UNFS

Upper North Farming Systems

2019
RESULTS

UPPER NORTH FARMING SYSTEMS ANNUAL RESEARCH AND EXTENSION COMPENDIUM

DISCLAIMER

Information in this report is presented in good faith without independent verification. The Upper North Farming Systems Group (UNFS) do not guarantee or warrant the accuracy, reliability, completeness or currency of the information presented nor its usefulness in achieving any purpose.

Readers are responsible for assessing the relevance and accuracy of the information presented. Reports presented here have been compiled using local and non-local data produced by members of the Low Rainfall Collaboration and other Partners. The UNFS will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this Report.

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A Message from the Chair

The Upper North has been challenged over the last couple of years, with rainfall being very hard to come by. We have done a lot of sowing on very small rain events during the 18 - 19 seasons and something that has become very apparent to me, is how well our systems are working for us. Stubble retention, no-till, summer spraying and in crop nitrogen management are all aspects that we have adopted with fantastic success. We are starting to understand the importance of building soil health, keeping soil covered and preserving summer rainfall; all processes that have allowed us to grow crops on minimal moisture. Much of this knowledge and understanding has been built on by the projects being undertaken by UNFS. Unfortunately, the frustrations of having very good commodity prices (grains, wool and meat) but not being able to grow it - are real ones. However, with good rains generally across our region in February, I am confident that the weather pattern is changing for the better. Fingers crossed for a wet 2020!!

The success of UNFS is largely a result of the hard work of the committee members and our paid staff. I would like to thank all the committee, both the Operations Committee and Strategic Board Members, for their support and efforts during my short time in this role. Many thanks to Ruth Sommerville and Kristina Mudge for keeping the group on the straight and narrow – I am sure they work well above their pay grades. Jamie Wilson started with us mid-year as our Project Manager. He comes to us with many years of experience in the agricultural sector having worked at Elders, Viterra and as a private consultant. Rachel Trengove also joined the group as a Project Officer on the Pulse Check Group. Sadly we farewelled Mary Timms mid-year as she took on a full time role in Orange NSW as an Agricultural Economist on a Climate Change Response project.

Sponsors, funding bodies and project partners are all vital in the success of UNFS. With their support, knowledge, time and funding we are producing positive outcomes for our members. We strive to produce high quality outputs through research, development and extension activities across the region particularly through conducting trial work and holding events like our annual members expo, field crop walks and hub events.

Whilst 2019 was another successful 12 months for UNFS, it has been one rounded off with tragedy. A week before Christmas we lost a committee member and friend, Matt McCallum. Matt's contributions in Agriculture are unquestionable, a very humble man who achieved a lot. He published many scientific papers in his time in research at the University of Melbourne in Horsham and CSIRO in Canberra. He undertook trial work locally and on the YP, was a UNFS Strategic Board Member and served most recently a two year term as the Chairperson of UNFS. We have put together a snapshot of his contributions to agriculture in this compendium as an acknowledgement of the knowledge and time he gave to the industry and his farming community. Our thoughts are with his family and friends.

A lot of hard work goes into putting this compendium together. It is a great way for UNFS to present trial results and show our members, sponsors, funding bodies and project partners what we have been up to over the past 12 months. Please take the time to read through this publication. There are numerous fantastic project reports and trial results for you to peruse over at your leisure.

Lastly, there are currently several exciting projects happening in the background that I feel will be of real benefit to UNFS and our industry. So, watch this space and hopefully we will have some exciting announcements coming soon!!

Matt Nottle,
UNFS Chairperson 2019/2020

Upper North Farming Systems

Contact List

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THANK YOU TO OUR FUNDING BODIES AND PROJECT PARTNERS

National Landcare Program: Smart Farming Partnerships; Department of Agriculture, Fisheries and Forestry; SAGIT; GRDC; Department of Water and Natural Resources; Northern and Yorke NRM Board; Eyre Peninsula NRM Board; SARDI; ACTFA, SPAA, Eyre Peninsula Agriculture Research Foundation, Birchip Cropping Group, Central West Farming Systems, Mallee Sustainable Farming, Hart Field Site Group, Ag Excellence Alliance; Rufous and Co., Ag Consulting Co., McAg Consulting, Elders, Safecom; Balco; University of Adelaide; Agbyte; NR Ag; Northern Ag; Rural Directions PL; Nutrien, Cox Rural, Seednet and Ag Tech Services.

Without the support and funding from these organisations and funding programs the Upper North Farming Systems Group would not remain viable.

Upper North Farming Systems Projects and Grants 2019

(including projects undertaken in the 2018-2019 FY)

