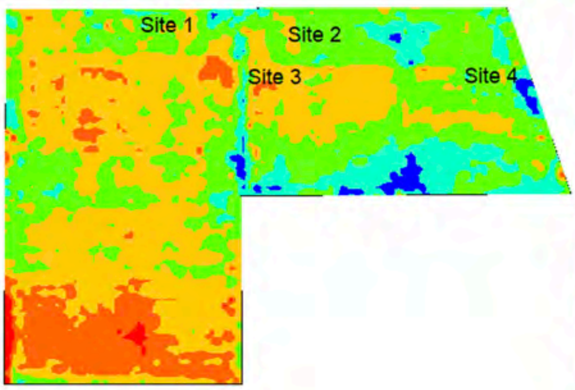
- Examining the relationship between soil mineral N pre-seeding with grain yield and protein maps from the previous season,
- Examining the relationship between historical grain yield and protein maps, and the spatial variability of nitrogen response across paddocks in the Mid North and Yorke Peninsula,
- Provide information towards the potential for protein maps to create variable rate nitrogen application maps.

Methodology

Paddock and trial site information

Two growers using standard yield monitors and retrofitted CropScan 3000H grain analysers were identified at Bute and Redhill. Wheat grain yield and protein maps from 2022 were analysed and one paddock per grower was selected for small scale field trials (Figure 1 and Figure 2).

Four sites per paddock were identified based on the 2022 data layers for small plot trials (Table 1). Each of the sites was predicted to have a different level of N fertiliser response based on historical crop performance. The 2022 grain yield and protein data from each of the selected trial sites are shown in Table 1. Soil available N for the Redhill site ranged from 38 – 56 kg N/ha and at Bute ranged from 31 – 56 kg N/ha. Organic carbon levels at both sites were low to moderate. There were no other constraints identified in the soil properties tested (data not shown).



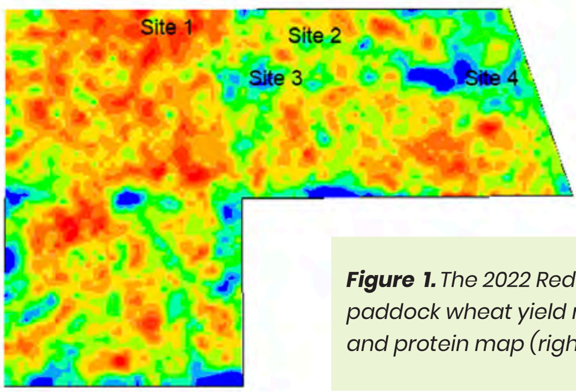


Figure 1. *The 2022 Redhill paddock wheat yield map (left) and protein map (right)*

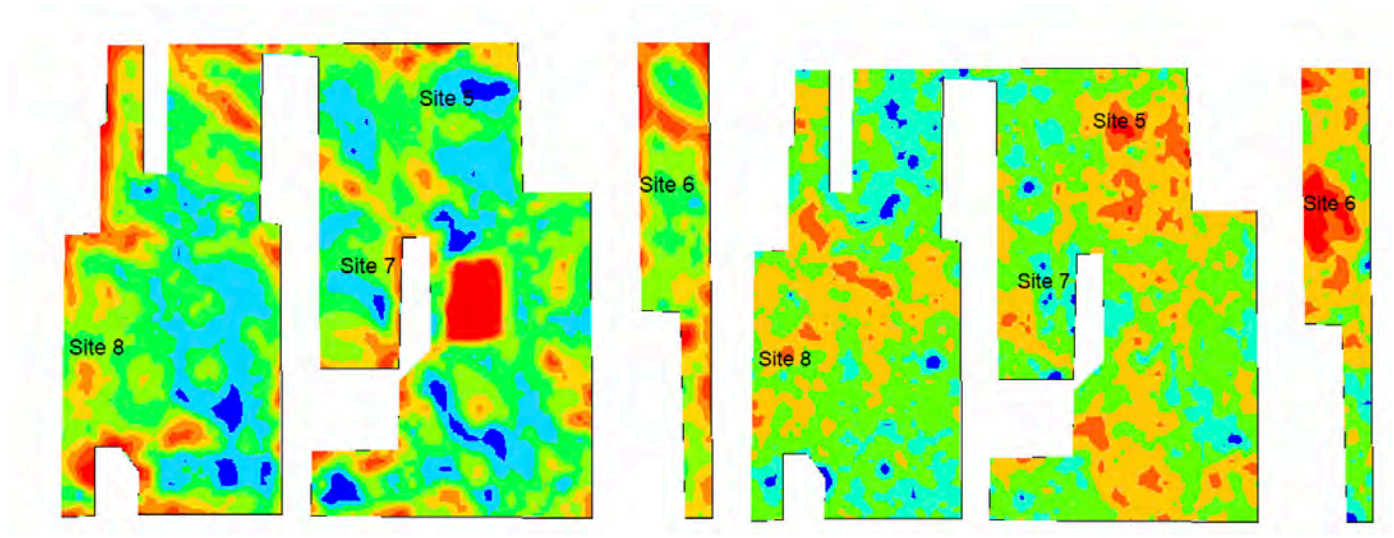


Figure 2. *The 2022 Bute paddock wheat yield data (left) and protein map (right).*

N trial site	Location	Description*	2022 Wheat grain yield (t/ha)	2022 Grain yield (relative)	2022 Protein (%)	2022 Protein (relative)	Soil available N (0-100 cm)	Organic carbon (%)
1	Redhill	MYLP	5.6	1.02	9.8	0.93	38	1.3
2		MYMP	5.7	1.04	11.1	1.06	38	1.4
3		MYHP	5.3	0.96	11.3	1.07	49	1.3
4		HYHP	5.8	1.05	11.8	1.12	56	1.2
5	Bute	HYLP	7.9	1.11	9.7	0.91	31	0.9
6		MYLP	7.2	1.03	9.3	0.88	48	0.9
7		MYHP	7.0	1.01	11.3	1.06	56	1.0
8		MYMP	7.0	1.01	10.2	0.96	38	1.0

**Example MYLP = Medium yield, low protein*

Table 1. *Grain yield (2022), protein (2022), soil available N (sampled March 2023) and organic carbon for the small-scale plot trial locations.*

Nitrogen fertiliser rate plot trials

The trials were randomised complete block designs with three replicates. Plot dimensions were 1.5 m x 10 m. The N fertiliser response at each trial site was assessed with fertiliser rates of 0, 25, 50, 75, 100, 150 and 200 kg N/ha applied as urea early post emergent.

Trial management details for the individual sites are shown in Table 2. Plots were sown with a knife point press wheel system on 250 mm spacing. All plots were harvested for grain yield and grain quality was assessed. Grain yield and quality statistical analysis was performed using ANOVA and ASREML in R.

Site	Redhill	Bute
Seeding date	15th May	16th May
Variety (Seeding rate)	Beast barley 80 kg/ha	Commodus CL barley 75 kg/ha
Starting fertiliser	MAP 100 kg/ha	MAP 100 kg/ha
N applications (Growth stage)	26th June (Z14)	26th June (Z14)
Harvest date	31st October	2nd November

Table 2. *Agronomic information for trial sites at Redhill and Bute in 2023.*

Yield potential was calculated = ((Rainfall (30% Oct to Mar) + April to October rainfall – 90mm evaporation) * 25 kg/ha/mm). Previous October rainfall is generally not included in this calculation however, 2022 was an exceptionally wet season and it would be unwise to ignore it. Barley nitrogen requirement = (yield t/ha * 10% protein * 1.61) / 45% N use efficiency.

Nitrogen response curves were fit to the yield data for each site as a polynomial function. Predicted grain yield was then used to conduct partial gross margin (PGM) analysis to find the N rate at maximum PGM for each site.

Prices used in the PGM were $700/t for urea and $270/t for BAR1 barley. All treatments met and were assessed as BAR1 grade, despite some treatments reaching malt classification standards (currently Beast and Commodus CL are pending malt accreditation). The N rate at maximum PGM was then compared to historical yield and protein data.

Seasonal conditions

At both Redhill and Bute, the season started well with good seeding rains and a wet June. This was followed by a very dry spring (Figure 3). Well below average rainfall was received through July to October. October rainfall at Redhill was 5mm and Bute 8.5mm and this resulted in moisture stress prior to maturity at this site. However, significant stored moisture was available for the crops throughout the growing season from the wet spring in 2022 (Figure 3).

Results and discussion

Exploring the relationship between historical data layers and pre-seeding soil available N

Grain protein from the previous season had a moderate correlation to pre-seeding soil available N (Figure 4). At both the Redhill and Bute sites, as 2022 protein increased, soil available N measured in March the following season also increased. The rate of increase was similar for both sites at an average of 7.5 kg N/ha for each percent protein increase. The Bute sites were more variable and as a result had a weaker correlation compared to Redhill.

The 2022 grain yield and the combination of 2022 grain yield and protein (shown as N removal) did not have the same relationship between sites (Figure 4). At the Bute sites grain yield had a moderate correlation with soil available N compared to no relationship at Redhill. The opposite was observed between the two sites for N removal.

This data suggests grain protein can better describe the variation in soil available N compared to grain yield or N removal.

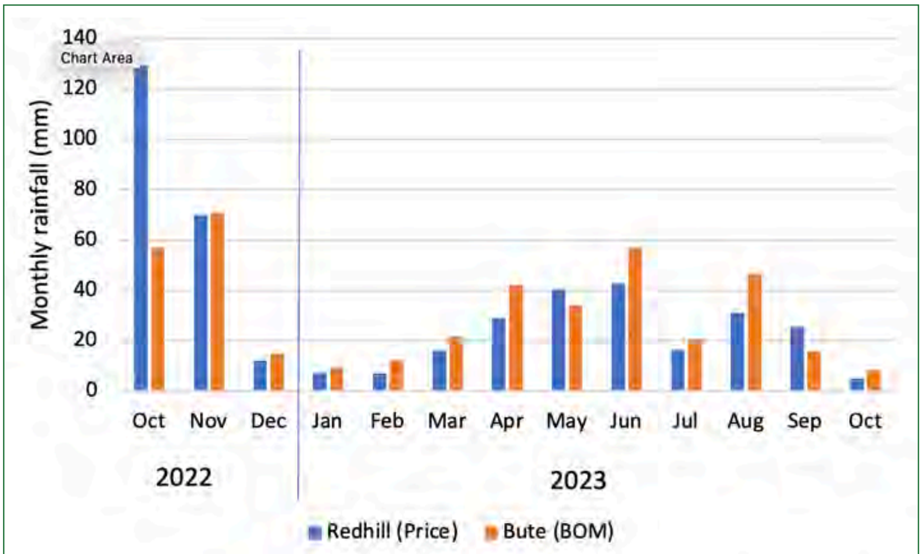


***Figure 3.** Monthly rainfall for Redhill and Bute from October 2022 to October 2023.*

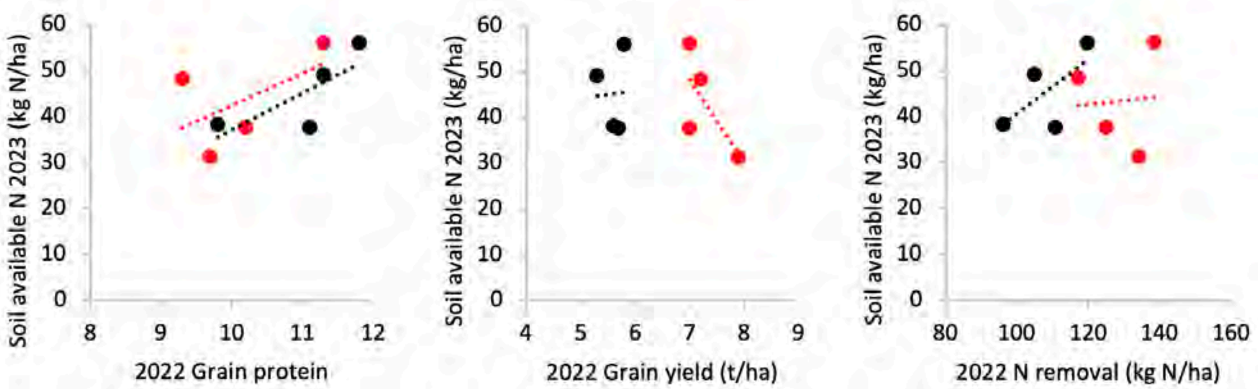


***Figure 4.** The relationship between 2022 protein (left), grain yield (mid) and N removal (right) and soil available N sampled March 2023 at Redhill (black) and Bute (red).*
Protein – Redhill; $y = 8.01x - 42.89$, $R^2 = 0.59$, Bute; $y = 6.94x - 26.91$, $R^2 = 0.30$
Grain yield – Redhill; $y = 1.67x + 35.91$, $R^2 = 0.001$, Bute, $y = -18.00x + 174.37$, $R^2 = 0.49$,
N removal – Redhill; $y = 0.5952x - 18.909$, $R^2 = 0.4456$, Bute; $y = 0.0855x + 32.393$, $R^2 = 0.0054$.

N rate (kg/ha)	0	25	50	75	100	150	200	*Pr (>F)*
Site 1 - MYLP								
Grain yield (t/ha	3.4 d	4.0 c	4.4 b	5.0 a	5.0 a	5.3 a	5.3 a	*<0.001*
Protein (%)	8.7 f	9.2 ef	9.6 e	10.5 d	11.7 c	12.9 b	13.9 a	*<0.001*
Screenings (%)	0.3 b	0.2 b	0.2 b	0.2 b	0.2 b	0.3 b	0.6 a	*0.02*
N removal (kg/ha)	53g	65 f	74 e	92 d	102 c	119 b	128 a	*<0.001*
Site 2 - MYMP								
Grain yield (t/ha	4.0 e	4.4 d	4.7 c	5.1 b	5.2 ab	5.2 ab	5.4 a	*<0.001*
Protein (%)	9.5 e	10.1 e	10.8 d	11.6 c	12.9 b	13.2 b	15.1 a	*<0.001*
Screenings (%)	0.2 b	0.3 b	0.3 b	0.3 b	0.2 b	0.4 b	0.6 a	*0.026*
N removal (kg/ha)	66 f	79 e	90 d	104 c	117 b	121 b	141 a	*<0.001*
Site 3 - MYHP								
Grain yield (t/ha	3.8 d	4.3 c	4.5 bc	4.8 ab	4.9 a	5.1 a	5.2 a	*<0.001*
Protein (%)	9.8 e	10.1 de	10.9 d	12.0 c	13.1 b	13.6 b	14.7 a	*<0.001*
Screenings (%)	0.3 a	0.2 a	0.2 a	0.3 a	0.3 a	0.3 a	0.5 a	*0.151*
N removal (kg/ha)	64 e	76 de	85 d	101 c	113 bc	122 ab	134 a	*<0.001*
Site 4 - HYHP								
Grain yield (t/ha	4.1 e	4.7 d	4.8 cd	5.0 bc	5.1 ab	5.3 a	5.1 ab	*<0.001*
Protein (%)	8.9 f	9.7 e	10.0 e	11.1 d	12.1 c	13.4 b	14.8 a	*<0.001*
Screenings (%)	0.6 a	0.3 a	0.2 a	0.3 a	0.5 a	0.5 a	1.0 a	*0.23*
N removal (kg/ha)	65 f	79 e	84 e	97 d	108 c	124 b	132 a	*<0.001*
Site 5 - HYLP								
Grain yield (t/ha	3.7 d	4.2 c	4.5 b	4.6 ab	4.7 a	4.6 ab	4.5 b	*<0.001*
Protein (%)	8.7 e	9.1 de	9.5 d	10.5 c	10.7 c	12.6 b	14.4 a	*<0.001*
Screenings (%)	2.4 b	1.0 b	1.4 b	2.1 b	2.5 b	5.3 a	7.0 a	*0.002*
N removal (kg/ha)	56 f	67 e	74 d	84 c	89 c	101 b	113 a	*<0.001*
Site 6 - MYLP								
Grain yield (t/ha	3.9 d	4.3 c	4.8 b	4.7 b	5.0 a	4.6 b	4.6 b	*<0.001*
Protein (%)	7.7 e	8.1 e	9.0 d	9.9 c	10.4 c	12.5 b	14.3 a	*<0.001*
Screenings (%)	0.6 d	0.6 d	0.9 d	2.1 c	2.1 c	4.9 b	8.4 a	*<0.001*
N removal (kg/ha)	52 g	61 f	75 e	81 d	91 c	101 b	115 a	*<0.001*
Site 7 - MYHP								
Grain yield (t/ha	4.0 bc	4.1 abc	4.3 a	4.3 ab	4.3 a	4.0 c	3.9 c	*<0.001*
Protein (%)	9.7 d	10.5 d	11.9 c	12.2 c	12.5 c	14.6 b	16.0 a	*<0.001*
Screenings (%)	0.9 d	1.4 cd	2.8 bc	3.4 b	4.1 b	10.6 a	10.6 a	*0.151*
N removal (kg/ha)	69 d	75 d	90 c	92 bc	94 bc	102 ab	110 a	*<0.001*
Site 8 - MYMP								
Grain yield (t/ha	4.1 d	4.5 c	4.7 ab	4.8 a	4.8 a	4.7 ab	4.6 bc	*<0.001*
Protein (%)	9.4 e	9.6 de	10.1 d	11 c	11.6 c	13.4 b	14.4 a	*<0.001*
Screenings (%)	0.9 d	1.0 d	1.4 d	2.5 cd	3.2 c	5.6 b	8.1 a	*<0.001*
N removal (kg/ha)	67 f	76 e	83 d	92 c	98 b	111 a	117 a	*<0.001*

Table 3. *Grain yield, quality and N removal for eight N response trials at Redhill and Bute 2023. Within a row, numbers that share a common letter are statistically similar.*

General crop performance across the paddocks

Redhill grain yields were highly responsive to N at all sites, with responses ranging from 1.2 t/ha at site 4 HYHP to 1.8 t/ha at site 1 MYLP, where maximum yield is compared with nil N applied (Table 3). Maximum barley grain yields were achieved with 75 kg N/ha or 100 kg N/ha across the four trial sites at Redhill. Grain quality was excellent with all samples having less than 1.0% screenings. Grain protein ranged from 8.7% to 14.8% and similar to grain yield was highly responsive to N fertiliser rate.