UNFS Project #	Other Names/ References	Full Name	Funding Source	Project Manager
219	Upskilling UNFS women	Upskilling the women of the Upper North to be future ready, sustainable, more productive farmers	South Australian Grain Industry Trust Fund	Jess Koch
220	Wheat Time of Sowing trial	Upper North Time of Sowing and Yield Loss from Frost/Heat stress	South Australian Grain Industry Trust Fund	Ruth Sommerville
223	Pasture Options Demonstration	Demonstrating improved pasture options for the Upper North	PIRSA/Ag Excellence Alliance/UNFS Commercial Paddock	Andrew Kitto
224	Micronutrients in the Upper North	Increasing the knowledge and understanding of micronutrient deficiency in the Upper North	South Australian Grain Industry Trust Fund	Matt Foulis
226	Pulse Check	Southern Pulse Extension Project	GRDC, subcontracted by BCG	Barry Mudge Rachel Trengove
227	Cover Crop	Warm and cool season mixed cover cropping for sustainable farming systems in south eastern Australia.	National Landcare Program; Smart Farming Partnerships initiative Rd 1 VIA AG Ex Alliance	Elders Jamestown - Darren Pech, Giles Kears
228	Barley Grass	Barley Grass Management Options	GRDC/ Subcontracted by University of Adelaide	Gurjeet Gill/ Amanda Matt McCallum
229	Dryland Legumes	Dryland Legume Pasture Systems	Rural R & DfP/MSF	Naomi Scholz
230	Vetch of Saline and Sodic Soils	Species selection for Saline and Sodic Soils in UN	UNFS Commercial Paddock	Stefan Schmidt
231	Weather Station Network	Upper North Fire Danger Index Alerting Weather Station Network Project	SAFECOM	Leighton Wilksch
232	Barley Time of Sowing	Upper North Barley Time of Sowing; Frost / Heat Stress Effects	South Australian Grain Industry Trust Fund	NR AG - Steph Lunn and Alex Burbury
233	Fodder Crop Trial	Cereal alternatives to oats for hay production in the Upper North	Balco Australia	NR AG - Steph Lunn and Alex Burbury

Upper North Farming Systems 2019

Event Summary

Date	Event	Location	Participants	Details
19/02/2019	Weather Essentials for Spray Application	Jamestown	25	AG Excellence Alliance coordinated GRDC funded workshop with delivery support from UNFS. Spray drift understanding and role weather plays.
23/2/2019	Pulse Check Meeting	Napperby	32	Local and trial results and findings presented by Sarah Day and Penny Roberts (SARDI) and facilitated discussion with local agronomists Matt Foulis and Daniel Hillebrand.
21/03/2019	Farming Well in 2019	Orroroo	55	Forum/Dinner: speakers on overall health and wellbeing of farming families, cropping in current conditions, livestock, feral animal control and many aspects of life on the land.
26/03/2019	Its Ewe Time	Jamestown	100+	AWI/MLA Making More from Sheep Ewe Forum.
18/04/2019	Ladies on the Land 'Weathering the Drought'	Morchard	10	Part 1 of a 2 part workshop series funded By PHN and WOTL. Upper North women coming together to discuss strategies to help weather the drought.
3/05/2019	Fencing Day	Morchard	40	Elders & Waratah provided information on fencing including a display. Hub Event.
7/05/2019	Dryland Legume Pasture System - Seeding Sticky Beak Day	Jamestown	14	An extensive look at new and varied pasture species over a 3 yr period.
19/6/19	Ladies on the Land 'Weathering the Drought'	Morchard	10	Part 2 of a workshop series funded By PHN and WOTL. Upper North women coming together to discuss strategies to help weather the drought.
1/07/2019	Pulse Check Meeting	Willowie	28	Pulse check group meeting - post-seeding crop walk meeting. Local agronomists Matt Foulis and Daniel Hillebrand presented trial information and facilitated pulse related discussion from the group.
24/07/2019	Ladies on the Land - Practical Business Planning	Booleroo Centre	12	Part One of two business planning workshops facilitated by Rural Directions, Clare, increasing knowledge of practical business planning.
25/07/2019	Winning with Weaners	Jamestown		Deb Scammell - Lifting the lifetime performance of young merino sheep.
1/08/2019	2019 Members Expo	Booleroo Centre	94	Mixed Farming Masterclass - Healthy Soils, Productive Paddocks (Joel Williams), Benchmarking across the business (James Hillcoat) Lifetime Ewe Management Farmer Panel, Sustainable, Regenerative & Holistic Farming (Ruth Sommerville), Precision Livestock Management (Rick Llewellyn), Implementing a safety culture on farm (Alex Thomas). Visits to Trial Sites: Time of Sowing for wheat & barley, Fodder Production Options.
22/8/2019	Pulse Check Meeting	Upper North Region	11	Bus trip by SARDI -Reducing limitations to pulse production - visiting trial sites at Willowie and Wirrabara.
28/08/2019	Ladies on the Land - Practical Business Planning	Booleroo Centre	10	Part Two of business planning workshops provided by Rural Directions, Clare, fostering accountability and action orientation within businesses.

Upper North Farming Systems 2019

Event Summary *cont.*

Date	Event	Location	Participants	Details
4/09/2019	Appila Hub event	Appila CFS shed	21	Guest speakers - GPSA Peter Cousins & Leet Wilksch, Agbyte on Automatic weather stations
11/09/2019	Eastern Spring Crop Walk	Booleroo/ Morchard	25	Trials visited: Dryland Legume Pasture—Morchard, Barley Grass Management—Melrose, Pre-emergent herbicide—Booleroo Centre, Barley Time of Sowing, Fodder Options - Booleroo Centre and launch of UNFS Weather Station Network.
12/09/2019	Pasture Options	Jamestown/ Caltowie	25	Panel Discussion on Mixed Species cropping, Pasture trial summary, soil biology & spray interaction project summary
13/09/2019	Western Spring Crop walk & Pulse Check meeting	Warnertown	30/26	Nelshaby Sticky Beak day - Vetch on Sodic/Saline soils trial, deep ripping, seeder trials & crop walk. Sponsors reps in attendance: ADM Trading, Davis Grain. Pulse Check Meeting - Warnertown SARDI Trial Site - Speakers - Stuart Sherrif, Penny Roberts
27/09/2019	Containment Ewe Facility tag-a-long tour	Jamestown/ Booleroo	60	Deb Scammell, Talking Livestock - Tag along tour
18/09/2019	Crop Science Meeting in collaboration with UNFS	Spalding	20	Leet Wilksch (AgByte) on new technology in weather stations. Pat Guerin (Balco Australia) discussing all things export hay. Mick Faulkner (Agrilink Consulting) provided a summary on the MESONET weather station project and its usefulness for planning spraying, harvesting & burning.
11/10/2019	Getting sheep through the drought - To mate or not to mate	Morchard	30	Guest speakers - Emma Shaddock/Ian Ellery/Jim Kuerschner, UNFS Pastume Legume trial
25/10/2019	Legume Pasture Trial site	Jamestown	10	Tom Moten
16/12/2019	UNFS Committee Christmas Dinner	Wirrabara	20	End of year dinner to thank staff and committee members for their contributions
21/12/2019	Booleroo Hub Event - Harvest Cut out	Booleroo	15	Joe Koch - opportunity to debrief on the 2019 season. Held in conjunction with Booleroo Tennis Club

UNFS 2018/2019 Financial Year Reports

UPPER NORTH FARMING SYSTEMS

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2019

	Note	2019 $	2018 $
INCOME			
Group Income			
Interest		1,173	1,760
Machinery Hire		3,073	3,141
Membership		5,022	5,182
Merchandise		112	27
Project Administration		14,078	58,047
Project Income		-	5,000
Field Days		2,900	5,020
Commercial Paddock		4,776	7,389
Sponsorship		9,961	18,182
Sundry Income		-	75,300
		41,095	179,048
Profit on sale of Fixed Assets		778	-
		41,873	179,048
OTHER INCOME			
Project Income			
Yield Prophet		150	6,200
GRDC Stubble Initiative		65,100	130,200
Ladies on the Land Workshop		2,700	800
Time of Sowing Trial		25,294	24,385
Production Wise		-	1,150
Pasture Options Demo		-	5,000
Micronutients in Upper North		30,600	23,500
Soil Acidity in Upper North		-	17,000
Pulse Check		18,537	13,086
Reallocation of Stubble Initiative Expenses		-	55,574
Cover Crop		5,000	-
		147,381	276,895
		189,254	455,943

UPPER NORTH FARMING SYSTEMS

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2019

	Note	2019 $	2018 $
EXPENDITURE			
Group Expenses			
Administration		22,730	14,892
Audit Fees		2,750	2,450
Minor Equipment & Maintenance		908	1,647
Insurance		2,760	2,002
Publications		1,687	2,390
Field Days		7,144	4,228
Commercial Paddock		2,299	2,815
Bank Fees		120	120
Depreciation		4,390	6,052
Other Project Expense		750	-
Travel		916	-
Total Wage Expense		20,086	3,694
		66,540	40,290
Project Costs			
GRDC Stubble Initiative		-	390,509
Yield Prophet		5,010	10,570
Overdependence Agrochemicals		-	1,628
Post Stubble Demo		-	3,498
Ladies on the Land		2,413	818
Time of Sowing Trial		15,463	19,333
Production Wise		-	785
Pasture Options Demo		2,324	1,356
Weed Seed Burning		-	5,922
Micronutrients in Upper North		15,665	11,476
Soil Acidity in Upper North		-	17,000
Pulse Check		9,661	4,524
Cover Crop		2,527	-
Barley Grass Trial		212	-
Dryland Legumes		255	-
Weather Station Network		750	-
Barley Time of Sowing		2,000	-
Fodder Crop Trials		653	-
		56,933	467,419
		123,473	507,709
Profit (Loss) before income tax		65,781	(51,766)

	Note	2019 $	2018 $
Profit (Loss) for the year		65,781	(51,766)
Retained earnings at the beginning of the financial year		260,855	312,620
Retained earnings at the end of the financial year		326,636	260,854

UNFS 2018/2019 Financial Year Reports (continued)

UPPER NORTH FARMING SYSTEMS

BALANCE SHEET
AS AT 30 JUNE 2019

	Note	2019 $	2018 $
ASSETS			
CURRENT ASSETS			
Cash and cash equivalents	3	324,227	235,378
Trade and other receivables	4	-	9,679
TOTAL CURRENT ASSETS		324,227	245,057
NON-CURRENT ASSETS			
Property, plant and equipment	5	3,517	22,554
TOTAL NON-CURRENT ASSETS		3,517	22,554
TOTAL ASSETS		327,744	267,611
LIABILITIES			
CURRENT LIABILITIES			
Trade and Other Payables	6	1,108	6,757
TOTAL CURRENT LIABILITIES		1,108	6,757
TOTAL LIABILITIES		1,108	6,757
NET ASSETS		326,636	260,854
MEMBERS' FUNDS			
Retained earnings	7	326,636	260,854
TOTAL MEMBERS' FUNDS		326,636	260,854

UPPER NORTH FARMING SYSTEMS

NOTES TO THE FINANCIAL STATEMENTS
FOR THE YEAR ENDED 30 JUNE 2019

		2019 $	2018 $
3	**Cash and Cash Equivalents**		
	Freedom Bank Account 92540	34,642	26,966
	Business Bank Account 93340	289,585	208,412
		324,227	235,378
4	**Trade and Other Receivables**		
	GST Account	-	9,679
		-	9,679
5	**Property, Plant and Equipment**		
	Plant & Equipment - at Cost	5,749	31,232
	Less Prov'n for Depreciation	(2,232)	(8,678)
		3,517	22,554
	Total Plant and Equipment	3,517	22,554
	Total Property, Plant and Equipment	3,517	22,554
6	**Accounts Payable and Other Payables**		
	Current		
	PAYG Withheld	-	4,722
	Superannuation Liability	-	1,989
	Membership Paid in Advance	-	46
	GST Account	1,108	-
		1,108	6,757
7	**Retained Earnings**		
	Retained earnings at the beginning of the financial year	260,855	312,620
	Net profit (Net loss) attributable to the association	65,781	(51,766)
	Retained earnings at the end of the financial year	326,636	260,854

UNFS 2018/2019 Financial Year Reports (continued)

INDEPENDENT AUDITOR'S REPORT
TO THE MEMBERS OF UPPER NORTH FARMING SYSTEMS

Report on the Audit of the Financial Report

Opinion

I have audited the accompanying financial report, being a special purpose financial report, of Upper North Farming Systems (the association), which comprises the balance sheet as at 30 June 2019, and the income and expenditure statement for the year then ended, and notes to the financial statements including a summary of significant accounting policies and other explanatory information, the statement by members of the committee.