Maximum grain yields at Bute were slightly lower than at Redhill. The maximum yield at Redhill averaged 5.3 t/ha compared with 4.7 t/ha at Bute. Responses to N were also slightly lower, ranging from 0.3 t/ha at site 7 MYHP to 1.1 t/ha at site 5 HYLP. However, at Bute maximum grain yields were achieved from N fertiliser rates between 50 to 100 kg N/ha depending on the site. The low rainfall in September and October lead to moisture stress and haying off at some sites at high nitrogen rates (Table 3). This resulted in reduced grain yields and increased screenings at the highest N rates.

Grain quality was also more variable across the Bute paddock. The protein levels ranged from 7.7% to 16% and screening levels were higher in some treatments, up to 10.6%. Despite the moisture stress and resulting higher screenings the quality assessments meet BAR1 receival standards from all treatments and sites.

Partial gross margin analysis

Historical protein to predict crop N response

From the first season of results, there is evidence that historical protein can be used to indicate the variability in N demand for the current crop in a given paddock (Figure 5). At Redhill, as the 2022 protein increased the N rate to maximise PGM in 2023 reduced at a rate of 16 kg N/ha for each 1% protein increase. The response was steeper at Bute, where the N rate to maximise PGM reduced by 43 kg N/ha for every 1% increase in historical grain protein.

The absolute N requirement for a given historical protein varied between the two paddocks in 2023. At 10% protein in 2022 the N fertiliser rate required to maximise PGM at Redhill was 125 kg N/ha compared to 61 kg N/ha at Bute. The specific reason for the large difference in optimum N rates remains unclear from one season of results. The Redhill paddock produced higher maximum yields at 5.3t/ha compared with 4.7t/ha, but a 0.6t/ha increase in yield target should not increase optimum N rate by 64kg N/ha.

Fertiliser N requirements are affected by many factors including;

- Grain yield potential, both sites were predicted to have similar barley yield potentials and N requirements of 4.3 t/ha and 153 kg N/ha for Redhill and 4.8 t/ha and 163 kg N/ha for Bute.
- Soil available N pre-seeding was on average, slightly higher at Redhill (38 – 56 kg N/ha) compared to Bute (31 – 56 kg N/ha).
- Soil organic carbon levels (0-10 cm) were generally moderate to low in both paddocks. The Bute paddock is a sandy textured soil with organic carbon levels ranging from 0.9 – 1.0% indicating low potential for soil N mineralisation. At the Redhill paddock, the soil texture is loam to clay loam and the organic carbon values were higher ranging from 1.2 – 1.4% and therefore a higher potential for N mineralisation.

These factors suggest the Redhill site should have had more available N in the soil compared to Bute and therefore a lower N fertiliser requirement. However, the opposite was observed in the field and further investigation is required.

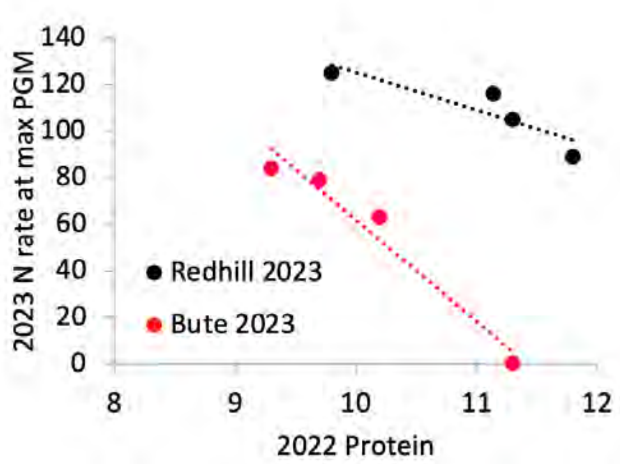


Figure 5. *The 2022 protein and N rate required to maximise PGM in 2023 for Redhill and Bute. Bute - y = -43.7x + 499, R^2 = 0.95, Redhill - y = -16.2x + 287, R^2 = 0.79*

Historical nitrogen removal to predict crop N response

Using historical yield and protein data the crop N removal from 2022 was calculated for each trial site (Table 1). The first season of trials show there is a strong relationship between the 2022 crop N removal and the 2023 fertiliser N requirement (Figure 6) and this relationship was similar for both the Redhill and Bute sites. As 2022 N removal increases, the N demand to achieve maximum PGM in 2023 was reduced. Where 2022 N removal reached 154 kg N/ha, no fertiliser N was required in the 2023 season to maximise PGM. In this instance all N from the following crop is being mined from soil reserves, which over time is expected to deplete organic matter reserves. When N removal reached 107 kg N/ha in 2022, N fertiliser rates that equal replacement were required to maximise PGM in the following season (Figure 6). Below this level of N removal, it was necessary to apply N fertiliser rates higher than removal to achieve maximum PGM. It is also expected applying higher fertiliser N rates than removal will result in an increase in soil available N going forward, as per the rationale behind N banking.

Using this methodology in practice suggests higher N fertiliser rates are required on low protein/low yielding areas of the paddock which may also increase the soil N bank. However, in high yielding/high protein areas of the paddock, soil N will be mined. If this strategy is used long-term it will result in a more spatially even N requirement across the paddock.

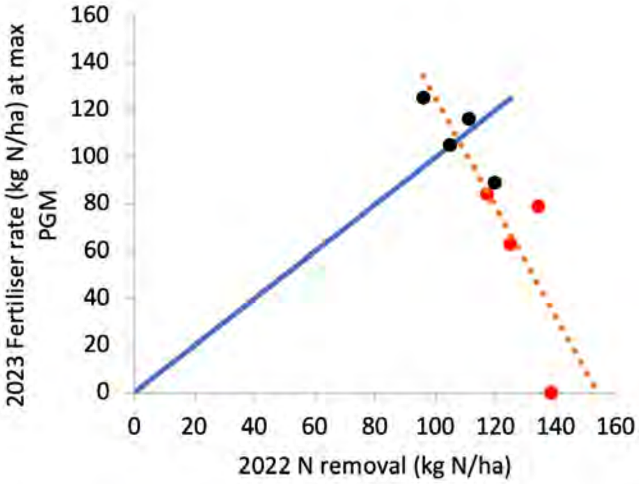


Figure 6. *Crop N removal 2022 and N fertiliser rate at maximum PGM 2023 for the Redhill (black circles) and Bute (red circles) trial sites, $y = -2.32x + 358$, $R^2 = 0.72$, the blue line shows where N removal = N applied*

Conclusions

Grain yield and protein maps collected in 2022 provided useful insight for understanding the variability in N response in the 2023 season. Protein data was more consistent at predicting soil available N and was useful in describing the variability in fertiliser N response in the following crop. The combination of 2022 yield and protein data into N removal produced a similar relationship with fertiliser N requirements for both paddocks. Further research is required across more paddocks and seasons to see if these relationships are maintained across a larger data set.

Acknowledgements

The authors gratefully acknowledge the financial support from SAGIT (TCO 02423) 'Using grain protein maps to optimise nitrogen fertiliser to paddock scale nitrogen variability' to conduct this research. We also acknowledge the following growers Linden & Rob Price and Bill Trengove for hosting the field trials this season.

SAGIT

DROUGHT RESILIENT SOILS:
MAPPING SOILS IN 3D TO INFORM LONG -TERM COST - EFFECTIVE AND YIELD RESPONSIVE SOIL & FERTILISER MANAGEMENT DECISIONS

***Authors:** Beth Humphris (Elders Jamestown), Jess Koch (Breezy Hill Precision Ag)*

***Funded By:** Future Drought Fund **Project Duration:** 2023 - 2024 **Project Delivery Organisations:** Upper North Farming Systems*

Key Points

- EM38 survey does a good job at differentiating between sands, loams and clays, but a poor job at differentiating between different clay types.
- The Upper North is home to varying clay types (carbonate, kaolinite and red clays) which all exhibit differing chemistries and hence management styles and yield potentials.
- Gamma radiometric soil survey maps, in combination with landscape and EM38 data, can spatially separate the above clay types, allowing growers to make more informed management decisions long-term around amendments and nutrition.

Background

GRDC has invested in a research and development project, which is being led by Sydney University, from 2022 through to 2024. This project aims to design products that could help growers map their soil constraints in three dimensions across paddocks, ultimately aiding in long term management decisions. There were 75 broadacre farms Australia wide where key precision ag soil data layers were collected and fed into the project to develop improved sampling strategies based on soil constraint maps, PAWC maps, and 'uncertainty' maps. The information from this project has been delivered to growers and agronomists through Australian software company PCT AgCloud.

From the 75 farms sampled, there were two that fell within the Upper North - one at JP Careys - 5km East of Booleroo Centre, and the other at Kochs/Arbons between Booleroo and Morchard. At these sites, EM38 soil surveys, Gamma radiometric surveys and comprehensive 0-100 cm soil cores were collected as part of the GRDC funded project. These sites also have several years of proximal data layers such as yield maps and satellite imagery.

Upper North Farming Systems group had the unique opportunity to utilise this data to develop a project, funded by the Future Drought Fund. The project aimed to analyse data layers (EM38, gamma radiometric, yield, biomass and soil core data) through a localised lens to identify yield production zones that can inform long term management decisions around nutrient and soil management.

Utilising these maps and soil cores to explain and define soil types is not new. This technology has been available to advisors and growers in Australia for over 20 years and has been widely used for precision ag management on the lower Eyre Peninsula and the wheat belt of Western Australia. The collection of these surveys in the Upper North however has been a slow path to adoption, due to lack of understanding for application and the value proposition in our soils, and ability to access a sensor for broad scale collection of data.

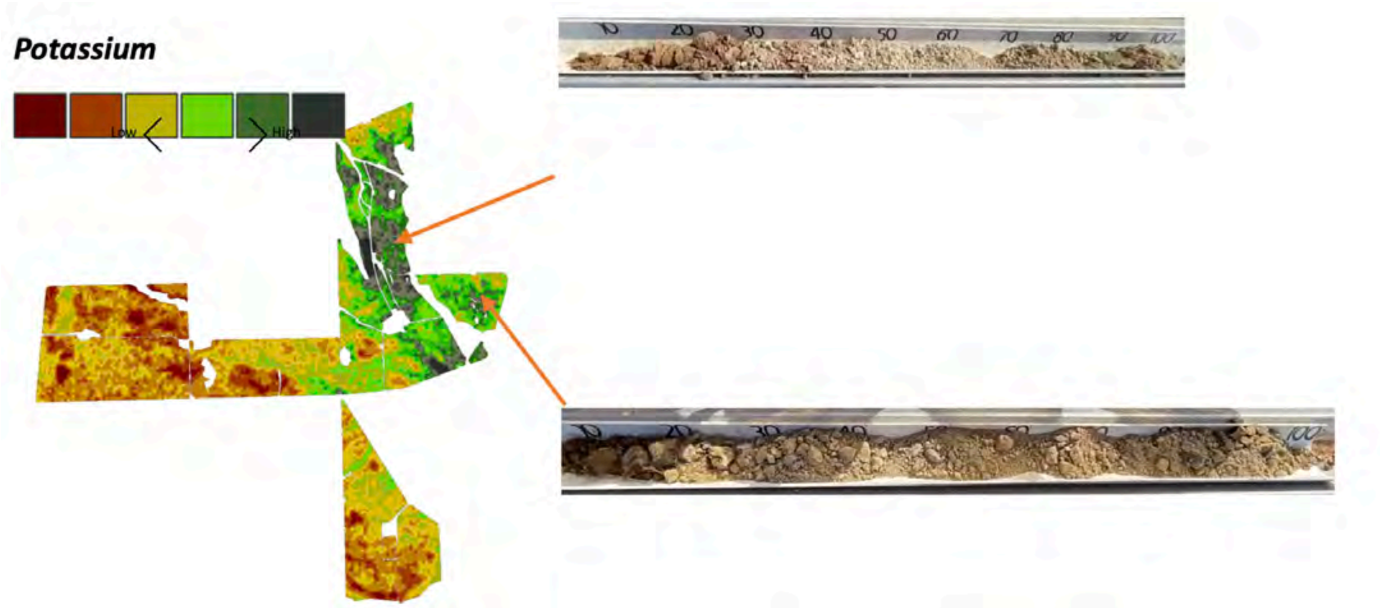
The results were presented in an interactive two-part webinar delivered by Jessica Koch and Beth Humphris in early 2024 and further summarised in the below report.

Results

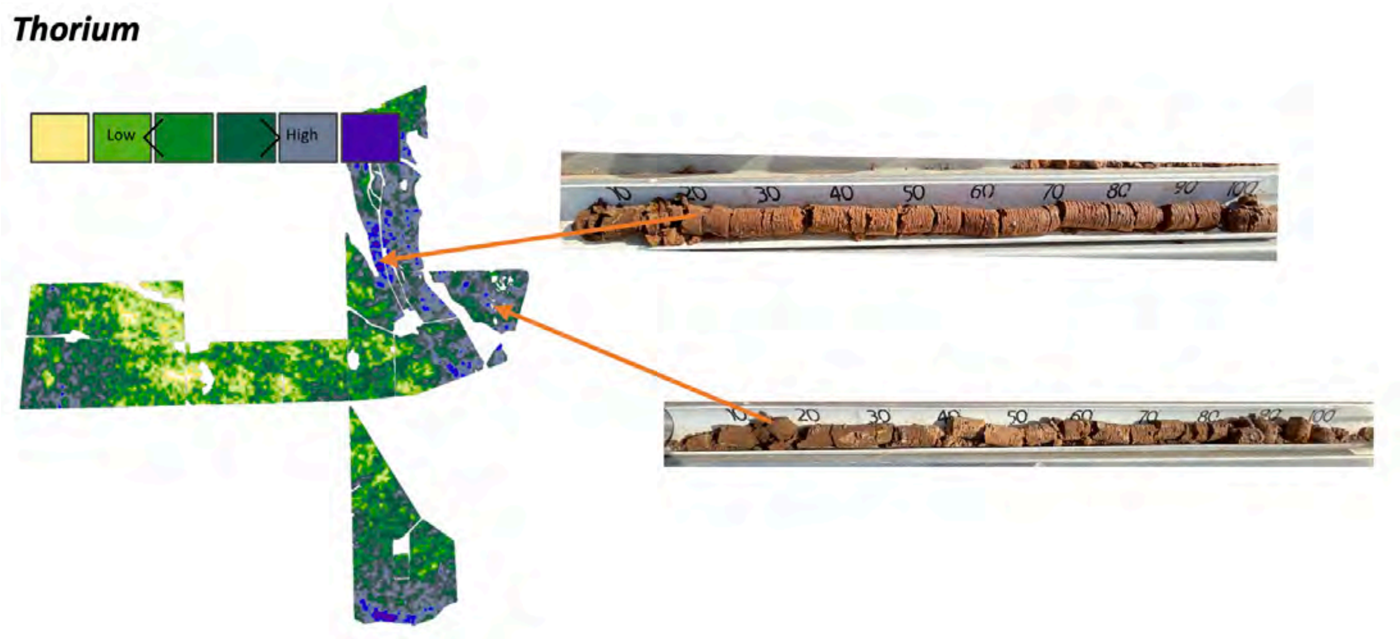
The Upper North Farming Systems region is home to a large variation in clay types, each presenting different agronomic challenges and management requirements. This includes anything from a highly alkaline carbonate to a low CEC kaolinite or a fertile red clay. EM38 soil surveys aren't a great indicator of differing clay soils across the field. However, when paired with gamma radiometric layers, the pairing of the two can assist with refining these differing clay zones.

Radiometric is also useful for the study of geomorphology and soils. Radiometric is also known as Gamma-ray spectrometry. A radiometric survey measures the spatial distribution of three radioactive elements (potassium-K, thorium-Th and uranium-U) in the top 30-45 cm of the earth's surface. This distribution data can be processed into a map of each elemental attribute and when paired with EM38 data can be a powerful tool of defining complex soil zones. Each of these account for a different chemical aspect of the soil and when paired with soil cores and ground truthing can help to divide paddocks into respective management zones.

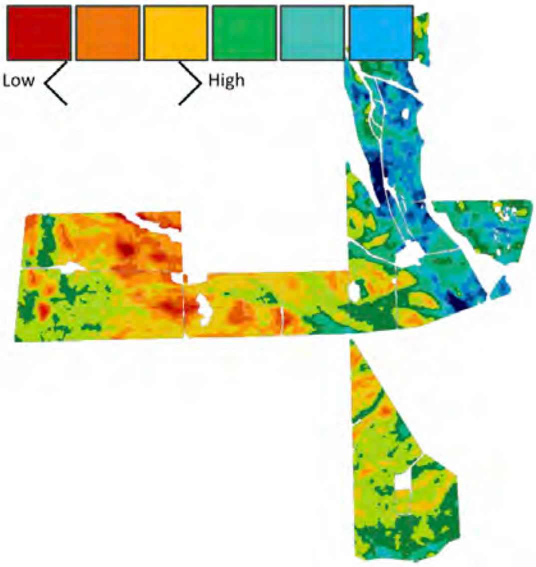
Each of the map layers below consider an important geological land forming factor that inherently feeds into the soils yield potential spatially.



The potassium layer can be driven by potassium dominated clays such as degraded granite or limestone (calcarosols). In the above map, the areas of dark green indicate soil types with high carbonate content, with lighter green indicating soil types with a fertile topsoil, moving into carbonate in lower fractions of the profile.



The thorium layer can be driven by 'buckshot' soil types, high in iron. These are typically clay types that are strongly red in colour. The above soil cores indicate examples of these soil types. Typically, these are assigned a higher yield potential compared to the carbonate types as shown on the potassium layer.