In my opinion, the accompanying financial report of the association for the year ended 30 June 2019 is prepared, in all material respects, in accordance with the Associations Incorporation Act 1985.

Basis for Opinion

I conducted my audit in accordance with Australian Auditing Standards. My responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Report section of my report. I am independent of the association in accordance with the auditor independence requirements of the ethical requirements of the Accounting Professional and Ethical Standards Board's APES 110 Code of Ethics for Professional Accountants (the code) that are relevant to my audit of the financial report in Australia. I have also fulfilled my other ethical responsibilities in accordance with the code.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for our opinion.

Emphasis of Matter- Basis of Accounting

I draw attention to note 1 to the financial report, which describes the basis of accounting. The financial report is prepared to assist the association in . As a result, the financial report may not be suitable for another purpose. My report is intended solely for the association and should not be distributed to or used by parties other than the association. My opinion is not modified in respect to this matter.

Responsibilities of Management and those Charged with Governance

Management is responsible for the preparation and fair presentation of the financial report in accordance with the Associations Incorporation Act 1985 and for such internal control as management determines is necessary to enable the preparation of the financial report is free from material misstatement, whether due to fraud or error.

In preparing the financial report, management is responsible for assessing the association's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the association or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the association's financial reporting process.

Auditor's Responsibility for the Audit of the Financial Report

My objectives are to obtain reasonable assurance about whether the financial report as a whole is free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with the Australian Auditing Standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of this financial report.

Name of Firm: Mid North Accounting
Certified Practising Accountant

Name of Principal: Vonnie Lea CPA

Address: 40 Irvine Street Jamestown SA

Dated this 17th day of November 2019

Upper North Farming Systems																	
Cashflow by Tag 1/7/18 to 30/06/19																	
This information is preliminary and subject to adjustments and modifications identified during the course of the audit work, which could result in significant differences from this preliminary unaudited financial information.																	
Category Description	101 Group Managment	103 Field Days & Tours	104 Commercial Paddock	209 Yield Prophet	211 Stubble Initiative	219 Ladies on the Land Workshops	220 Time of Sowing Trial	223 Pasture Options Demo	224 Micronutrients	226 Pulse Check	227 Cover Crop	228 Barley Grass Trial	229 Dryland Legumes	231 Weather Station Network	232 Barley TOS	233 Fodder Crop Trials	OVERALL TOTAL
INFLOWS																	
Interest	1174																1,174
Events		1,000															1,000
Machinery Hire_Vehicle Use	3072																3,072
Membership	5022																5,022
Merchandise	112																112
Project Administration	14078																14,078
Project Income		1,000	4,776	150	65,100	2,700	25,294		30,600	18,537	5,000						153,156
Sale of Capital Items	14545																14,545
Sponsorship	9962	900															10,862
Sundry Income																	-
TOTAL INFLOWS	47966	2,900	4,776	150	65,100	2,700	25,294	-	30,600	18,537	5,000	-	-	-	-	-	203,022
																	-
OUTFLOWS																	-
Administration	22731	3,213		5,010		-	2,529		3,060	1,854	500						38,897
Audit Fees	2750																2,750
Bank Fees	120																120
Event Expenses																	-
Event Catering		769				370											1,140
Event Expense		515				830											1,345
Field Day Expenses		909					500		500								1,909
Presenter						1,120											1,120
Hub Expenses		102															102
Insurance	2760																2,760
Minor Equipment & Maintenance	908																908
Project Expenses																	-
Communications										500							500
Consultants									700	750							1,450
Project Management						85	255	43	128	85	850	213	255		2,000	653	4,565
Travel	916	135					2,017	275	687	112	327						4,469
Other Project Expenses	750		1,419				383	1,455	7,132	5,123	850			750			17,862
Publications	1687						1,000		500	500							3,687
Wages																	-
Computer_Data Allowance	350									30							380
Superannuation	2722																2,722
Wages Administration Officer																	-
Wages Project Officer	17014	1,501				7	8,780	551	2,958	707							31,518
TOTAL OUTFLOWS	52708	7,144	1,419	5,010	-	2,413	15,463	2,324	15,665	9,661	2,527	213	255	750	2,000	653	118,203
																	-
OVERALL TOTAL	-4742	-4244	3357	-4860	65100	287	9830	-2324	14935	8876	2473	-213	-255	-750	-2000	-653	84,818
																	-
OPENING BALANCE as at 1/7/18	236,165	19,619	21,044	4,860	- 65,100	1,526	18,671	3,235	12,025	8,561	-						260,606
MOVEMENT	- 4,742	- 4,244	3,357	- 4,860	65,100	287	9,830	- 2,324	14,935	8,876	2,473	- 213	- 255	- 750	- 2,000	- 653	84,818
CLOSING BALANCE as at 30/06/19	231,423	15,375	24,401	0	0	1,813	28,501	912	26,960	17,437	2,473	-213	-255	-750	-2,000	-653	345,424

UNFS 2019 HUB ACTIVITY

Upper North Farming Systems sincerely thanks Grain Growers for sponsoring our hub activities

Booleroo Centre, Melrose, Laura, Gladstone, Jamestown, Morchard/Orroroo/Pekina/Black Rock, Nelshaby, Quorn, Wilmington, Ladies on the Land and New Farmers

Appila Hub Report

2019 was a challenging season for the Appila region, receiving 208 mm rainfall for the year (172 mm growing season rainfall). Although 2019 was down by 38mm from the previous year, (246 mm) due to a wet November (62 mm) the growing season rainfall was well above 2018. (147 mm) This extra growing season rainfall resulted in improved yields for hay and cereal crops.