Uranium

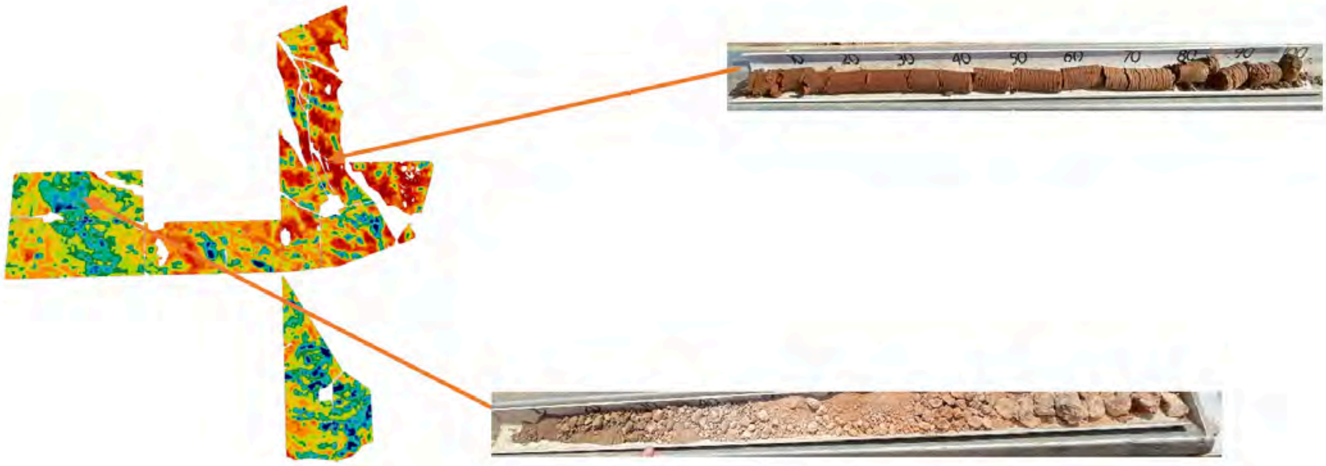
The uranium layer commonly shows a high level of noise and is therefore typically given the least weighting in analysis. This is due to interference from climatic conditions such as wind, rain and humidity.

Total Count

The total count layer is a combination of the above potassium, thorium and uranium maps.

EM38 (50 cm)

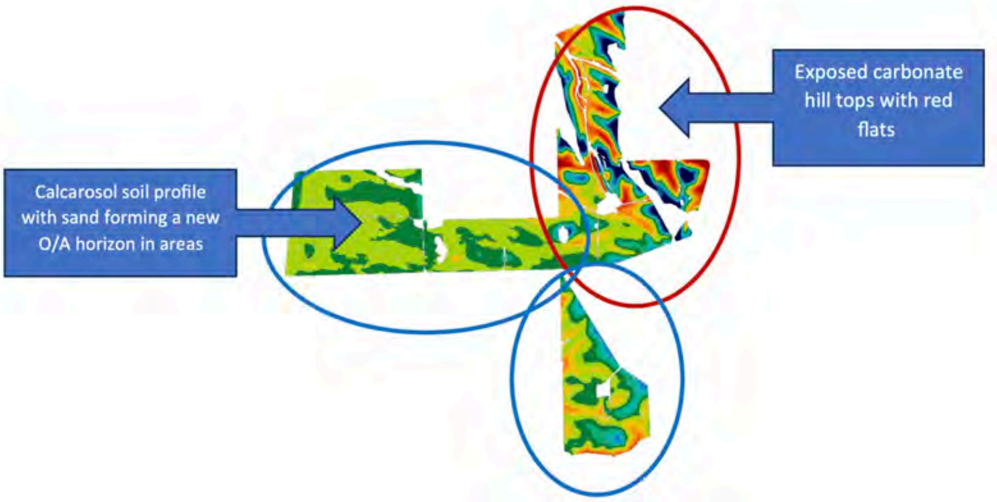
EM38 refers to electromagnetic soil mapping. This data is collected by vehicle towed sensor that measures electroconductivity in the soil at designated depths. This measurement is mostly influenced by soil texture in particular – clay content, soil salinity and moisture levels. Higher EM38 values in this case, are indicated in blue (soils with greater negative charge).



Landscape Change

Landscape change maps are generated using elevation data:

- An elevation map provides absolute height differences across a field – expressed as a metre above sea level value. Red indicates a lower value, blue indicating a higher value.
- A landscape change map can give more intricate detail about localised height difference. To explain in basic terms – you could be standing on top of a hill, but still be standing in a localised, minor hollow. The landscape change map picks up this detail, whereas the elevation map does not. The landscape map could provide great value and insight into movement (shedding and pooling) of water and cold air movement and soil type (due to topography). It is expressed as a positive or negative value, once again represented by red as low, and blue as high.



Conclusions

Bringing it all together into Management Zones

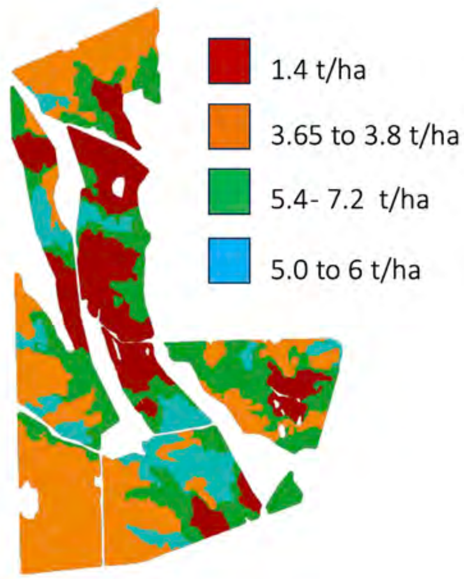
Using the above layers, management zones were generated, statistically clustering 'like' zones between correlated maps to help differentiate dominate soil types across the farm. These could then be 'ground truthed' against the comprehensive soil core data and by physically driving the paddocks. Models could also be re-run, increasing/decreasing the influence of different maps depending on the soil type in question.

It was decided, due to the inherent land forming characteristics of the property, the block would be split into two major zones for analysis. The first zone, around the house, was defined by quick changes in elevation, with dominant soil types being exposed carbonate profiles on hilltops and fertile red clays on lower lying areas. Alternatively, the paddocks to the western and northern end of the farm showed much less variation in elevation and were defined by a carbonate throughout the original soil profile and in areas a new O/A horizon comprising of sand through to a sandy loam that had historically moved with water from surrounding hilltops.

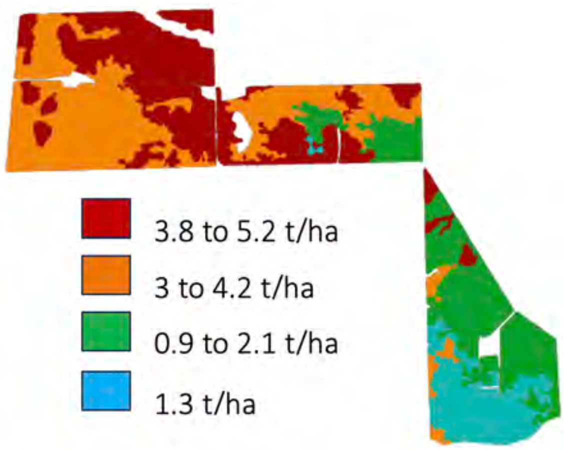
Using soil texture and gravel percentage for the 0-15, 15-30, 30-60 and 60-100 cm fractions, a yield potential was calculated based on water holding capacity of the soil for each soil core. Then, an average for each soil core within each zone was used to determine the productive capacity of each management zone. Where there were sufficient cores, a standard deviation was also calculated to give a final yield bracket. These yield estimations can then be used, in combination with seasonal rainfall to help in management decisions, particularly in-season nitrogen management.

These initial management zones and yield values will serve as a starting point on this farm. As more data is collected over time, these zones and yield potentials will evolve, becoming more accurate.

Macro Analysis



Zone	Red	Orange	Green	Blue
Soil Type	Exposed Carbonate	Red clay over carbonate	Red Clay	Red Clay + High OC
Management Style	Work with soil constraints to maintain yield. There will be a lower ROI for inputs in this zone.	Ensure 0-30 cm fraction is ameliorated to maintain yield.	Economic to ameliorate soil constraints if present in this zone. Yield should be pushed where possible and fertility should be a main focus.	



Zone	Red	Orange	Green	Blue
Soil Type	Sand over loam	Loam	Red Clay	Red clay over Carbonate
Management Style	Focus on correcting soil constraints in the 30-60 cm fraction of this zone. Feed this soil type as ROI will be high here.	Economic to ameliorate soil constraints if present in this zone. Yield should be pushed where possible and fertility should be a main focus.		Ensure 0-30 cm fraction is ameliorated to maintain yield.

Ground Truthing for Micro-analysis

Whilst the majority of the zones were in line with soil cores and grower knowledge, there were a few micro-trends that were missed when running the analysis on a 'whole of farm' basis. These were picked up in the ground truthing process of driving across the property. Above is one such example, where a ~80 ha paddock was zoned as a red clay over carbonate. However, when driving the paddock, a rise was observed through the centre of the paddock, with exposed carbonate and a fertile red clay soil type was found to the northeastern corner. Therefore, this paddock was re-zoned individually to account for these changes. This process was also completed in three other paddocks across the farm.

Economics

An EM38 dual depth survey will typically cost \$10/ha. The gamma radiometric sensor is typically run in tandem to an EM38 sensor and costs an additional \$4/ha, depending on the supplier. Elevation data can be collected at the same time, assuming RTK signal is used, for no additional collection cost. The data from these surveys is then sent to a precision ag consultant to process out at an additional cost.

Once these layers have been collected, they can be utilised long-term, as soil chemistry and landscape patterns will not change over time.

Gamma Radiometric Sensor

EM38 Sensor

Summary

The above management zones, in combination with the yield potential assigned to each zone, can be utilised moving forward to aid in management decisions. This process may appear complex, but the underlying advantage for the grower and the consultant is to make sound and well-informed input decisions throughout the growing season and when applying expensive corrective ameliorants.

Greater understanding of major sub soil constraints and water holding capacity of each soil zone means that the yield potential of these soils can be calculated with confidence. This is invaluable in aiding with calculations for variable rate management, for example, the application of nitrogen.

Acknowledgements

This project utilised data that was collected as part of the GRDC's investment into the 'Next Generation Machine Learning Models for 3D Soil Mapping Applications', in partnership with The University of Sydney and PCT AgCloud.

This project received funding from the Australian Government's Future Drought Fund: project title '*Building farming systems resilience and future proofing the impacts of drought through accelerating the adoption of proven cost-effective and yield responsive soil and fertiliser management practices by farmers across southern Australia*'. Thank you to our project partners Mallee Sustainable Farming.

A special acknowledgement to the growers - Joe and Jess Koch at Breezy Hill and John and Nicolle Carey for providing land and sharing data.

The data was processed by Jess Koch at Breezy Hill Precision Ag Services and interpreted by Beth Humphris at Elders Jamestown. This report was complied by both Beth and Jess.

Australian Government Department of Agriculture, Fisheries and Forestry
Future Drought Fund
Elders BETH HUMPHRIS CONSULTANCY
Breezy Hill Precision Ag Services

LIVESTOCK & MIXED FARMING SYSTEMS

PDS: IMPROVED PASTURE MANAGEMENT SYSTEMS – 2023 update

Author: Rachel Trengove, Project Officer, UNFS

Funded By: Meat & Livestock Australia (MLA) | **Project Title:** PDS: Improved Pasture Management Systems
Project Duration: Feb 2022 – Feb 2025 | **Project Delivery Organisations:** UNFS, CIBO labs

Background

The Upper North Agricultural Zone of South Australia is a predominantly mixed farming system incorporating a rotation of pastures and cereal and/or legume/canola cropping. Over 85% of the farmers in the region operate under this model, however there are significant challenges balancing the needs of the cropping enterprise with a livestock production system.

Currently this pasture phase is often a monoculture of medic or vetch to provide a grass free break to the cropping rotation, and build N in the soil for the following cereal. There are problems associated with grazing of a monoculture including animal health issues such as red gut, bloat, pulpy kidney and cow pea aphid toxicity. They are also slow to establish in the cold winter climate of the region and produce limited residues exposing the soil to erosion over the summer period. Producers are interested in assessing whether a mixed sown pasture can provide equal or better food on offer (FOO) and superior animal performance, improve soil cover and do so without negative implications for the cropping program.

Many producers are becoming aware of the importance of feed budgeting and understanding their available FOO, however with limited labour units on most farms, producers struggle to fit this assessment into their work program. Producers have outlined the need for better understanding of FOO, pasture quality, feed budgeting and are interested in assessing alternative tools available to make planning and managing pastures easier and therefore more likely to be done.

Currently a low percentage of producers are implementing mixed sown pastures (10-20%) and a similar percentage are using feed budgeting tools and/or pasture monitoring assessment tools (remote or in-field).

The aim of this PDS project is to improve the pasture management systems implemented in the Upper North of South Australia through demonstrating:

1. Better pasture options that improve the mixed farming enterprise, and 2. That a better understanding of Food On Offer, including feed budgeting and the use of remote sensing pasture assessment tools will improve overall livestock productivity, enterprise profitability and farm sustainability.

Methodology

Demonstration: Trial pasture species mixes including measures of biomass and animal performance at 1 site in the Upper North Region.

Site located near Caltowie North.

Compare performance of the sown mixed pasture (demonstration) with the traditional monoculture or self-regenerating pasture (control). Paired trial sites (2 similar (scale and soil-type) paddocks each with 1 treatment per paddock per site. The site is one 25 ha paddock split into 2 with electric fencing (to ensure paddock history is comparable). Each pair is sown with the same seeder, sowing time and treated with same fertilizer regime. Grazing of paired sites occurs at the same time with similar grazing pressure from a mob of 300 hoggets split in half. A pre-grazing final ground cover level and/or sheep condition will be stipulated and when one of the two paired sites/mobs reaches this both sites will cease to be grazed. In the event that one of the paired paddocks can be grazed after recovery then sampling will be repeated for all parameters.

Paired site for 2023:

i. Single Species: 5kg/ha Subzero (forage brassica)

ii. Mixed Species: 2kg/ha Sub Zero, 65kg/ha Kracken Barley, 45kg/ha Morawa Vetch

Assessments/measurements for 2023:

i. Animals weighed in and out

ii. Animals Condition Score (CS) in and out

iii. Biomass cuts, feed quality (feed tests), groundcover and composition in-field assessment pre & post grazing including a recovery assessment 1 month post grazing

iv. Remote monitoring of biomass/FOO and groundcover – Cibo Labs satellite imagery – Pasture Key Service

v. v.Monitoring Agriwebb FOO reports using integration of satellite imagery data into the App

	Av Pre Graze Weight	Av Post Graze Weight	Av Pre Graze CS	Av Post Graze CS	Av Weight gain	Av CS difference
2022 Results						
Mixed Species	47.47	55.4	Not available	3.49	7.93	Not available
Single Species	46.2	50.01	Not available	3.44	3.81	Not available
2023 Results						
Mixed Species	40.17	48.95	3.15	3.46	8.78	0.31
Single Species	41.01	51.25	3.22	3.48	10.24	0.26

Table 1. *Summary of results 2022 and 2023 – Caltowie North grazing site.*

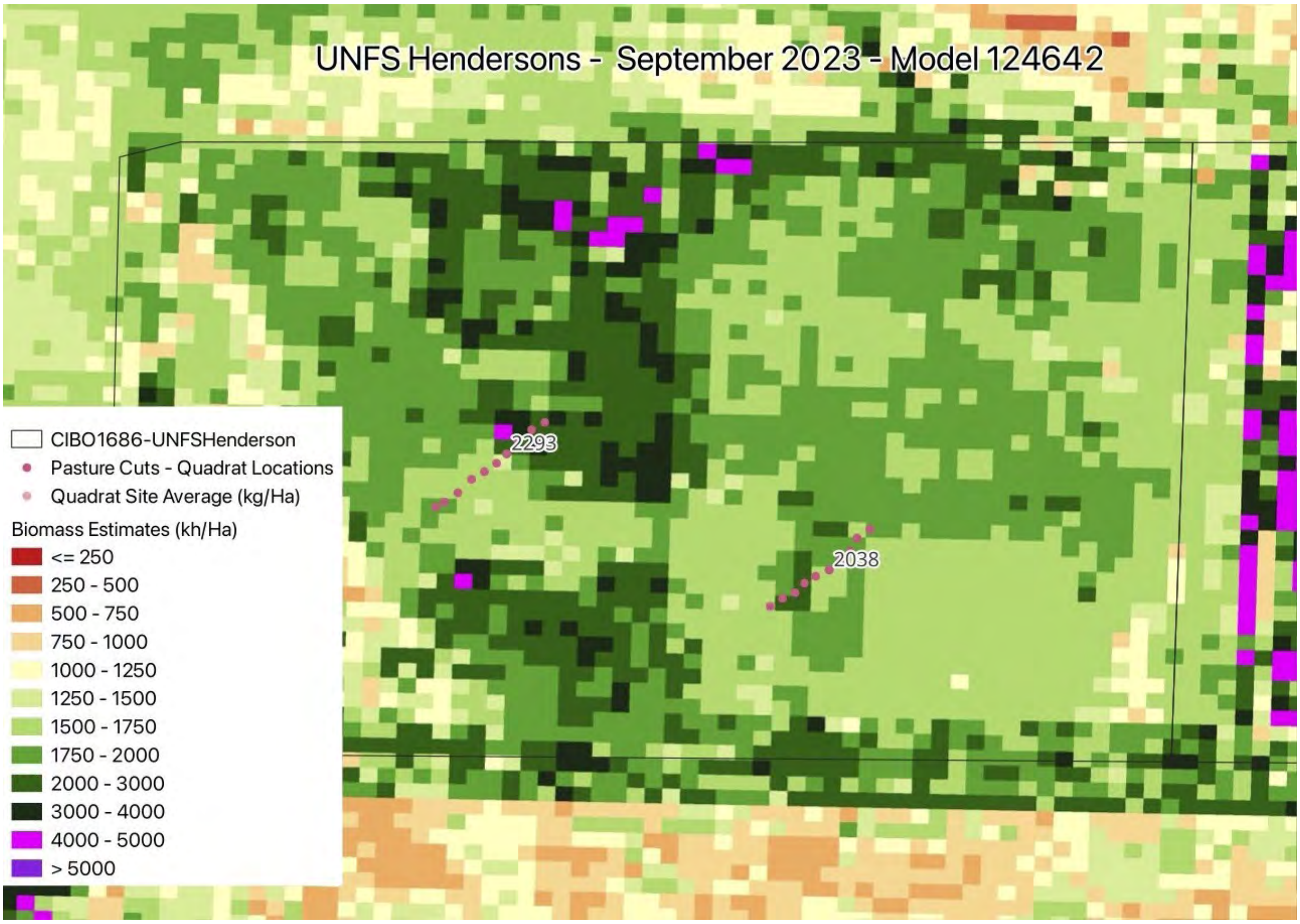


Image 1. *Satellite imagery – mixed and single species pastures – September 2023.*