On the 4th September 2019, the Appila CFS station was a great location to host the Appila Hub event. Peter Cousins and Leet Wilksch both gave fantastic presentations in front of over 20 local farmers. Leet gave some great tips on how to use and interpret the new automatic weather stations that had been recently installed. Peter talked about the importance of hitting your target while spraying and how to reduce this risk of spray drift. All that attended enjoyed the presentations and the BBQ and drinks afterwards.

The local community came together on the 8th of December 2019 for the Appila Christmas Service. This was the first time that the entire event was held at Stacey Park and it was a great success. The solid crowd that turned up enjoyed an evening of Christmas carols, good food and drink and even better company.

A perfect way to end a challenging season.

The 2020 season has got off to a wet start so far, 85 mm has fallen in Jan and Feb. Looking forward to the season ahead.

By James Heaslip , Hub Rep

Jamestown Agricultural Production Systems Hub

Japs year started off with the sowing of a dryland pasture legume trial. Although with limited success it was great to get a trial in the area. It was well attended over the year, even with a visit from a group from NSW that found it very interesting. The Japs would like to thank Tom from landmark, as well as the other resellers in town for their help over the year with the trial.

We also co-hosted the confinement feeding day which was well attended by both locals and farmers from outside the area.

By Luke Clark, Hub Rep

Morchard/Orroroo/Pekina/Black Rock Hub Report

Well who would have thought 2019 - 135mm would have been dryer than 2018 - 150mm at Morchard. But it was!!

Therefore our hub is facing some very difficult decisions in 2020, notably to keep cropping or go all out for livestock.
Who knows ??

In 2019 our Hub had 4 significant meetings:

11th Feb: A small group of 12 met at Ellery's shed to view their new Boomspray followed by a chat from Andrew Catford, Local agronomist on issues for the upcoming cropping season.

5th May: Forty farmers attended a Fencing expo at the Morchard complex. Two Reps from Waratah discussed new fencing products with particular emphasis on exclusion fencing (Kangaroo numbers in plague proportions) and a comparison between Australian made and Chinese imports was discussed with a practical demonstration available outside.

In Sept Mary Ann Young from PIRSA and the Hub organised a meeting at Ellery's Shearing shed to Identify issues relating to getting sheep through the drought. This discussion identified that education on Lot Feeding was the main issue. Thirty farmers attended.

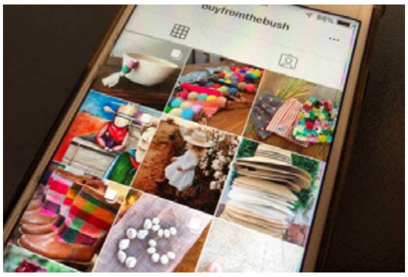
11th Oct a meeting was held at the Morchard Complex to address the Issue of Education for Lot feeding . Forty farmers attended to hear discussion on Containment and Lot Feeding & Nutrition. Guest Speakers included Emma Shaddock Animal Health Nutritionist from Elders and Local Lot Feeders Ian Ellery and Tom Kuerschner, discussing their local experiences including available data/results.

The Morchard/Orroroo Hub is looking forward to season 2020. Hopefully it will be a much wetter year, allowing us to look at the challenges that will bring.

By Gilmour Catford
Morchard/Orroroo/Pekina/Black Rock Hub Rep

Ladies on the Land Hub

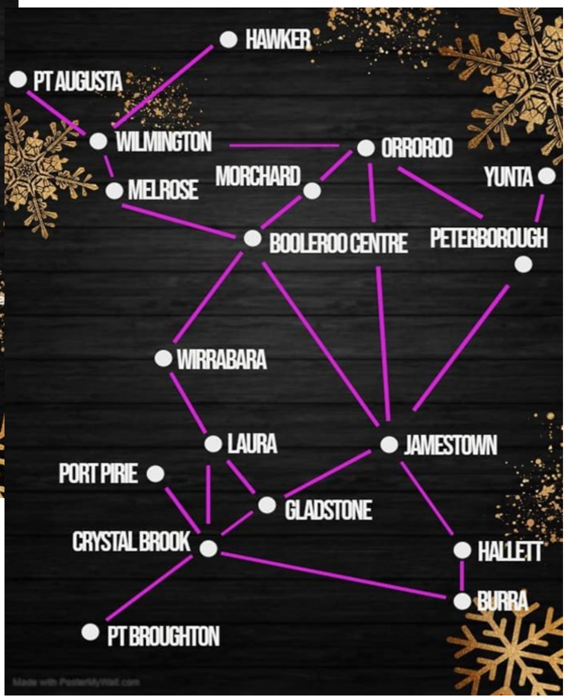
Ladies on the Land held two very well attended workshops at Morchard titled ‘Weathering the Drought’, an initiative of WoTL. Facilitated by Jeanette Long and Judy Wilkinson, this series of workshops gave some excellent tools and tips for women to help overcome the challenges that come from a business and personal perspective of a drought event. ‘The workshops were very well timed with a dry start to 2019 and very little feed in the north east of our state, it was great to see some new faces of women from pastoral properties that hadn’t attended our LOTL days before’, said Jess Koch, hub rep. These workshops were a great lead in to the Practical Business Planning workshop series held in Booleroo Centre during July and August, facilitated by Rural Directions PL. Topics covered practical business planning, accountability and action orientation within your business.



Ladies on the Land had a very busy end to 2019, jumping on board the #buyfromthebush campaign, an online campaign fuelled by social media, designed to encourage Christmas shopping from rural businesses, particularly those that had been affected by drought.

Given the Facebook following of nearly 8000 people, the LOTL Facebook page was the perfect platform to showcase businesses in the Upper North. Businesses sent a short profile and some photos explaining their wares through Jess, who then profiled a new business every day. The feedback was phenomenal and eventuated in well over a hundred businesses registering. Jess said ‘after receiving some great suggestions I decided to put the business locations into a Christmas mud map and list registry to give shoppers a sense of how close the businesses were in our area. It was also a great opportunity to show off our local businesses to shoppers outside the area that my be able to inject some cash into the area which was encountering its second nasty drought in a row’.

A competition encouraging shoppers to post a picture of them out and about in the #buyfromthebush businesses was also a resounding success, with Michelle Kay, who captured a photo of her shopping in Wirrabara taking out the $200 prize.



By Jess Koch, Hub Rep

Supported by

Nelshaby Ag Bureau Hub

3rd June Ag Bureau Meeting

Guest Speakers: Rocky River AG talking all things Red plus much more. Carmel McNamara from centre link speaking about drought relief options.

13th June Regional Cropping Solutions Local Forum

The bureau organised a local forum at the Wandearah Memorial Institute to discuss GRDC investment in R, D & E on behalf of grain growers with GRDC representatives. Dr. Therese McBeath also talked about increasing the productivity of Sandy Soils.

Nelshaby Ag Bureaus AGM 1st July

Guest speakers: Tristan Baldock speaking about his farm at Buckelboo and some of the experiments he is trying on his farm as well as his trip to Argentina with the Australian AG Minister.

20th 21st August Bureau Trip

The local bureau went for a two day trip down the Yorke Peninsula visiting several farms and businesses. These included Anna Binna with Ben Wundersitz, Moonta Engineering, Sunny Hill Distilery, a $1million on farm man cave and an on farm seed cleaning business.




13th September Ag bureau sticky beak day

The bureau had a full day planned starting with the pulse check group looking at different pulses and legumes in low rainfall areas. After this we looked at some Deep ripping, spading and Plozza ploughing trials Brendan Johns had done on his farm. We then had Lunch Supplied by ADM who talked about there recently put up grain delivery site in Port Pirie. After lunch we Looked at Local agronomist Stefan Schmitts’ vetch trials on Byron and Leighton Johns farm and finished the day off looking at some crops that had been flooded in 2016 on Nathan Crouchs’ Property as well as some other local crops.

2nd December Christmas Tea

The bureau all got together for a Christmas tea

3rd Feb Ag Bureau meeting

Guest Speakers Stephen Kitschke & Scott Wilson. Both are local hay contractors with 50 years cutting and bailing experience between them. We also had Local Ben Mumford Speak about his experience with his property being completely burnt in the Kangaroo Island fire

By Nathan Crouch, Hub Rep

Matthew Harvie McCallum – The Legacy

In December 2019 Matt McCallum's life was tragically cut short in a motor vehicle accident. His death has had a significant impact on all that knew him and left a hole in the lives of his family and friends that will never be filled. Matt's contribution to his community and his love of his family were well known, however his contributions to agriculture and improving the profitability, productivity and sustainability of the farming operations in the Upper North and across the country were less well known. Dr Matt was a modest fellow.

His contribution to the agricultural industry has been significant and the roles he played in the Upper North Farming Systems group vast. He was a long-standing member of the Strategic Board of the group and recently completed a 2-year term as Chairman. He was active in all areas of management of the group and delivered on ground trial work across many areas of cropping and livestock production.

His past roles saw him undertake research across southern Australia including within the CSIRO, Victorian Department of Agriculture, Ag Consulting Co, Alkaline Soils Group and his own consultancy McAg Consulting. He completed his PhD in 1998 at the University of Melbourne and was the first draft pick (as he used to say) of the Joint Centre for Crop Improvement- a joint initiative between the Victorian Department of Agriculture and the University of Melbourne.

Matt was an active participant in extension events, providing educational and inspirational presentations on a wide variety of topics through-out his agronomic career including No-Till, Controlled Traffic, New Technology Uptake, Weed Management, Pasture options, Novel Farming Systems and Soil Health. He was passionate about what he knew and wanted to share that with his farming community. His enthusiasm for agriculture and the people who worked in it was contagious and his sense of humour renowned through-out the industry.

Below is a list of papers and projects that Matt put his stamp on and many he authored. This list is by no means complete, as he was an advisor to many, always willing to chat through a problem or nut out a solution. His legacy to the agricultural industry in Australia will be long felt. The farmer and the scientist, a great mate and family man.

Scientific Papers, Conference Proceedings and Results Publications

Water and nitrogen dynamics of lucerne-based cropping systems in the Victorian Wimmera.
In: Asghar, M. (ed.) McCALLUM, M.H., O'LEARY, G.J. and CONNOR, D.J. (1996) Proceedings of the 8th Australian Agronomy Conference, Toowoomba. p. 685. (The Australian Society of Agronomy: Toowoomba, Qld).