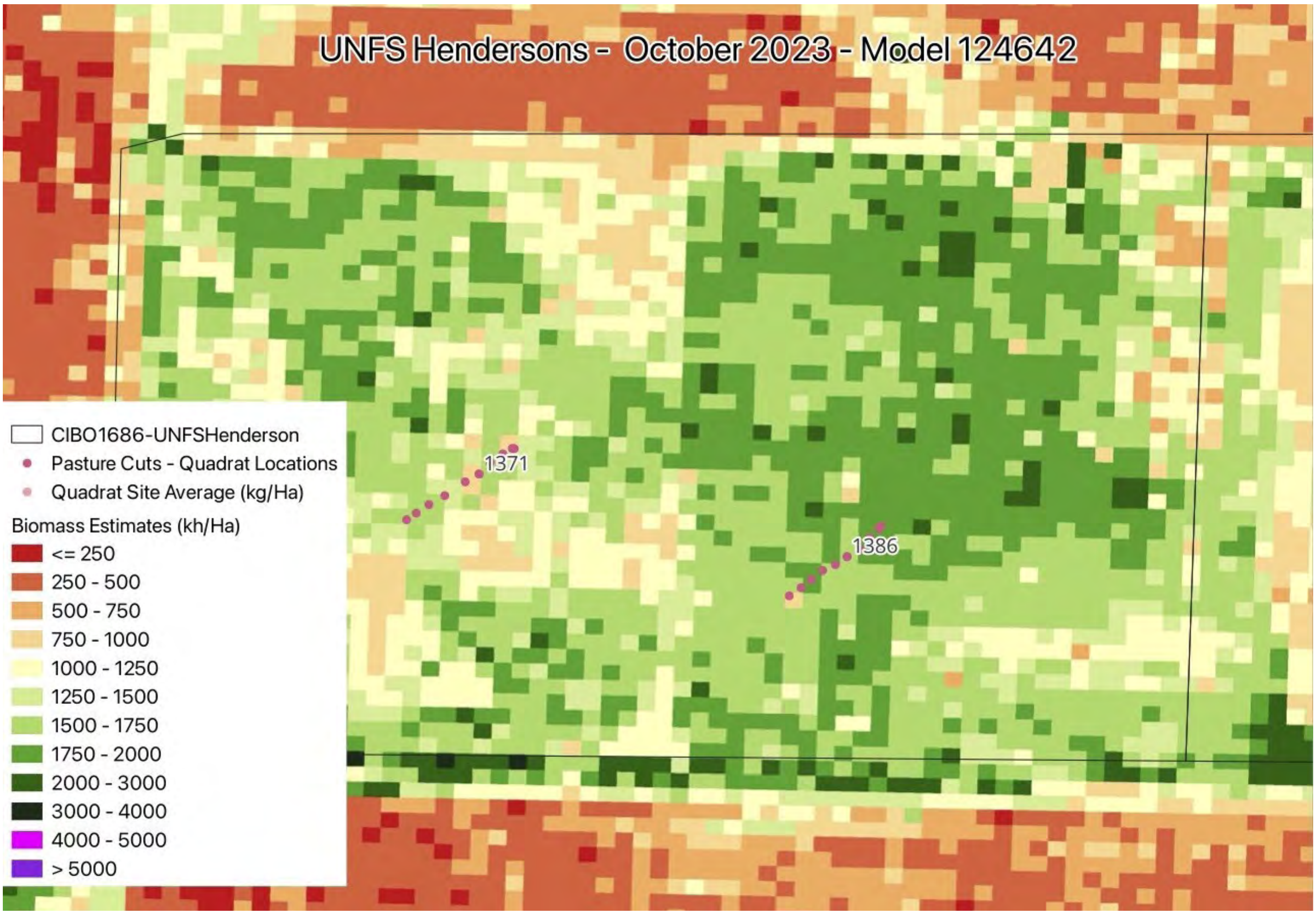


Image 2. *Satellite imagery – mixed and single species pastures – October 2023*

It was hypothesized that the mixed species pasture would have better FOO across the year and improved groundcover. Voluntary ryegrass and barley grass in 2023 meant the composition of the single species pasture resembled a mixed species pasture, as seen in image 3 & 4. As a result, field biomass measurements and satellite imagery estimates were similar for both treatments, see image 1 & 2.

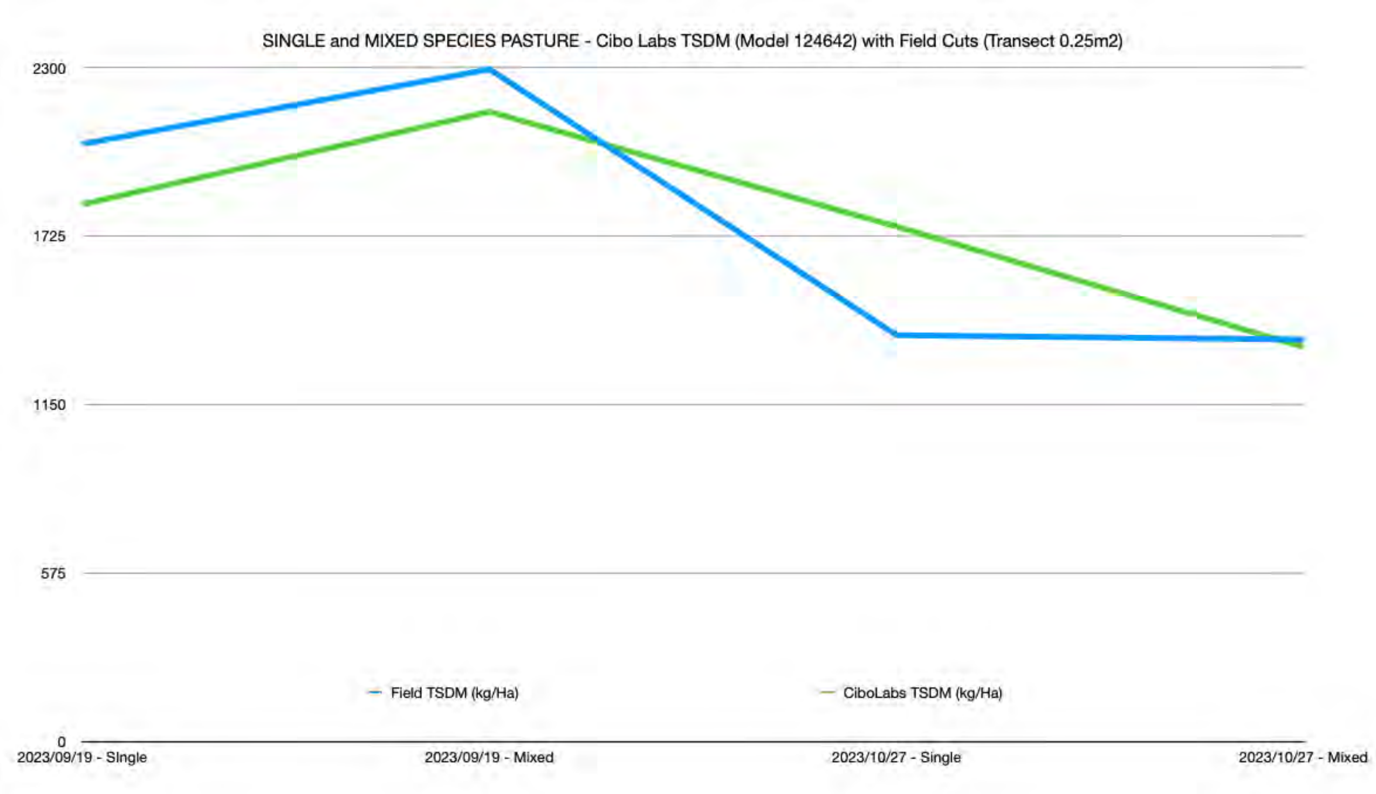
Image 3. *Single Species pasture, pre-graze (July)*

Image 4. *Mixed species pasture, pre-graze (July)*

Image 5. *Sub zero (Brassica napus)*

It was predicted that the mixed species pasture would result in improved live weight growth in sheep and better condition scores. However, weight gain in 2023 was slightly higher for sheep grazing the single species pasture as shown in Table 1. This higher weight gain is attributed to a good balance of protein and energy giving better nutritional value shown in pasture feed test results for the single species pasture. The higher nutritional value of the single species pasture is explained by the higher sowing rates of subzero (5kg compared with 2kg/ha in mixed species) and therefore increased weight gain in sheep. Condition score differences pre-grazing vs post-grazing was higher for the mixed species. Differences for both weight gain and condition scores were not significant.

Forage brassicas (shown in image 5) are highly digestible with high metabolisable energy and low fibre content compared to other forage sources. They also provide adequate levels of crude protein for growing livestock. Brassicas also maintain their quality for longer than many other forage options, because they maintain a higher proportion of leaf and are often slower to initiate reproductive development. Hence, while brassicas may not produce as much biomass, their higher quality means they often provide equal or more metabolisable energy for livestock.



Graph 1. *A comparison of field biomass cuts and satellite imagery estimates of TSDM (kg/ha) for September (post-grazing) and October (1 month recovery) 2023.*

Biomass pasture cuts were sampled to ground truth the satellite imagery estimates, See Graph 1, which shows results for September (post-grazing) and October (1 month recovery post-grazing). The graphed results indicate confidence in the estimated Total Standing Dry Matter (TSDM – kg DM/ha). 'Dry Matter' refers to the weight of plant material available without water and provides a consistent measure to compare feeds and pasture types across grazing environments or when developing livestock rations. July (pre-grazing) biomass cut measurements and satellite imagery data did not correlate well. The modelling of TSDM (kg DM/ha), relies on field data collected and there is insufficient data for early growth phases or lush green pastures for accurate modelling at this stage. The higher the DM value of a pasture, the more accurate the modelling of estimates. 2024 data sets for pre-grazing at a similar time of the year around July will enable further refinement of the modelling.

The satellite imagery was integrated into the producer's farm management app which uses the data to estimate Feed on Offer (FOO) in total kg/paddock and generate an estimate of number of grazing days remaining (see image 6). The FOO estimates were utilized as a tool by the producer throughout the season. The grazing day estimates were comparable to the anecdotal visual observations made by the producer through spring. The use of satellite imagery to assess and monitor pasture growth in the Upper North may improve capacity of farmers to undertake feed budgeting in the future.

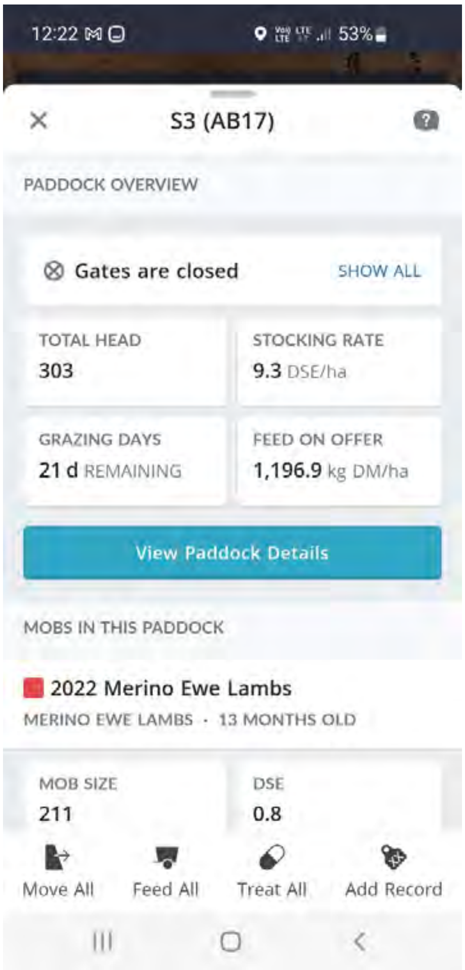


Image 6. *Estimate Feed on Offer (FOO) in total kg/paddock in AgriWebb App*

Image 7. *Ewe hoggets grazing the demonstration pastures near Caltowie North.*

This PDS project runs for the final year in 2024 with a similar demonstration planned. Three years of data and experience from the project will provide livestock producers in the Upper North with a better understanding of the costs and benefits of implementing a more complex, multi-species pasture into their rotations and provide them with the confidence to trial these in their enterprise. The PDS project has used technology such as CIBO Labs PastureKey and techniques such as in-paddock biomass monitoring and feed quality testing to increase the information used for decision making and the confidence to make decisions based on the overall profitability and productivity of their enterprises.

Acknowledgements:

- Thank you to the 2023 demonstration site landholder – Alison Henderson
- This Producer Demonstration Site project is funded by Meat & Livestock Australia.

UNFS Upper North Farming Systems

Producer Demonstration Site

mla MEAT & LIVESTOCK AUSTRALIA

PDS: LOTSA LAMBS – *Improving Reproduction Success - 2023 update*

Author: *Rachel Trengove, Project Officer, UNFS*
Funded By: *Meat & Livestock Australia (MLA)* | ***Project Title:*** *PDS: LOTSA LAMBS - Improving Reproduction Success*
Project Duration: *Feb 2022 - Feb 2025* | ***Project Delivery Organisations:*** *UNFS, Talking Livestock*

Background

As a result of the impact of drought, ewe numbers are low both locally and nationally. To facilitate the rebuild of the flock, it is necessary to produce more from the existing ewe base through maximising reproductive efficiency and minimising mortality. Seasonal conditions have led to many producers aiming for an autumn lambing to utilise feed available to lambs due to shorter springs and extended low feed on offer due to extended summer conditions. Producers are aware of the research that indicates higher lamb survival from twin bearing ewe flocks run as smaller groups at lambing. Most are unsure how to best implement this strategy, particularly in a mixed farming system with a focus on cropping. On the ground solutions and demonstrations are required for producers to be able to see how this strategy could possibly work in their sheep flock.

Many producers have adopted the strategy of feeding ewes in containment in late summer and early autumn, often through much of their pregnancy. Common practice for a Nov-Dec joining is a 7-8 week joining period, and a lack of pregnancy scanning resulting in significant variation in nutritional requirements of the ewes at any one time. The adoption of early pregnancy scanning, scanning for multiples and condition scoring should allow targeted feeding of mobs while held in containment, and reduce problems such as dystocia due to over feeding of later lambing single bearers.

Part of this project will look at improved genetic selection in commercial flocks, incorporating data collection and analysis on reproduction success, understanding ram genetics and Merino Flock Profiling (MFP). The aim being to refine breeding objectives and plan for future breeding decisions with fertility in mind, including an understanding of the traits to focus on, to breed robust animals for UNFS production systems.

Methodology

Review and demonstrate:

1. At two sites demonstrate the value of;
   i. reduced joining period to 5-6 weeks
   ii. correct ewe to ram ratios
   iii. managing and feeding mobs separately based on condition score and foetus number.
   iv. matching nutrition needs to rations

Measure feed consumption, lamb survival and ewe condition score. Analyse gross margins and cost of production ($/kg lamb produced). Record other observations of variations in animal health and condition. (2 lambing cycles).

2. Establish two demonstration sites for improved pregnant ewe management incorporating:
   i. Development of a clear breeding objective including improved genetic data and decision making
   ii. Pregnancy scanning
   iii. Splitting twin bearing ewes into smaller groups for lambing.
   iv. Ewe condition scoring and segregation within single bearing ewes based on condition.

Measure lamb survival and assess the cost:benefit of the practices. Record other observations of variations in animal health and condition. (3 lambing cycles)

Run 5 extension activities for UNFS members. The workshops to be delivered by recognised industry experts in condition scoring, feed budgeting, impact of mob size, effective confinement feeding, using ASBVs and the RamSelect app, breeding objective development and interpreting Merino Flock Profile results. Principles will be based on the AWI Life Time Ewe Management Course content.

Results and Discussion

	Number of lambs	Number of ewes	% Lambing	Industry Target % (sheep connectSA website)
Site 1				
Singles 2022	68	62	110%	92%
Multiples 2022	150	128	117%	150%
		AV	115%	
Site 1				
Singles 2023	71	65	109%	92%
Multiples 2023	104	76	137%	150%
		AV	124%	
Site 2				
Singles 2022	124	139	89%	92%
Multiples 2022	198	225	88%	150%
		AV	88%	
Site 2				
Singles 2023	327	232	141%	92%
Multiples 2023	453	292	155%	150%
		AV	149%	
Site 3				
Singles 2023	333	322	103%	92%
Multiples 2023	299	181	165%	150%
			126%	

Note: Ewe deaths & drys removed from data

Table 1. *Lamb marking results – multiple and single bearing ewes*

Site 1 and 2

Two demonstration sites were provided by Upper North producers located at Gladstone and Caltowie to implement the practice of pregnancy scanning and lambing multiples in smaller mobs. The demonstration sites ran twin-bearing ewes in mobs of 100 or fewer during lambing to reduce the risks of mismothering, ewe-lamb separations, and lamb mortality. 2022 presented challenging lambing conditions at the demonstration properties due to a late break in the season, lack of feed on offer for pregnant ewes and harsh cold conditions during lambing. Adequate shelter is a limiting factor for both site 1 & 2 and was reflected in poorer results in 2022 compared with 2023, as shown in Table 1.

Site 1 showed an increase in lamb survival in 2023 from already strong results in 2022. Site 2 showed the most significant improvement in lamb survival from 2022 to 2023. Smaller paddocks were available at site 2 in 2023 which enabled mob size to be further reduced for twin bearing ewes. Additionally, ewe mortality decreased at site 2 in 2023.

Environmental factors also played a role in positive results in 2023, with an earlier break in the season providing nutritional green pick for pregnant ewes and lambs and as well as milder weather conditions at the time of lambing. Ewes were supplementary fed at both sites for 2022 and 2023 with rations provided as part of the project for consistency.

Site 3

Feedtests on hay, grain and pastures were conducted and rations provided for optimal ewe health during pregnancy. Ewes were pregnancy scanned and twin bearing ewes split into mobs of less than 100. Lambing results were above industry targets at this site, indicating that implementing practices such as pregnancy scanning, matching nutrition with pregnancy status and lambing twin bearing ewes in smaller mobs results in improved reproductive success. Single bearing ewes had an average condition score of 3, and twin bearing ewes were 3.5 which was ideal condition for ewes pre-lambing as a result of tailoring supplementary nutrition to ewe needs as well as seasonal conditions being favourable with good feed on offer in 2023 at the time of late pregnancy and lambing.