The water and nitrogen dynamics of a lucerne-based farming system in the Victorian Wimmera.
1998 – PhD Thesis University of Melbourne- McCallum, Matthew Harvie
http://hdl.handle.net/11343/114436

Lucerne in a Wimmera farming system: water and nitrogen relations.
Agronomy Australia Proceedings – Australian Society of Agronomy Annual Conference 1998. M.H. McCallum[1], D.J. Connor[2] and G.J. O'Leary[3].
http://www.regional.org.au/au/asa/1998/2/231mccallum.htm

Comparisons of the efficiency of nitrogen fixation in pastures
M.B. Peoples[1], R.R. Gault[1], J.F. Angus[1], A.M. Bowman[2] and M. McCallum[3] Agronomy Australia Proceedings – Australian Society of Agronomy Annual Conference 1998
http://www.agronomyaustraliaproceedings.org/images/sampledata/1998/9/073peoples.pdf

Contributions of nitrogen by field pea (Pisum sativum L.) in a continuous cropping sequence compared with a lucerne (Medicago sativa L.)-based pasture ley in the Victorian Wimmera.
M. H. McCallum, M. B. Peoples and D. J. Connor**.** Australian Journal of Agricultural Research 51(1) 13 – 22. (2000**)**
https://www.publish.csiro.au/CP/AR99023

Factors regulating the contributions of fixed nitrogen by pasture and crop legumes to different farming systems of eastern Australia.
M.B. Peoples, A.M. Bowman, R.R. Gault, D.F. Herridge, M.H. McCallum, K.M. McCormick, R.M. Norton, I.J. Rochester, G.J. Scammell & G.D. Schwenke . *Plant and Soil* **228,** 29–41 (2001).
https://doi.org/10.1023/A:1004799703040

Water use by lucerne and effects on crops in the Victorian Wimmera. McCallum MH, Connor DJ, O'Leary DJ (2001). *Australian Journal of Agricultural Research* **52**, 193–201.
https://www.publish.csiro.au/cp/AR99164

Using Lucerne to Improve the Reliability of Cropping on Waterlogged Soils
MH McCallum[1], MB Peoples[1], RR Gault[1], JF Angus[1], JA Kirkegaard[1], T Green[2], and HP Cresswell[2]. Agronomy Australia Proceedings – Australian Society of Agronomy Annual Conference 2001
http://www.agronomyaustraliaproceedings.org/images/sampledata/2001/p/1/mccallum.pdf

A Case Study to Reduce Dryland Salinity on a Temora Farm
M.H. McCallum[1], J.S. Salmon[2] and J.F. Angus[1]. Agronomy Australia Proceedings – Australian Society of Agronomy Annual Conference 2001
http://www.regional.org.au/au/asa/2001/3/b/mcallum.htm

Contributions of Fixed Nitrogen by Crop Legumes to Farming Systems of Eastern Australia
M.B. Peoples[1], R.R. Gault[1], D.F. Herridge[2], M.H. McCallum[1], K.M. McCormick[3], R.M. Norton[3], G.J. Scammell[4], G.D. Schwenke[2] and H. Hauggaard-Nielsen[5] Agronomy Australia Proceedings – Australian Society of Agronomy Annual Conference 2001
http://www.agronomyaustraliaproceedings.org/images/sampledata/2001/1/c/peoples.pdf

Improved subsoil macroporosity following perennial pastures
M. H. McCallum, J. A. Kirkegaard, T. W. Green, H. P. Cresswell, S. L. Davies, J. F. Angus and M. B. Peoples
Australian Journal of Experimental Agriculture 44(3) 299 – 307. 2004
https://www.publish.csiro.au/an/EA03076

Wide Row Cropping Options, CT and Guidance
Dr Matt McCallum, Bill Long, Stephen Wentworth, Sam Holmes, John Tiller, Clinton Tiller, Derek Tiller. 2004 Unknown Publication.

Stubble Trouble? Inter-Row is the way to go!
Dr Matt McCallum. SANTFA The No-Till Journal. Vol 1 No 4. 2004

Stubble Management – inter-row sowing using two cm auto steer.
Dr Matt McCallum. 2005 National Farm Groups Manual

Effectiveness of grazing and herbicide treatments for lucerne removal before cropping in southern New South Wales
S. L. Davies, J. M. Virgona, M. H. McCallum, A. D. Swan and M. B. Peoples
Australian Journal of Experimental Agriculture 45(9) 1147-1155. 2005 https://doi.org/10.1071/EA04202

Farmer Case Studies on the Economics of PA Technologies
Dr Matthew McCallum. Agronomy Australia Proceedings – Australian Society of Agronomy Annual Conference 2008 http://www.agronomyaustraliaproceedings.org/images/sampledata/2008/concurrent/managing-site-season/5839_mccallumm.pdf

Application of automated "spot spray" technology in the Upper North.
Matt McCallum and Ruth Sommerville. Upper North Farming Systems Annual Results Book 2013 pg 70 https://unfs.com.au/wp-content/uploads/2016/09/UNFS-2013-Annual-Results-Book-Final.pdf

Plains Producer 22-5-04

Ground-breaking machinery for Verners

Mallala farmers, John, Richard and Anthony Verner have made groundbreaking history by becoming the first SA farmers to buy a new Morris disc machine.

Instead of conventional tynes, the Morris disc machine uses discs to open the soil for seeding with small, neat slots with minimal soil disturbance.

The new Morris machine allows farmers to sow at high speeds, between 12 and 14km/h.

It also has the ability to sow through heavy stubbles without "hairpinning" due to its unique never-pin mechanism.