Conclusion

The PDS project has enabled demonstration site landholders to have individual sessions and ongoing support with Deb Scammell from Talking Livestock. These sessions plan for selective management of twin-bearing ewes, including ewe nutrition, condition scoring, feed budgeting, the impact of mob size, and effective confinement feeding based on the principles of Life Time Ewe Management. Breeding objectives and genetic selections have been taken into consideration at all demonstration sites as part of the management decisions.

Segregation of ewes within mobs based on condition score was recommended but not always practical or possible due to paddock availability at the demonstration sites. If there is too much of a range in condition scores while supplementary feeding, it can affect ewe mortality, lamb birthweights and survivability This could have improved lambing results further and is a management practice that could be considered by these producers into the future.

Overall, results so far indicate that reproduction success can be maximised by implementing the best practice management strategies demonstrated in this project. This demonstration will continue in 2024, with additional confinement feeding sites in the project. Undertaking a cost benefit analysis will provide producers with the confidence to consider implementing these principles to their enterprise.

Image 1. *2023 PDS landholders – Alison Henderson, Lachie Smart, Andrew Kitto and Nathan May with Rachel Trengove, UNSF and Deb Scammell, Talking Livestock.*

Image 2. *Workshop 4 at Lachie Smart's farm, Wirrabara – Containment feeding pregnant ewes and lambing in smaller mobs demonstration.*

Image 3. *Workshop 4 – Rachel Trengove and Deb Scammell collecting feed samples in Lachie Smart's lambing paddock. Lachie*

Image 4. Workshop 4 – Guest presenters – Colin Trengove, ProAg Consulting, Caitlin Evans, Adelaide University, Jessie White, Northern & Yorke Landscape Board, Deb Scammell, Talking Livestock, Rachel Trengove, UNFS and Lachie Smart, PDS landholder, Wirrabara.

Image 5. *Workshop 4 – Guest presenters – Colin Trengove, ProAg Consulting, Deb Scammell, Talking Livestock, Megan Tscharke, Adelaide University with Rachel Trengove, UNFS and workshop hosts, Michael & Katherine Battersby.*

Image 6. *Pregnancy scanning at Andrew Kitto's farm to split twin bearing ewes into smaller mobs.*

Activity	Date & Location	Workshop Objective	Activity Description
Workshop 3: Implementing eID's on farm and Improving Reproductive Success	23rd February 2023 Caleb Girdham's farm, Melrose	To provide a hands-on demonstration by presenter and farmer on how to incorporate technology into containment yard design as well as implementation of eID's on farm for efficiency and productivity outcomes.	**NATHAN SCOTT (Achieve AG Solutions) – eID – what's in it for me?** The what, how, and why (or why not) of applying it practically on your farm. ▪ Equipment options ▪ How the technology works ▪ What data to collect ▪ Understanding the implications of applying selection pressure ▪ How to collect data & tips on managing data **DEB SCAMMELL (Talking Livestock) – Improving Reproductive Success** ▪ Pregnancy requirements & this season's feed ▪ The fit of containment this year ▪ Containment costs $$ - benefits and feed on offer – the data FREE FEED TEST WAS AVAILABLE FOR ALL PARTICIPANTS STICKY BEAK AT GIRDHAM'S AUTODRAFTER, YARDS AND CONTAINMENT FEEDING SET UP CO-FUNDED WITH N&Y LANDSCAPE BOARD
Workshop 4: LOTSA LAMBS Improved Weaner Management	9th June 2023 Smarts Farm, Wirabara 20th June 2023 Battersby's Farm, Wilmington	For guest presenters and sheep experts to provide valuable insights and guidance on optimizing weaner management practices such as nutrition, health, and other relevant topics.	**Deb Scammell, Talking Livestock** ▪ The weaning process ▪ Weaner growth targets ▪ Weaner nutrition & maximising spring feed ▪ Successful breeders from weaners **Colin Trengove, ProAg Consulting** ▪ Strategies to optimize weaner health ▪ Preventing worms and other common challenges **Adelaide University - Heat Stress in Sheep project in the Upper North** ▪ Managing heat stress in sheep ▪ The benefits of using vitamins & melatonin (Regulin®) to improve the productivity of sheep during periods of heat ▪ Results from the Upper North FREE FEED TEST WAS AVAILABLE FOR ALL PARTICIPANTS STICKY BEAK AT SMART'S AND BATTERSBY'S YARDS AND CONTAINMENT FEEDING SET UP CO-FUNDED WITH N&Y LANDSCAPE BOARD

Table 1. *Summary of the extension activities undertaken in 2023 for PDS: LOTSA LAMBS*

Acknowledgements:

▪ Thank you to the 2023 demonstration site landholders for sharing data and hosting workshops – Alison Henderson, Andrew Kitto & Nathan May and Lachie Smart

▪ This Producer Demonstration Site is funded by Meat & Livestock Australia.

IMPROVING *the* PRODUCTIVITY *and* CLIMATE RESILIENCE *of the* AUSTRALIAN SHEEP INDUSTRY

Author: *Megan Tscharke [1], Jamee Daly [1], Billie-Jaye Brougham [1], Bobbie Lewis Baida [1], William van Wettere [1]*
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THE UNIVERSITY *of* ADELAIDE

Trial Information

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Caltowie

Alison Henderson

Orroroo

Brenton Byleree

Spalding

Tom and Sam Trengove

Quorn *(2024 trial site only)*

Paul Rodgers

Trial Design:

Randomised block design

Table 1. *Ewe numbers and antioxidant treatments (Regulin® - melatonin; ADE – vitamin) at Upper North Farming Systems sites, 2023/24*

Location	Number of ewes	Control	Regulin®	ADE
Spalding	572	299	273	
Quorn	350	96	104	116
Caltowie	195	97	98	
Orroroo	160	76	84	

Table 2. *Change figure title to: Ewe numbers and antioxidant treatments (Regulin® - melatonin; ADE – vitamin) at Upper North Farming Systems sites, 2023/24*

Location	Number of ewes	Control	Regulin®	ADE
Spalding	617	313	304	
Caltowie	117	58	59	
Orroroo	212	106		106

Livestock:

Merino

Key Points

- High ambient temperatures during mating and pregnancy can cause heat stress in sheep which impair reproductive outputs, costing the Australian sheep industry approximately $168 million each year.
- Alleviation strategies such as the antioxidants melatonin and vitamin ADE, have previously been linked to reducing the negative impact of heat stress in other species.
- Ewe supplementation just prior to joining with melatonin and/or ADE drench increased the number of potential lambs at pregnancy scanning.
- Two prototype calculators were developed; first, to predict the impact of Melatonin and Vitamin ADE on productivity and profitability of flocks, and the second, to use climate data for a particular location to predict the impact of heat events during joining on their lambing rates to then make decisions around adoption of heat alleviating management strategies.

Background

The aim of this trial was to determine the impacts of melatonin implants (Regulin®) and a vitamin ADE drench on the fertility and fecundity, and thermoregulation of sheep across South Australia. High ambient temperatures during mating and pregnancy impair health, reproduction and welfare of sheep. Each day in excess of 32°C during the week of mating reduces the number of lambs born per 100 ewes mated by 3.5%, with high temperatures during pregnancy retarding fetal growth and, thus, reducing lamb survival and weaning rates.

Strategies which increase the capacity of sheep to tolerate heat and mitigate the negative impacts on reproduction are essential to maintain flock productivity and sustainability. Both melatonin and vitamin ADE have potent antioxidant properties which can act by reducing free radicals within the body that are produced during heat stress. Determining their capability in reducing the negative effects of heat stress in sheep will also provide the sheep industry with the ability to predict the impact of heat events on flock productivity and make informed decisions around the adoption of amelioration strategies.

Methodology

The first trial work ran from the 20 November 2022 until July of 2023 at 21 producer sites, across South Australia. The producer sites were obtained through collaborations with multiple farming systems group including; South Australian Research and Development Institute (SARDI), MacKillop Farm Management Group (MFMG), Barossa Improved Grazing Group (BIGG), Upper North Farming Systems Group (UNFS), Northern and Yorke Landscape Board (NYLB), Mallee Sustainable Farming Systems Group (MSF), Murray Plains Farming Systems Group (MPF), and Agricultural Innovation and Research Eyre Peninsula (AIR EP).

The second repeat of the trial ran from the 16 November 2023 until July 2024 at 18 sites across South Australia. The producer sites were obtained through collaborations with multiple farming systems group including; South Australian Research and Development Institute (SARDI), MacKillop Farm Management Group (MFMG), Barossa Improved Grazing Group (BIGG), Upper North Farming Systems Group (UNFS), Northern and Yorke Landscape Board (NYLB), Mallee Sustainable Farming Systems Group (MSF) and Agricultural Innovation and Research Eyre Peninsula (AIR EP).

The trial consisted of three treatments; control (no supplementation), melatonin and ADE; across 21 (2022/23) and 18 (2023/24) producer sites, each site acting as a replicate. Just prior to joining, ewes were randomly allocated into three treatments consisting of Melatonin, Vitamin ADE and Control. The melatonin ewes received an 18 mg melatonin capsule (Regulin®) via a subcutaneous injection behind the ear, the Vitamin ADE ewes received a 10 ml oral drench of Maxivit Vitamin A, D & E Oral (Compass Feeds), and the Control ewes did not receive any treatment. Following administration of the treatment the ewes were returned as one mob through till pregnancy scanning and managed according to standard husbandry for that particular farming site. All ewes were individually identified using either visual or electronic ear tags, or the use of branding paint. Pregnancy status and the number of fetuses carried by each ewe were determined by an experienced commercial operator using ultrasound. These data were used to calculate the following outcomes for each flock and each treatment: percentage of ewes pregnant, and the percentage of ewes carrying 1, 2, 3 or 4 fetuses, which in turn was used to calculate potential lambing rate (expressed as fetuses as a percentage of ewes joined and fetuses as a percentage of pregnant ewes).

Additionally, in 2022/23, on each producer site, at least one temperature device (tiny tag; Hastings Data Loggers) was placed in the paddock in which joining occurred, and was moved with the flock as required. The tiny tag was set to record ambient temperature and humidity at hourly intervals during the joining period. These data were used to understand the potential impact of climate on potential lambing rates, with each day over 32oC during the week of joining. The original objective was to use the climate data collected for each producer site to develop a prototype calculator for use by sheep producers to make informed decisions around implementation of heat alleviating strategies, which will hereon be referred to as the "*Sheep_Heat_Economics_HotDays*" calculator. However, due to the milder than normal climate experienced during summer of 2022 / 2023, it was decided to use historical climate data obtained from the Bureau of Meteorology (BoM) to develop this calculator. The additional benefit of using the BoM data is that it is a more robust data set, with data being available for the past 65 years, and is also available over a wider range of locations and is, thus, more relevant to a wider range of producers. The underlying premise for this calculator is that producers can insert their location, and receive outputs predicting the extent to which lambing rate is likely to be decreased by heat events (days > 32°C) in their location and for their chosen joining period, with each day > 32°C during joining (the average per week for the joining period) multiplied by 3.5 to give the expected reduction in lambing rate (fetuses per 100 ewes joined; as per Lindsay et al., 1975; Kleemann and Walker, 2005; van Wettere et al., 2021).

In addition, a second prototype calculator (the "*SheepHeat_Economics_Supplement*" calculator) was developed to provide sheep producers with the ability to determine the effect of using either melatonin or ADE on productivity and profitability of their flock. This calculator incorporates the cost of production values provided in the PIRSA Gross Margin Guide, and allows a range of scenarios to be modelled, whereby flock size, DSE rating, lambing rate, treatment type and efficacy (improvement in lambing rate), cost of production and lamb sale price can be altered to test the financial outcome.

Statistical analysis was conducted using SPSS (IBM). A general linear mixed model, with region, breed and age included in the model, was run to determine the impact of treatment on all parameters measured.

Table 3. *Overall effect of treating ewes in flocks at three properties in the Upper North of South Australia with Regulin® and Vitamin ADE at joining on pregnancy rate and fetal number at pregnancy scanning in 2023.*

	Total Ewes treated	Total lambs scanned	% Dry	% Single	% Twin	% Triplet	% Mult	% Preg	Lambs, % ewes joined	Lambs, % ewes Preg
Control	461	525	13.45	60.30	25.16	1.08	26.25	86.55	1.14	1.32
Regulin®	355	479	7.61	50.14	41.97	0.28	42.25	92.39	1.35	1.46
ADE	106	158	8.49	34.91	55.66	0.94	56.60	91.51	1.49	1.63

Table 4. *Effect, by location and treatment, of treating ewes with Regulin® and ADE in the Upper North of South Australia at joining on pregnancy rate and fetal number at pregnancy scanning in 2023*

Location	Ewe Treatment	Total ewe	Total Lamb	% Dry	% Single	% Twin	% Triplet	% Mult	% Preg	Lambs, % ewes joined	Lambs, % ewes Preg
Caltowie	Control	53	70	0.11	0.47	0.40	0.02	0.42	0.89	1.32	1.49
	Regulin®	59	90	0.03	0.42	0.53	0.02	0.54	0.97	1.53	1.58
Orroroo	Control	106	145	0.10	0.44	0.43	0.02	0.45	0.90	1.37	1.53
	ADE	106	158	0.08	0.35	0.56	0.01	0.57	0.92	1.49	1.63
Spalding	Control	302	310	0.15	0.68	0.16	0.01	0.17	0.85	1.03	1.21
	Regulin®	296	389	0.08	0.52	0.40	0.00	0.40	0.92	1.31	1.44

Table 5. *Effect of treating ewes in Spalding, South Australia with Regulin® at joining on pregnancy rate and fetal number at pregnancy scanning in 2024.*

Treatment	Total ewe	Total Lamb	% Dry	% Single	% Twin	% Triplet	% Mult	% Preg	Lambs, % ewes joined	Lambs, % ewes Preg
Control	297	394	0.07	0.53	0.40	0.00	0.40	0.93	1.33	1.43
Regulin®	297	428	0.08	0.43	0.47	0.02	0.50	0.92	1.44	1.56

Treatment	Ewe No.	Lamb No.	% Preg	% Single	% Twin	% Triplets	Lambs, % ewes joined
Control	4075	5013	84[a]	46[a]	36[a]	1	123[a]
Vitamin ADE	3005	4194	90[b]	42[ab]	47[b]	1	140[b]
Regulin®	3343	4653	87[b]	37[b]	48[b]	2	139[b]

[ab] Within column indicate differences between means; $P < 0.05$

Table 6. *Effect of treating ewes in flocks across South Australia with Regulin® and Vitamin ADE at joining on pregnancy rate and fetal number at pregnancy scanning in 2023.*

Using the data obtained from the tiny tags on each of the producer sites, the number of days ≥ 32°C was calculated for the period of joining, this was then divided by the duration of joining to calculate the mean number of days ≥ 32°C during each week of joining.

Using the equations developed by Lindsay et al. (1975) and Kleemann and Walker (2005), the number of days per week ≥ 32°C were multiplied by 3.5 to generate the impact on potential lambing rates (Table 7).

Trial Site	Region	Days per week of joining ≥ 32 °C	Potential decrease in lambing rates for an average joining week
7	Barossa	3	10.5%
19	Eyre Peninsula	4.6	16.1%
5	Eyre Peninsula	3	10.5%
17	Mallee	2.4	8.4%
6	Upper North	3.8	13.3%
16	Upper North	5.4	18.9%
2	Upper North	4.2	14.7%
3	Upper North	3.6	12.6%
9	Murray Plains	1.4	4.9%
10	Murray Plains	1.6	5.6%
12	South East	2.4	8.4%
1	South East	1.4	4.9%
4	South East	0.6	2.1%

Table 7. *Days per week of joining ≥ 32 °C and potential decrease in lambing rate for an average joining week on a subset of producer sites.*

Using historical BoM data (1957 to 2023), and five sites across South Australia chosen as representative of climate, the incidence of days ≥ 32°C during typical joining periods (late December through to end of January) was calculated, and used to calculate the loss of potential lambs. This was done for an average joining period, as well as the hottest joining period since 1957. These data are presented in Figure 1, and in Figure 2 the financial impost of these losses are presented, based on a flock of 100 ewes.

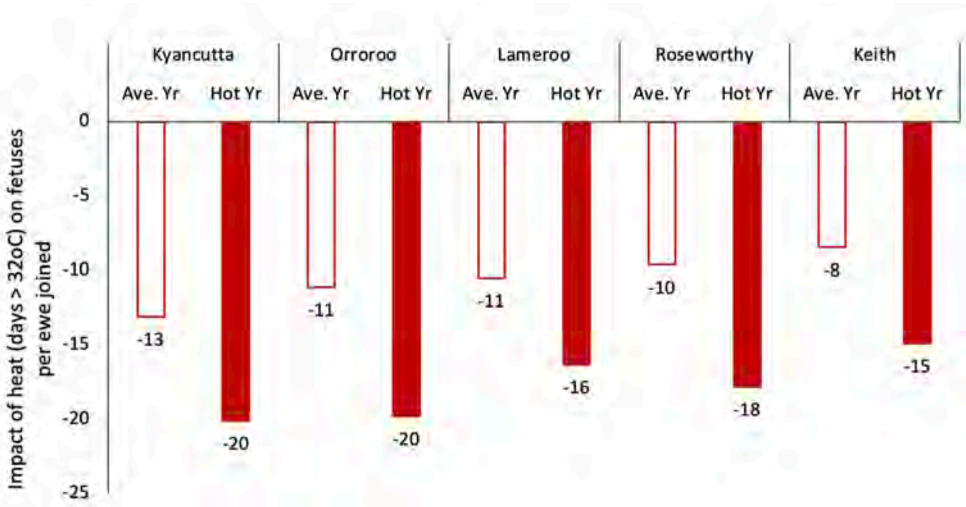

Figure 1. *Impact of days ≥ 32 during joining on potential lambing rate (fetuses per ewe joined) in an average summer joining period and the hottest summer period since 1957.*

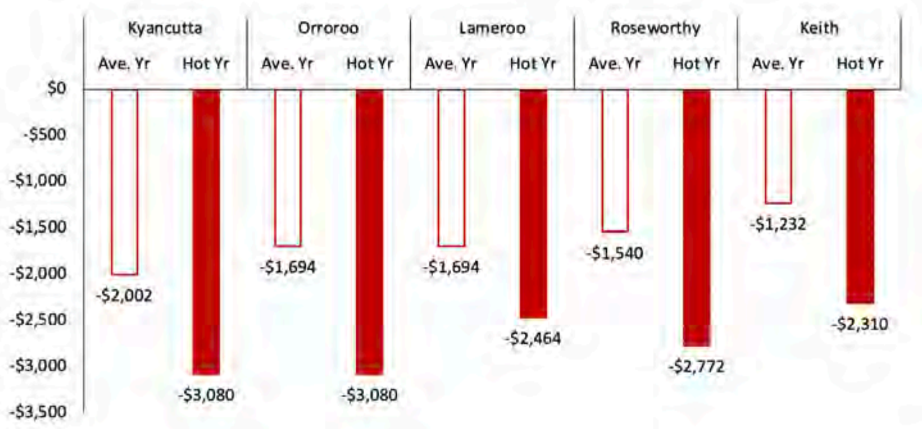

Figure 2. *Financial loss due to the reduction in lambing rates that occur when 100 ewes are exposed to days ≥ 32 during the week of joining. Calculated for an average summer joining period and the hottest summer joining period since 1957. Assumptions: lamb price of $130 / head minus $21 COP / head and a base line lambing rate of 140%.*

Image 1. *Photo - William van Wettere (Adelaide University) implanting ewes with melatonin at UNFS demonstration site 2023.*

Image 2. *Pregnancy scanning ewes treated with melatonin implants and ADE drench at UNFS demonstration site 2023.*

Conclusion

This project has demonstrated two easy to implement, highly adoptable and effective strategies to improve the fertility and, thus, productivity of sheep flocks which mate their ewes during late spring to early autumn. These strategies, Melatonin implants (Regulin®) and Vitamin ADE (oral drench), when given just prior to joining increased potential lambing rates and the percentage of ewes pregnant. Considering their mode of action, which relates to improved thermoregulation, as well as improved development and survival of embryos (eg Bouroutzika et al., 2020 and 2022; Contreras-Correa et al., 2023; Viola et al., 2023), adoption of these supplements is likely to improve the climate resilience of the South Australian sheep flock, and help to ensure its sustainability and productivity in the face of climate change.

Overall, Regulin® and Vitamin ADE treatment of ewes to increase lambing rate appears a robust, profitable management practice. Treatment efficacy and lamb sale price will impact the return on investment of Regulin® and Vitamin ADE treatments and should be considered when deciding to implement these practices. Further confirmation of the true heat-mitigating effects of these treatments on sheep flock fertility will then allow complex predictions of financial return across different production environments.

Acknowledgements

We wish to acknowledge the 21 producers who took part in the trial and were willing to be involved and the farming systems groups, to Compass Feeds for the Maxivit ADE Drench, and to CEVA for the Regulin®. Further acknowledgements go to the funding bodies for this trial including the Davies Research Centre University of Adelaide, SARDI, SA Sheep Industry Fund, and the South Australian Drought Resilience Adoption and Innovation Hub.

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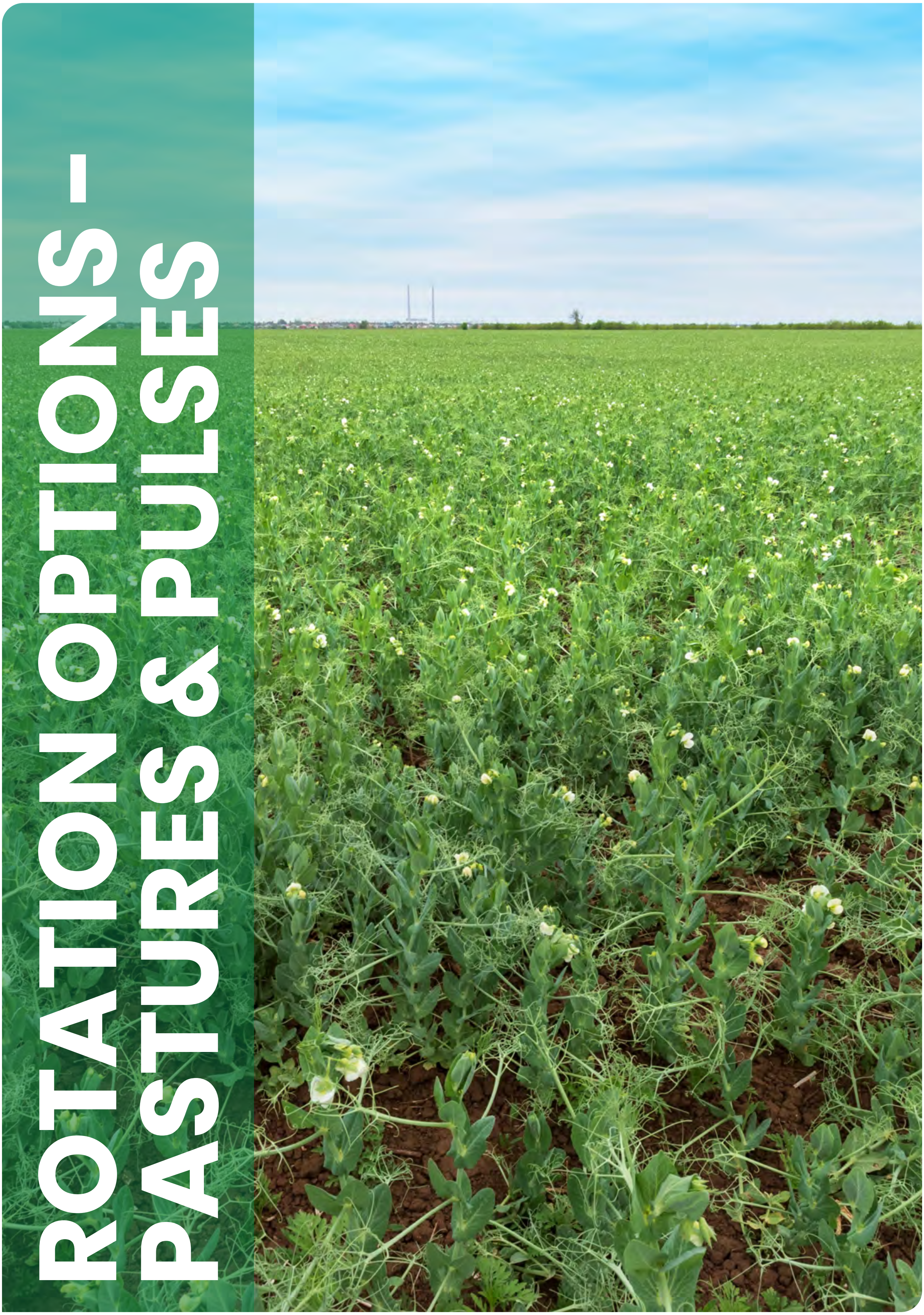
ROTATION OPTIONS – PASTURES & PULSES



INTERCROPPING IN BREAK CROPS IN THE UPPER NORTH

202 Field Trial(s) Results

Author: Sarah Day, *SARDI*

Background

Objective: Demonstrating the use of a canola/vetch intercrop combination as the break crop in a wheat/break rotation in the Upper North of SA and reviewing the different in-crop management decisions and their impact on profitability of the rotation and soil condition including biology, chemistry and physical parameters.

Hypothesis: Increasing complexity in the break crop from a vetch pasture to a dual species vetch and canola inter-crop will increase the profitability of the rotation and reduce the risk by providing multi-end use options to adapt and respond to climatic variations.

Methodology

Soil cores were taken across the site prior to sowing for nutrition characterisation of the soil profile (Table 1, Table 2). The pulse-oilseed field experimental trial was sown using an experimental plot seeder, with 8 rows spaced 23 cm apart and each plot 10 m long. Treatments, as outlined in Table 3, were sown on a single date (Table 4) into a 2022 barley stubble. Seeding rates differed between sole crops and inter crops (Table 4). Plots were arranged in a randomised complete block design with three replicates. Intercrop treatments were sown with vetch and canola in alternate rows (Figure 1), while the mixed row intercrop was sown with canola and vetch in the same rows (Figure 2). Biomass was measured prior to each grazing treatment timing by cutting just above the furrow height of the middle 4 rows by 1 m of each plot. Biomass samples from 1 replication were sent to the FeedTest Laboratory for NIR fodder quality testing.

Figure 1. *Alternate row intercrop treatments were sown with vetch and canola in alternative rows. Photo taken on the 8th of September 2022, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 2. *Mixed row intercrop treatments were sown with canola and vetch in the same rows, rather than alternate rows. Photo taken on the 8th of September 2022, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Grazing was simulated by using a lawn mower to graze plots to an even height above the furrow and removing the above ground biomass from each plot. Manure treatments were completed by applying 2L/ha Round Up Ultra Max at two treatment timings (Table 4), followed by 2L/ha Spray.Seed that was applied for crop topping/desiccation (Table 4). Plots were harvested with a mechanical plot harvester at crop maturity. Grain of individual crops was separated post-harvest into individual seed lots to enable grain weights to be recorded and grain yield converted from kg/plot to t/ha. Grain samples were assessed for grain quality parameters.

The 2022 pulse-oilseed field experimental trial was over-sown with wheat in 2023 to assess the legacy and rotation effect of the intercrop combinations. The wheat over-sow field experimental trial was sown using an experimental plot seeder, with 8 rows spaced 23 cm apart and each plot 10 m long. Plots were harvested with a mechanical plot harvester at crop maturity. Grain weights were recorded and grain yield converted from kg/plot to t/ha. Grain samples were assess for grain protein content. Soil cores were taken in each individual plot post-harvest to assess soil nitrogen levels following the wheat phase.

To determine the relative benefit of intercropping, compared to growing crops as monocultures, land equivalent ratio (LER) values were calculated. The LER is expressed as:

$$LER = LA + LB = YA/SA + YB/SB$$

Where LA and LB are the LER for the individual crop yield components, YA and YB are the individual crop yields in the intercrop combinations, and SA and SB are the yields of the monocultures (adapted from Mead and Willey, 1980). An LER value of <1.0 means the productivity of the intercrop components are less than the monocultures, while an LER value >1.0 means the intercrop components are more productive than the monocultures. pLER represents partial LER, where pLER of intercrop component 1 + pLER of intercrop component 2 = total LER.

Data were analysed using ASReml-R in the statistical program R (Rstudio Team, 2020). A separate linear mixed model was built for the actual biomass, biomass LER, actual grain yield and grain yield LER (sole crop LER was automatically set at 1). The model specified treatment as the fixed effect and replicate as the random effect. The residual section of the model included plot location in the trial (bay x row) to account (as much as possible) for differences within a trial site that are hard to control (e.g. slope, moisture gradients etc).

Depth (cm)	NH3-N	NO3-N	P (mg/kg)	K	S	OC (%)	EC (dS/m)	pH ($CaCl_2$)	pH (H_2O)
0-10	1	2	42	555	3.8	0.39	0.066	6.1	6.6
10-30	1	1	27	472	3.3	0.31	0.051	7.0	8.0
30-60	<1	2	26	340	10.5	0.27	0.114	7.0	7.9
60-90	1	3	28	355	33.8	0.34	0.213	7.5	8.1
90-120	2	3	24	306	17.8	0.20	0.231	7.4	8.2

Depth (cm)	Cu	Fe	Mn (mg/kg)	Zn	B	Exc Ca	Exc Mg	Exc K (meq/100g)	Exc Na	Exc Al
0-10	1.38	13.6	18.72	0.55	0.68	6.49	1.51	0.89	0.11	0.03
10-30	1.36	6.5	13.47	0.46	0.80	7.64	2.36	0.71	0.14	0.04
30-60	1.13	9.8	9.42	0.32	0.72	7.81	2.62	0.49	0.26	0.04
60-90	1.08	9.0	9.90	0.52	0.51	7.48	2.73	0.47	0.41	0.04
90-120	0.89	7.5	7.59	0.41	0.47	7.38	2.92	0.43	0.46	0.05

Table 1. *Soil profile characterisation (brown-green loamy clay soil) for the Melrose wheat field trial site (Trial Site #1), 2023.*

Table 2. *Soil profile characterisation (brown-red to brown-orange clay soil) for the Melrose pulse-oilseed field trial site (Trial Site #2), 2023.*

Depth	NH3-N	NO3-N	P	K	S	OC	EC	pH	pH
(cm)			(mg/kg)			(%)	(dS/m)	($CaCl_2$)	(H_2O)
0-10	3	9	58	421	14.5	0.98	0.114	5.9	6.4
10-30	2	4	6	524	24.8	0.62	0.217	6.9	8.1
30-60	1	2	5	469	58.4	0.45	0.504	7.1	8.5
60-90	<1	1	3	477	168.6	0.24	0.981	8.0	8.9
90-120	<1	<1	6	441	235.6	0.19	1.220	7.8	8.7

Depth	Cu	Fe	Mn	Zn	B	Exc Ca	Exc Mg	Exc K	Exc Na	Exc Al
(cm)			(mg/kg)					(meq/100g)		
0-10	1.63	33.7	55.94	6.37	0.92	5.99	2.62	0.85	0.59	0.016
10-30	1.68	13.6	4.68	0.33	3.30	12.10	10.25	1.31	3.74	0.039
30-60	1.58	14.1	3.08	1.69	6.06	11.82	11.73	1.33	5.68	0.030
60-90	1.28	14.2	4.42	0.17	7.81	11.22	11.06	1.27	7.28	0.023
90-120	1.17	13.3	3.84	0.66	11.85	11.88	10.80	1.25	7.71	0.019

Table 3. *Name and details of treatments included in the canola/vetch intercropping drought resilience trial at Melrose, 2023.*

Treatment name	Sole crop	Mixed crop	Inter crop	MAP at sowing	Urea in crop	Grazed Winter	Grazed Winter + Spring	Brown Manure Early	Brown Manure Late	Grain harvested
Sole canola	✓			✓	✓					✓
Sole vetch	✓			✓						✓
Sole vetch grazed	✓			✓		✓	✓			
Mixed row intercrop		✓		✓						✓
Alternate row intercrop			✓	✓						✓
Intercrop + urea			✓	✓	✓					✓
Intercrop winter grazed			✓	✓		✓				✓*
Intercrop winter + spring grazed			✓	✓		✓	✓			✓*
Intercrop vetch removed early			✓	✓				✓		
Intercrop vetch removed late			✓	✓					✓	

*Opportunistic harvest for seed, depending on seasonal conditions, grazing intensity and crop recovery

Table 4. *Key details and dates of treatments and agronomic management applied to the canola/vetch intercropping drought resilience trial at Melrose, 2023.*

	Trial Site 1	Trial Site 2
Sowing Date	14 June 2023	14 June 2023
Fertiliser	80 kg/ha Monoammonium phosphate (MAP) at sowing.	80 kg/ha Diammonium phosphate (DAP) at sowing
Row spacing	23 cm	23 cm
Varieties	Vetch: Volga Canola: HyTTec Trophy.	Wheat: Scepter
Plant density	Vetch Sole crop: 60 plants/m^2 Intercrop: 46 plants/m^2 Canola: Sole crop: 40 plants/m^2 Intercrop: 20 plants/m^2	Wheat: 180 plants/m^2
Biomass assessment date(s)	Winter assessment: not assessed due to low rainfall and low early crop growth during winter. The decision was made not to "graze" the trial as plant growth was not adequate enough for a grower to graze the crop. the trial as plant growth was not adequate enough for a grower to graze the crop. (Figure 4-Figure 8). Spring assessment: 28 September 2023 (Figure 9-Figure 10).	N/A
Plant height assessment date(s)	29 September 2023	N/A
Grazing treatment date(s)	Winter grazing: not completed due to low rainfall and low early crop growth during winter. The decision was made not to "graze" the trial as plant growth was not adequate enough for a grower to graze the crop. (Figure 4-Figure 8). Spring grazing: not completed due to low rainfall and low crop growth. The decision was made not to "graze" the trial as plant growth was not adequate enough for a grower to graze the crop. (Figure 9-Figure 10).	N/A
Manure treatment details and date(s)	2 L/ha Round Up UltraMax. Removed early: 13 October 2023 Removed late: 26 October 2023	N/A
Harvest index cut date	16 October 2023.	N/A
Crop topping/desiccation	2 L/ha Spray.Seed 250 26 October 2023	N/A
Harvest date	14 November 2023	14 November 2023

Figure 3. *Wheat germinating at the over-sown trial site. Photo taken on the 30th of June 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 4. *Canola germinating at the pulse-oilseed trial site. Photo taken on the 19th of July 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 5. *Vetch germinating at the pulse-oilseed trial site. Photo taken on the 19th of July 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 6. *Vetch-canola intercrop. Photo taken on the 23rd of August 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 7. *Sole canola. Photo taken on the 23rd of August 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 8. *Sole vetch. Photo taken on the 23rd of August 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 9. *Vetch-oilseed field trial. Photo taken on the 22nd of September 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Figure 10. *Wheat over-sown field trial. Photo taken on the 22nd of September 2023, by Sarah Day, SARDI (sarah.day@sa.gov.au).*

Location

Site # and name	Latitude (decimal degrees)	Longitude (decimal degrees)	LGA
Trial Site #1 / Melrose	32°45'17.0"S	138°14'16.8"E	District Council of Mount Remarkable
Trial Site #2 / Melrose	32°49'28.1"S	138°16'06.5"E	District Council of Mount Remarkable

Results

Average spring biomass (vetch): 1.05 t/ha

Average spring biomass (canola): 0.44 t/ha

Average spring plant height (vetch): 30 cm

Average spring plant height (canola): 66 cm

Average HI (vetch): 3%

Average HI (canola): 6%

Average grain yield (TOTAL combined) – 0.13 t/ha

The Melrose field trial site experienced numerous frost events during the 2023 growing season, with a total of 37 events where overnight temperatures fell below zero degrees Celsius (Figure 12). Six frost events occurred in May, with the lowest temperature reaching -2.9°C. No frost events occurred in June, coinciding with the average rainfall for the region. As rainfall events reduced throughout winter and spring, frost event occurrence increased. 11 frost events were recorded in July, at times occurring for 3 consecutive nights, with the lowest temperature reaching -2.1°C. A total of ten frost events occurred in August, with seven of these events occurring consecutively in early August. Of these consecutive frost events, three nights fell below -4.4°C, with the lowest recorded at -4.7°C. September saw a further eight frost events, with four occurring consecutively in early September, with the lowest recorded at -3.8°C. Two frost events occurred in October. Late September and October frost events occurred as daytime temperatures were increasing, providing both cold stress and heat stress events to crops.

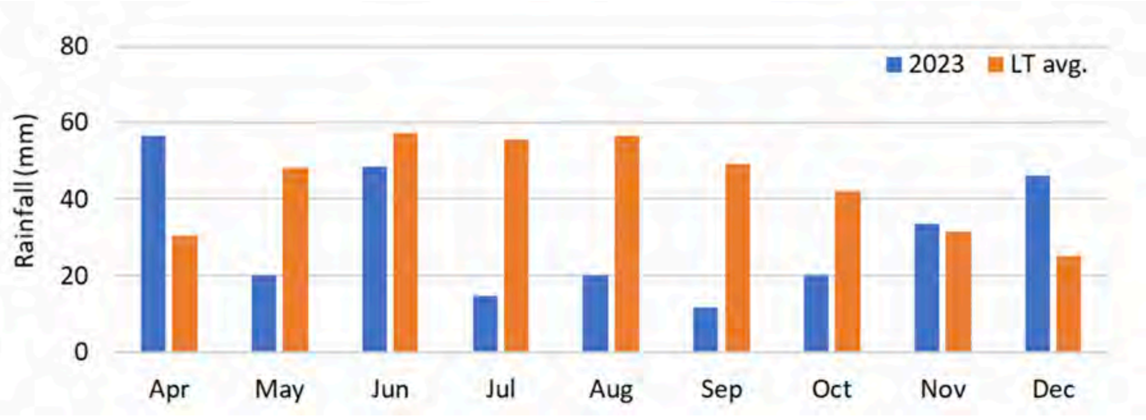


Figure 11. *Monthly rainfall recorded at the Melrose field trial site in 2023 compared to the long-term average rainfall from the Melrose (Para Gums) BOM weather station (19042).*

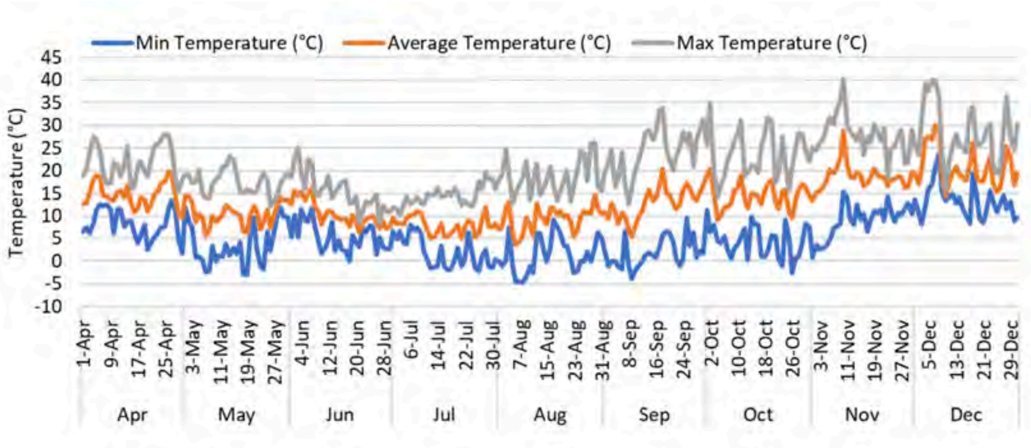


Figure 12. *Minimum, average, and maximum temperature recorded at the Melrose field trial site, 2023.*

Treatment name	Vetch	Canola	Crude Protein	Acid Detergent Fibre	Neutral Detergent Fibre	Digestibility (DMD)	Digestibility (DOMD)	Fat	Ash	Metabolisable Energy
			% of dry matter							MJ/kg DM
Sole vetch	✓		20.5	20.8	30.7	73.9	69.5	5.1	10.1	11.1
Sole vetch grazed	✓		21.3	21.7	32.3	73.4	69.0	5.0	10.5	11.0
Mixed row intercrop	✓		18.2	22.4	32.5	72.5	68.3	5.1	10.3	10.9
Alternate row intercrop	✓		19.5	22.1	31.6	73.0	68.6	5.0	10.5	10.9
Intercrop + urea	✓		18.0	20.7	29.4	75.0	70.3	5.0	9.8	11.3
Intercrop winter grazed	✓		19.7	20.4	29.7	73.2	68.9	5.2	10.2	11.0
Intercrop winter + spring grazed	✓		16.4	20.5	29.8	74.1	69.6	5.2	10.3	11.1
Intercrop vetch removed early	✓		18.3	21.9	31.5	72.8	68.5	5.1	10.9	10.9
Intercrop vetch removed late	✓		17.8	21.6	31.2	73.5	69.1	4.9	10.1	11.0
Mixed row intercrop		✓	18.2	24.2	34.0	72.9	68.6	4.5	9.1	10.9
Alternate row intercrop		✓	17.5	27.7	37.8	69.1	65.4	4.2	9.4	10.3
Intercrop + urea		✓	18.2	24.6	34.7	71.8	67.7	4.6	9.0	10.7
Intercrop winter grazed		✓	20.1	22.2	31.8	73.9	69.5	4.8	10.2	11.1
Intercrop winter + spring grazed		✓	17.6	26.9	37.7	69.3	65.5	4.2	9.2	10.3
Intercrop vetch removed early		✓	21.3	20.4	30.5	78.0	72.9	4.9	10.2	11.8
Intercrop vetch removed late		✓	22	21.1	31.2	78.0	72.9	4.7	10.4	11.8
Sole canola		✓	20.9	22.3	32.1	75.1	70.4	4.7	10.3	11.3

Table 5. *NIR FeedTest results for pulse-oislseed intercropping samples, separated by crop type, from Melrose, 2023.*

INTERCROPPING IN BREAK CROPS IN THE UPPER NORTH

Independent Cost: Benefit & Risk Analysis, 2022 and 2023 seasons

Author: Jana Dixon, *Agribusiness Consultant Pinion Advisory*

COST: BENEFIT

A cost benefit is useful for comparing the partial return of single input or rotation decision in a farming business. Here, the cost benefit analysis will be comparing the cost of establishing and managing various break crop options, with their relative benefit (grazing, grain income, nitrogen benefits and follow wheat yield benefits).

Simply the cost:benefit represents the return-on-investment per dollar spent. A $1:1 ratio represents a 'break-even' decision (i.e. $1 return per $1 invested). A $2:1 ratio indicates a $2 return per $1 invested. The higher the ratio, the stronger business case for the decision, and lower the risk.

In this case, the cost benefit is only a 'partial' cost benefit analysis, as it does not account for all costs associated with establishing the break crop treatments. It is only looking at the costs which vary between the treatments, to be used for comparison purposes. For example: seeding fertiliser, seeding operational expenses and any summer spraying or post emergent spraying costs are not included in this analysis as they were assumed to be consistent across all treatments.

The costs ($/ha) which varied between treatments were:

- Cost of the seed (vetch and canola).
- Cost of urea applied (only applied to two treatments).
- **Operational expenses:**
    - Two treatments were manured and not taken to grain, hence required an additional spraying expense.
    - The two treatments which had urea top-dressed encountered a spreading expense.
    - All treatments but two were taken through to harvest, so harvest cost was only applied to eight treatments.
    - Some treatments were harvested as grain + canola, and needed a grain separation expense to be accounted for.

The benefits ($/ha) varied between the treatments based on:

- Grain yields harvested. Vetch and/or canola grain was harvested from the treatments. A $/ha benefit was given based on the grain income (yield x price) of the vetch and/or canola harvested.
- **Grazing benefit:**
  The grazing benefit has been assessed by determining the amount of stock that could be sustained by the total pasture produced for each treatment. This was calculated by combining the total biomass of vetch and/or canola, and converting to kg DM/ha (see assumptions in Appendix A below), which can then determine the livestock capacity which the pasture could sustain in DSE/ha. A industry average number for the livestock gross margin was given as $65/DSE in the 2022 season, and $20/DSE in the 2023 season.
  Whilst feed test samples were taken, livestock production and profitability is known to be driven more by total feed production, rather than by specific feed quality parameters. This is why the feed test results have not been included in the grazing benefit analysis.
- **Nitrogen benefit:**
  This has been assessed by looking at the residual nitrogen left after each of the treatments (from soil test results); comparing them to the starting soil nitrogen of the site. The difference in kg N/ha was then multiplied by the cost per unit of nitrogen in ($3.26 kg/N in 2022 and $1.57 kg/N in 2023).
- **Benefit to the following wheat crop 'wheat oversow':**
  The 2022 intercropping site was sown to Scepter wheat in 2023, and taken through to harvest. There only variable to compare was the previous years intercrop treatment; influencing the wheat grain yield in 2023. The wheat yields ranged from 0.9t/ha to 1.31t/ha across the treatments. As there was no 'control' plot as such, a baseline yield of 1t/ha was used for comparison. The treatments yield difference from 1t/ha, was then multiplied by the 2023 harvest price for APW1 wheat, to get the $/ha benefit to be used for the analysis.

Treatment	2022 Cost: Benefit ($:1) without 2023 wheat yield benefit	2022 Cost: Benefit ($: 1) with 2023 wheat yield benefit	2023 Cost: Benefit ($:1) without 2024 wheat yield benefit
Sole_vetch	15.83	16.16	0.91
Sole_canola	4.94	4.95	0.54
Mix_vetch+canola	11.74	12.11	0.80
Inter_vetch+canola_retained	12.59	12.92	0.84
Inter_vetch+canola_retained_urea	6.54	6.61	0.45
Inter_vetch+canola_earlymanure	4.11	5.87	1.65
Inter_vetch+canola_latemanure	3.56	5.04	1.98
Inter_vetch+canola_retained_1grazed	13.42	13.88	1.09
Inter_vetch+canola_retained_2grazed	4.77	4.72	0.77
Sole_vetch_graze	6.44	6.07	0.66

Table 1. *The Partial Cost: Benefit ratios for the various treatments in 2022 and 2023, the detailed analysis and assumptions are shown in Appendix A*

Comments on the Data

- In 2022, the large differences in the partial cost:benefit rations were driven by the income generated from harvested canola and/or vetch grain from the treatments. The 'sole_canola' and 'inter_vetch+canola_retained_urea' treatments had high fertiliser costs due to urea prices at $1500 per tonne; negatively impacting the cost:benefit ratio even though grain was harvested.
- In 2023, there was much smaller differences in both costs and benefits across the treatments. $/ha benefits across the treatments were a lot smaller than in 2022, due to the dry season, and a poor livestock gross margin. The cost of urea was much less in 2023, at only $720 per tonne. The only two treatments that exceeded a $1:1 partial cost benefit were the two treatments which did not have a harvesting operation ($80/ha cost).

2023 WHEAT OVERSOW DATA

2022 Intercrop Treatment	2023 Oversow Wheat Yield (t/ha)	
Inter_vetch+canola_earlymanure	1.306	a
Inter_vetch+canola_latemanure	1.257	ab
Inter_vetch+canola_retained_1grazed	1.173	abc
Mix_vetch+canola	1.136	abc
Inter_vetch+canola_retained	1.121	abc
Sole_vetch	1.094	bcd
Inter_vetch+canola_retained_urea	1.054	cd
Sole_canola	1.006	cd
Inter_vetch+canola_retained_2grazed	0.976	cd
Sole_vetch_graze	0.897	d

Table 2. *2023 wheat oversow data, showing a significant difference between treatments (P<0.05).*

RISK ANALYSIS ON 2022 DATA

It was identified that the following variables have a significant influence on the results of each treatments. The cost benefit analysis shown in Table 1 above, went through a series of sensitivity analysis' for each of the four variables below. Tables 3 – 5 are individual sensitivity analysis' of how each variable influences the final cost benefit outcome of the treatments.

Urea price:

- Influences cost of urea application (high urea price = higher input costs for the two treatments with urea applications, and potentially lower cost:benefit).
- Influences the nitrogen benefit of each of the treatments (high urea price increases $/ha nitrogen benefit for treatments with additional residual nitrogen).

SENSITVITY OF UREA PRICE			
Treatment	2022: Urea @ $1500/T	Urea @ $500/T	Urea @ $1000/T
Sole_vetch	15.83	15.41	15.62
Sole_canola	5.00	7.35	5.96
Mix_vetch+canola	11.74	11.74	11.74
Inter_vetch+canola_retained	12.59	12.41	12.50
Inter_vetch+canola_retained_urea	6.54	9.71	7.81
Inter_vetch+canola_earlymanure	4.11	3.03	3.57
Inter_vetch+canola_latemanure	3.56	2.95	3.26
Inter_vetch+canola_retained_1grazed	13.42	13.14	13.28
Inter_vetch+canola_retained_2grazed	4.77	4.75	4.76
Sole_vetch_graze	6.44	6.25	6.35

Table 3. *Sensitivity analysis of urea price on the partial cost benefit ratio ($:1) of each treatment.*

Vetch price:

- Influences the treatments where vetch grain was harvested (high vetch price = higher grain income / $ benefit).
- Influences all treatments which had vetch sown (high vetch price = higher seed cost).

SENSITVITY OF VETCH PRICE			
Treatment	2022: Vetch @ $450/T	Vetch $300/T	Vetch $700/T
Sole_vetch	15.83	12.17	20.87
Sole_canola	5.00	5.00	5.00
Mix_vetch+canola	11.74	9.21	15.53
Inter_vetch+canola_retained	12.59	10.18	16.22
Inter_vetch+canola_retained_urea	6.54	5.36	8.41
Inter_vetch+canola_earlymanure	4.11	4.49	3.61
Inter_vetch+canola_latemanure	3.56	3.89	3.13
Inter_vetch+canola_retained_1grazed	13.42	10.80	17.37
Inter_vetch+canola_retained_2grazed	4.77	3.90	6.09
Sole_vetch_graze	6.44	5.38	7.91

Table 4. *Sensitivity analysis of vetch grain price on the partial cost benefit ratio ($:1) of each treatment.*

Canola Price

- Influences the treatments where canola grain was harvested (higher canola price = higher grain income / $ benefit).
  - It did not influence seed costs for canola.

SENSITVITY OF CANOLA PRICE			
Treatment	2022 Canola @ $700/T	Canola @ $500/T	Canola @ $900/T
Sole_vetch	15.83	15.83	15.83
Sole_canola	5.00	3.72	6.29
Mix_vetch+canola	11.74	11.30	12.17
Inter_vetch+canola_retained	12.59	11.84	13.34
Inter_vetch+canola_retained_urea	6.54	5.98	7.10
Inter_vetch+canola_earlymanure	4.11	4.11	4.11
Inter_vetch+canola_latemanure	3.56	3.56	3.56
Inter_vetch+canola_retained_1grazed	13.42	12.73	14.12
Inter_vetch+canola_retained_2grazed	4.77	4.67	4.87
Sole_vetch_graze	6.44	6.44	6.44

Table 5. *Sensitivity analysis of canola grain price on the partial cost benefit ratio ($:1) of each treatment.*

Livestock Gross Margin

- Influences all treatments as a $/ha grazing benefit was allocated based on the number of DSE's that could be sustained by each treatment.

SENSITVITY OF LIVESTOCK GROSS MARGIN			
Treatment	Control $65/DSE	$55/DSE	$75/DSE
Sole_vetch	15.83	15.59	16.07
Sole_canola	5.00	4.91	5.09
Mix_vetch+canola	11.74	11.53	11.94
Inter_vetch+canola_retained	12.59	12.40	12.78
Inter_vetch+canola_retained_urea	6.54	6.44	6.65
Inter_vetch+canola_earlymanure	4.11	3.73	4.49
Inter_vetch+canola_latemanure	3.56	3.16	3.97
Inter_vetch+canola_retained_1grazed	13.42	13.21	13.64
Inter_vetch+canola_retained_2grazed	4.77	4.57	4.97
Sole_vetch_graze	6.44	6.17	6.72

Table 6. *Sensitivity analysis of the livestock gross margin on the partial cost benefit ratio ($:1) of each treatment.*

Influence of the variables on the data:

- The variable which had the greatest impact on the cost benefit of the treatments, was the vetch grain price, followed by urea price, then canola grain price, with the variation in livestock gross margin having the smallest impact on the cost benefit ratios.
- The treatment which had the most variation in the sensitivity analysis was sole vetch, followed by all the three retained intercropping treatments, then the mix of vetch and canola; followed by sole canola. The remaining treatments had a much smaller variation in the sensitivity analysis.

COMBINED SENSITIVITY ANALYSIS			
Treatment	Control	Scenario 1	Scenario 2
Sole_vetch	15.83	15.50	20.71
Sole_canola	5.00	5.87	7.48
Mix_vetch+canola	11.74	11.52	15.72
Inter_vetch+canola_retained	12.59	12.07	16.23
Inter_vetch+canola_retained_urea	6.54	8.47	12.47
Inter_vetch+canola_earlymanure	4.11	3.25	2.99
Inter_vetch+canola_latemanure	3.56	3.07	2.94
Inter_vetch+canola_retained_1grazed	13.42	12.85	17.31
Inter_vetch+canola_retained_2grazed	4.77	4.70	6.25
Sole_vetch_graze	6.44	6.29	7.98

Table 7. *Combined sensitivity analysis based on two likely scenarios*

Control: Urea @$1500/T, Vetch @$450/T, Canola @$700/T, Livestock G.M. @$65/DSE

Scenario 1: Urea @$700/T, Vetch @$450/T, Canola @$600/T, Livestock G.M. @$65/DSE

Scenario 2: Urea @$500/T, Vetch @$700/T, Canola @$700/T, Livestock G.M. @$75/DSE

APPENDIX A: Detailed cost benefit analysis

Assumptions used:

- Assumed solo seeding rates: 50kg/ha vetch, 2kg/ha canola
- Intercrop seeding rate 75% of the solo rate for vetch, and 50% of the solo rate for canola
- The input costs, operational costs and commodity prices were representative of the values faced in the 2022 and 2023 seasons:
    - Urea price, $1,500 per tonne in 2022, $720 per tonne in 2023
    - Vetch seed & grain cost of $450 per tonne in 2022, and $500 per tonne in 2023.
    - Canola seed cost of $40 per kg in 2022 and $32 per kg in 2023
    - Canola grain price of $700 per tonne in 2022, and $640 in 2023
    - Spraying and spreading cost of $10/ha
    - Harvesting cost of $80/ha
    - Grain separation cost of $5/ha
- Grazing benefit assumptions:
    - Dry Matter of 40% (fresh green pasture is 20%, silage is around 45-50%. 40% used due to being a spring measurement)
    - Feed utilization of 80% (biomass cuts were taken at 15cm to mimic grazing)
    - Feed requirement of 365 kg DM per DSE/ha (assuming 1kg of DM/DSE/day)
    - Gross margin per DSE:
        - In 2022: $65 (assuming $80/DSE of net income (after replacements) and $15/DSE of variable costs)
        - In 2023: $20 (assuming $45/DSE of net income (after replacements) and $25/DSE of variable costs)

	TREATMENTS									
	Sole_vetch	Sole_canola	Mix_vetch+ canola	Inter_vetch+canola _retained	Inter_vetch+canola_retained_urea	Inter_vetch+canola_ earlymanure	Inter_vetch+canola _latemanure	Inter_vetch+canola _retained_1grazed	Inter_vetch+canola_ retained_2grazed	Sole_vetch_graze
Seed costs	$ 22.50	$ 80.00	$ 56.88	$ 56.88	$ 56.88	$ 56.88	$ 56.88	$ 56.88	$ 56.88	$ 22.50
Urea cost		$ 150.00			$ 150.00					
Partial Input Costs ($/ha)	*$ 22.50*	*$ 230.00*	*$ 56.88*	*$ 56.88*	*$ 206.88*	*$ 56.88*	*$ 56.88*	*$ 56.88*	*$ 56.88*	*$ 22.50*
spraying						$ 10.00	$ 10.00			
spreading		$ 10.00			$ 10.00					
harvest	$ 80.00	$ 80.00	$ 80.00	$ 80.00	$ 80.00			$ 80.00	$ 80.00	$ 80.00
seperation			$ 5.00	$ 5.00	$ 5.00			$ 5.00	$ 5.00	
Partial operations ($/ha)	$ 80.00	$ 90.00	$ 85.00	$ 85.00	$ 95.00	$ 10.00	$ 10.00	$ 85.00	$ 85.00	$ 80.00
***Partial* COST $/ha**	$ 102.50	$ 320.00	$ 141.88	$ 141.88	$ 301.88	$ 66.88	$ 66.88	$ 141.88	$ 141.88	$ 102.50
Grazing benefit	$ 158.99	$ 167.54	$ 186.35	$ 174.95	$ 201.73	$ 166.40	$ 176.66	$ 199.45	$ 183.50	$ 181.22
Vetch grain	$ 1,399.82	$ -	$1,231.81	$ 1,200.22	$ 1,158.96	$ -	$ -	$ 1,300.58	$ 438.23	$ 449.39
Canola grain	$ -	$ 1,439.14	$ 214.51	$ 372.94	$ 591.50	$ -	$ -	$ 345.19	$ 49.96	$ -
N benefits	$ 63.59	$ -24.95	$ 32.25	$ 38.64	$ 22.99	$ 108.59	$ 61.63	$ 59.18	$ 5.38	$ 29.84
2023 wheat yield benefit	$ 34.20	$ 3.80	$ 53.20	$ 45.60	$ 19.00	$ 117.80	$ 98.80	$ 64.60	$ -7.60	$ -38.00
TOTAL BENEFIT $/ha	$ 1,656.60	$ 1,585.53	$1,718.12	$ 1,832.35	$ 1,994.18	$ 392.79	$ 337.09	$ 1,969.00	$ 669.47	$ 622.44
Cost: Benefit Ratio	**16.16**	**4.95**	**12.11**	**12.92**	**6.61**	**5.87**	**5.04**	**13.88**	**4.72**	**6.07**

Table 8. *2022 partial cost benefit analysis, (updated) with the 2023 oversown wheat income added in, see '2023 wheat yield benefit'.*

	TREATMENTS									
	Sole_vetch	Sole_canola	Mix_vetch+ canola	Inter_vetch+canola _retained	Inter_vetch+canola_retained_urea	Inter_vetch+canola_ earlymanure	Inter_vetch+canola _latemanure	Inter_vetch+canola _retained_1grazed	Inter_vetch+canola_ retained_2grazed	Sole_vetch_graze
Seed costs	$ 25.00	$ 64.00	$ 50.75	$ 50.75	$ 50.75	$ 50.75	$ 50.75	$ 50.75	$ 50.75	$ 25.00
Urea cost		$ 72.00			$ 72.00					
Partial Input Costs ($/ha)	*$ 25.00*	*$ 136.00*	*$ 50.75*	*$ 50.75*	*$ 122.75*	*$ 50.75*	*$ 50.75*	*$ 50.75*	*$ 50.75*	*$ 25.00*
spraying						$ 10.00	$ 10.00			
spreading		$ 10.00			$ 10.00					
harvest	$ 80.00	$ 80.00	$ 80.00	$ 80.00	$ 80.00			$ 80.00	$ 80.00	$ 80.00
seperation			$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	
Partial operations ($/ha)	$ 80.00	$ 90.00	$ 85.00	$ 85.00	$ 95.00	$ 15.00	$ 15.00	$ 85.00	$ 85.00	$ 80.00
***Partial* COST $/ha**	$ 105.00	$ 226.00	$ 135.75	$ 135.75	$ 217.75	$ 65.75	$ 65.75	$ 135.75	$ 135.75	$ 105.00
Grazing benefit	$ 28.52	$ 16.54	$ 23.38	$ 25.02	$ 22.56	$ 21.57	$ 22.91	$ 21.98	$ 21.10	$ 24.78
Vetch grain	$ 33.00	$ -	$ 20.00	$ 12.50	$ 5.50	$ 14.50	$ 28.50	$ 20.00	$ 3.00	$ 25.50
Canola grain	$ -	$ 105.60	$ 46.08	$ 64.64	$ 60.16	$ 46.08	$ 69.12	$ 53.12	$ 71.68	$ -
N benefits	$ 33.81	$ -	$ 18.78	$ 11.27	$ 9.39	$ 26.30	$ 9.39	$ 52.59	$ 9.39	$ 18.78
TOTAL BENEFIT $/ha	$ 95.33	$ 122.14	$ 108.24	$ 113.43	$ 97.61	$ 108.44	$ 129.92	$ 147.69	$ 105.17	$ 69.06
Cost: Benefit Ratio	**0.91**	**0.54**	**0.80**	**0.84**	**0.45**	**1.65**	**1.98**	**1.09**	**0.77**	**0.66**

Table 9. *2023 partial cost benefit analysis, (does not include following wheat yield benefit)*

UPPER NORTH FARMING SYSTEMS MEMBERSHIP LIST 2022 - 2023

Title	First Name	Last Name	Partners Name	Town or Business
Mr	Ashley	Afford	Les	Port Pirie
Mr	Jordan	Arthur		Booleroo Centre
Mr	Tim	Arthur		Melrose
Ms	Shannen	Barratt		Intergrain
Mr	Peter	Barrie	Di	Orroroo
Mr	Braden	Battersby	Emilie	Wilmington
Mr	Michael	Battersby	Catherine	Wilmington
Mr	Colin	Becker	Joy	Caltowie
Mrs	Joy	Becker	Colin	Caltowie
Mr	Henry	Bennett	Adele	Tarcowie
Mr	William	Bennett	Emma	RSD Pekina
Mr	Dustin	Berryman		Northern Ag PL
Mr	Shaun	Borgas	Marisa	Booleroo Centre
Mr	Donald	Bottrall	Heather	Jamestown
Mr	Damian	Bradford		ADM Australia PL
Mr	Brendon	Bradtke		Jamestown
Ms	Anne	Brown		Wirrabara
Mr	Malcolm	Buckby		SAGIT
Mr	Ben	Bury	Bevin	Wilmington
Mr	David	Busch	Lisa	Tothillbelt
Mrs	Emily	Byerlee		Orroroo
Mr	Malcolm	Byerlee		Orroroo
Mr	Neil	Byerlee		Orroroo
Mr	Todd	Carey		Wilmington
Mr	John	Carey		Wilmington
Mr	John (JP)	Carey	Nicole	Booleroo Centre
Mr	John (Snr)	Carey		Booleroo Centre
Mrs	Nicole	Carey	John	Booleroo Centre
Mr	Derek	Carkle		NAB
Mr	Ben (Jnr)	Carn		Quorn
Mr	Ben (Snr)	Carn	Susan	Quorn
Mr	Adrian	Carter		Nuseed
Mr	Andrew	Catford	Gilmour & Michelle	Orroroo
Mr	David	Catford	Andrea	Gladstone
Mr	Gilmour	Catford	Michelle & Andrew	Orroroo
Mr	Grant	Chapman		Orroroo
Mr	Dion	Clapp		Peterborough
Mr	Luke	Clark	Dette	Jamestown
Mr	Scott	Clark	Jaimie	Jamestown
Mr	David	Clarke	Chloe	Booleroo Centre
Mr	Ian	Clarke	Sue	Booleroo Centre
Mr	Piers	Cockburn		Wirrabarra
Mr	Peter	Cockburn	Toni-Louise	Wirrabarra
Mrs	Anne	Collins	Glenn	Quorn
Ms	Amanda	Cook		Uni of Adelaide

Title	First Name	Last Name	Partners Name	Town or Business
Ms	Pru	Cook		Birchip Cropping Group
Mr	Michael	Cousins		CBH Group
Mr	David	Coyner		Riverland Lending Service
Mr	Ben	Crawford	Beck	Georgetown
Mr	Bruce	Crawford	Jan	Georgetown
Mr	John	Crawford	Jan	Georgetown
Mr	Luke	Crawford		Jamestown
Mr	Mark	Crawford	Heidi	Georgetown
Mr	Trevor	Crawford	Christine	Jamestown
Mr	Chris	Crouch	Iris	Wandearah via Crystal Brook
Mr	Nathan	Crouch		Wandearah
Ms	Jenny	Davidson		SAGIT
Mr	Nicholas	Davis		Davis Grain
Mr	Wayne	Davis		Davis Grain
Mr	Brad	Dennis	Ellie	Baroota
Mr	Matt	Dennis		Baroota
Mr	Robert	Dennis	Michelle	Baroota
Mr	Phillip	Dibben		Financial Services SA
Mrs	Rosalie	Dibben		Financial Services SA
Mr	Hugh	Drum		SARDI
Ms	Libby	Duncan		Landscape SA Northern & Yorke
Mr	Joel	Durnford		MGA
Mr	Colin	Edmondson		LongReach Plant Breeders
Mr	Damian	Ellery		Orroroo
Mr	Ian	Ellery	Sue	Orroroo
Mr	Michael	Eyers	Holly	Field Systems Aust Ltd
Mr	Bentley	Foulis	Michelle	Willowie
Mr	Matt	Foulis		Willowie
Mr	Douglas	Francis		Quorn
Mr	Rehn	Freebairn		Intergrain
Mr	Kym	Fromm		Orroroo
Mr	Neville	Gibb	Daryl & Ian	Orroroo
Dr	Gurjeet	Gill		Uni of Adelaide
Mr	Caleb	Girdham		Melrose
Mr	Brendan	Groves	Meridee	Booleroo Centre
Mr	Patrick	Guerin		BALCO
Miss	Rebecca	Gum	Geoff	Orroroo
Mr	Trevor	Gum	Dianne	Orroroo
Mr	Jonathan	Hancock		Brinkworth
Mr	Kym	Harvie	Leeanne	Booleroo Centre
Mr	James	Heaslip	Kara	Appila
Mr	Jim	Heaslip	Genevieve	Appila
Mr	Will	Heaslip		Appila
Miss	Alison	Henderson		Caltowie
Mr	David	Henderson	Joy	Caltowie
Mr	Roger	Hilder	Cheryl	Quorn

Title	First Name	Last Name	Partners Name	Town or Business
Ms	Beth	Humphris		Elders
Mr	Neil	Innes	Anne	Booleroo Centre
Mr	Aaron	Jak		Fieldworks SA
Mr	Steve	James		Yongala
Mr	Tony	Jarvis		Booleroo Centre
Mr	Ben	Jefferson		Tarcowie
Mr	Paul	Jenke		Pioneer Seed
Mr	Brendon	Johns	Denise	Northern Grain
Mr	Leighton	Johns		Port Pirie
Mr	Phillip	Johns		Port Pirie
Mr	Steven	Johns		Port Pirie
Mr	Bart	Joyce		Wandearah West
Mr	Ziek	Kay		Platinum Ag Services
Mr	Ian (Danny)	Keller		Appila
Mr	Chris	Kelly		Kelly Toyota
Mr	Shane	Kelly	Jo	Booleroo Centre
Mr	Andrew	Kitto	Maria	Gladstone
Mr	Joe	Koch	Jess	Booleroo Centre
Mr	Jamie	Koch	Jody	Nuriootpa
Mr	Lachie	Koch		Booleroo Centre
Mr	Robert	Koch	Joyleen	Georgetown
Mr	Jim	Kuerschner	Gaye	Orroroo
Mr	Sam	Kuerschner		Orroroo
Mr	Tom	Kuerschner		Orroroo
Mr	David	Kumnick	Katrina	Booleroo Centre
Mr	Jaxon	Kumnick		Booleroo Centre
Mr	Neil	Lange	Judy	Laura
Ms	Tracey	Lehmann		E.P.I.C.
Mr	David	Long		Advantage Grain
Mr	Tim	Luckraft	Christy	Orroroo
Ms	Stephanie	Lunn		AgXtra
Ms	Hannah	McArdle		BASF
Mr	Andrew	McCallum	Melissa	Booleroo Centre
Mr	Cameron	McCallum	Toni	Melrose
Mrs	Carly	McCallum	Nicholas	Melrose
Mr	David	McCallum	Lyn	Melrose
Mr	Nicholas	McCallum	Carly	Melrose
Mr	Ras	McCallum		Flinders Machinery
Mr	Richard	McCallum	Michelle	Booleroo Centre
Mr	Warren	McCallum	Jennifer	Laura
Ms	Krystal	McMahon	Josie	S.A. & J.A. Wild
Mr	Larn	McMurray		Global Grain Genetics
Ms	Taryn	Mangelsdorf		Landscape SA Northern & Yorke
Mr	Robert	Mills		Booleroo Centre
Mr	David	Moore	Bec	Jamestown
Ms	Millie	Moore		S & W Seed Co.

Title	First Name	Last Name	Partners Name	Town or Business
Ms	Tanja	Morgan		Mallee Sustainable Farming
Mr	Tom	Moten		Pekina
Mr	Barry	Mudge	Kristina	Port Germein
Mrs	Alice	Nottle	Matt	Booleroo Centre
Mr	Matthew	Nottle	Alice	Booleroo Centre
Mr	Morgan	Nutt	Joy	Orroroo
Mr	Stuart	Ockerby		Seednet
Ms	Molly	O'Dea		O'Dea Daughters Farming
Ms	Kim	Oldfield		Carrieton
Mr	Mitch	Orrock		Murray Town
Mr	Todd	Orrock	Brooke	Orrock Farming
Mr	Adrian	Paynter	Jane	Quorn
Ms	Kate	Pearce		Landscape SA Northern & Yorke
Mr	Darren	Pech		Elders
Mr	Marcus	Perry		Perrys Fuels
Mr	Nicholas	Piggott	Emily	Booleroo Centre
Mr	John	Polden		Booleroo Centre
Mr	Chris	Pole	Michelle	Port Germein
Mr	Thomas	Porter		Washpool
Ms	Courtney	Ramsey		GRDC
Mr	Patrick	Redden		Pinion Advisory
Mr	Mark	Reichstein		Appila
Mr	Brett	Reid	Ebony	Port Broughton
Mr	Kym	Reid	Iola	Port Broughton
Dr	Jodie	Reseigh		National Landcare/Red Meat & wool Growth Programs
Mr	Steve	Richmond		Nutrien Ag - Jamestown
Ms	Penny	Roberts		MSF
Mr	Paul	Rodgers		Quorn
Mr	Joe	Ross	Lauren	Emu Downs
Mrs	Lauren	Ross	Joe	Emu Downs
Mr	Stephen	Sanders	Elishia	Melrose
Mr	Ed	Scott	Catherine	Field Systems Australia Ltd
Mr	Craig	Shearer		E.P.I.C.
Mr	Keith	Slade	Lisa	Bangor
Ms	Sarah	Slee	Josh	Wilmington
Mrs	Ruth	Sommerville	Damien	Rufous & Co
Ms	Kerry	Stockman		AgExcellence Alliance
Miss	Grace	Teate		Booborowie
Ms	Andrea	Tschirner	Kurt	Acacia Park Consulting
Mr	Daniel	Vater		AGT
Ms	Krisite	Vater		SA Arid Lands Landscape Board
Mr	Henry	Voigt		CentreState Exports
Mr	Andrew	Walter	Lydia	Melrose
Mr	Ken	Walter	Denise	Melrose
Mr	Steve	Whillas		E.P.I.C.
Mrs	Jessie	White		Landscape SA Northern & Yorke

Title	First Name	Last Name	Partners Name	Town or Business
Mr	Nigel	Wilhelm		SARDI
Mr	Lachie	Williams		Booleroo Centre
Mr	Tim	Wilmshurst		Advanta Seeds
Mr	Andrew	Wilsdon		Viterra
Mr	Craig	Woolford	Bek	Wirrabara
Mr	Dion	Woolford	Chelsea	Solomon
Mr	Wayne	Young		Port Pirie
Mr	Andrew	Zanker		Laura
Mr	Bryan	Zanker		Booleroo Centre
Mr	Eric	Zanker	Raelene	Booleroo Centre
Mr	Graham	Zanker	Lyn	Laura
Mr	Bryan	Zanker		Booleroo Centre
Mr	Eric	Zanker	Raelene	Booleroo Centre
Mr	Graham	Zanker	Lyn	Laura
Mr	Jason	Zohs	Kim	Crystal Brook
Mrs	Kim	Zohs	Jason	Crystal Brook
Mr	Michael	Zwar		Ag Tech Services

Collation and editing of this report was undertaken by
Deb Marner & Jade Rose on behalf of the Upper North Farming Systems Group.

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