Morris disc machines are sold and serviced by GPS Ag, Ardrossan.

For further details ring Matt McCallum on 0438 895 167.

▲ NEW SEEDER: Anthony and Richard Verner of Redbanks with Matt McCallum (left).

Upper North Farming Systems Stubble Management Guidelines. 2013-2018 https://unfs.com.au/resources/

Application of Controlled Traffic Farming (CTF) to the Upper North
Matt McCallum. Upper North Farming Systems Annual Results Book 2016. Pg 75
https://unfs.com.au/wp-content/uploads/2017/11/UNFS-2016-Annual-Results-Book_Website_small.pdf

Inter-row seeding reduces impact

THE USE OF PRECISION AGRICULTURE TECHNOLOGY CAN HELP PLACE THIS YEAR'S CROP AWAY FROM HIGH LEVELS OF DISEASE INCIDENCE

PRECISION PLANTING IN last year's inter-row offers growers a tool to reduce the impact of disease on the current crop, but it has minimal impact on reducing disease inoculum levels. These are the findings of Dr Matthew McCallum, of Ag Consulting Co in South Australia, and Dr Steven Simpfendorfer in trials in northern New South Wales.

Previous research identified that the level of stubble-borne disease inoculum was two to seven times lower in the inter-row than under last year's stubble row. This information, combined with the fact that crown rot infection was found to occur only if crops came into contact with infected stubble, led researchers to look at the benefits that might be obtained by sowing in the inter-row area. Inter-row sowing is achieved using global positioning systems (GPS) that provide two-centimetre accuracy.

In 2004, precision seeding trials were sown into wheat stubble using knife points and press wheels on 23-centimetre (nine-inch) row spacing. Take-all was the only disease recorded as being at a high-risk level in-row, but was low risk on the inter-row. A significantly lower number of dead heads was recorded in wheat plants sown in the inter-row area compared to wheat sown in-row – that is, directly over last year's wheat stubble. This was reflected in a significant difference in yield: 4.11 tonnes per hectare inter-row compared with only 3.88t/ha in-row.

In 2005, wheat was again sown inter-row and in-row. Effectively, the inter-row treatment was being sown into the stubble rows of the first year of wheat. A nine per cent increase in yield was recorded inter-row as well as significant improvements in protein and screenings. Take-all and cereal cyst nematode (CCN) were at high-risk levels in-row.

Of the wheat plants sown in-row, 50 per cent were infected with take-all and the rating for CCN was 2.3 out of five. However, plants sown in the inter-row area had only 18 per cent infection with take-all and the CCN score was 0.4.

Similar improvements in yield were recorded at sites where crown rot was at high risk in-row and at sites where no specific disease pressure was recorded.

Both of these results are from a single year of trial work and further research is required to quantify all benefits and impacts that may result from sowing on the inter-row.

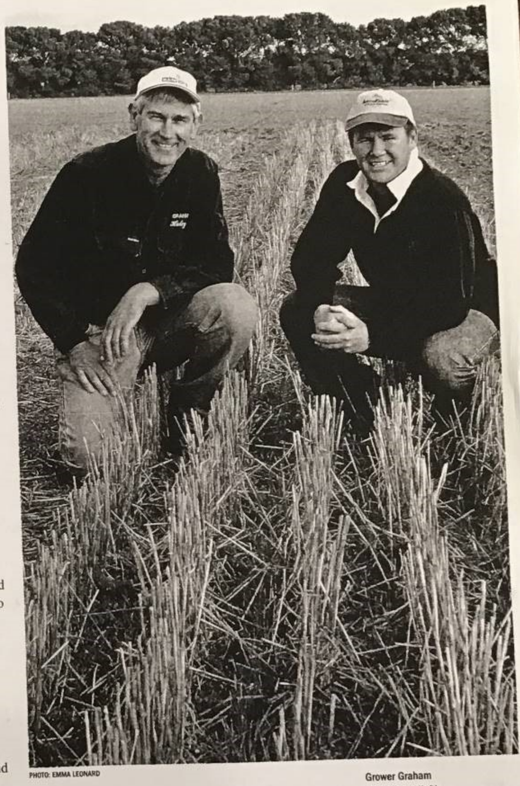


PHOTO: EMMA LEONARD

Grower Graham Mattschoss (left) and researcher Matt McCallum inspect the inter-row seeding plots on Graham's farm near Sandilands on the Yorke Peninsula. Inter-row seeding can help reduce inoculum levels in the year of sowing, but has little impact on reducing disease pathogen levels in the soil.

Steven Simpfendorfer reports that his inter-row seeding trials are more effective at reducing damage from crown rot when inoculum levels are lower. He emphasises that inter-row seeding has less impact on reducing inoculum levels over seasons, which is central to successfully managing crown rot. However, this seeding system can offer yield benefits due to reduced disease pressure, making it a useful tool in the integrated management of soil and crown disease.

GRDC Research Code DAN485
More information: Dr Matthew McCallum, 08 8837 3993, matthew@agconsulting.com.au; Dr Steven Simpfendorfer, 02 6763 1261, steven.simpfendorfer@agric.nsw.gov.au

January – February 2007 ROOT & CROWN DISEASES GROUND COVER 17

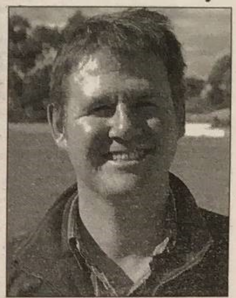
Y.P. COUNTRY TIMES 24-10-06

FARMING

CROP DOCTOR With Peter Reading

FOCUS ON

Precision agriculture provides seasonal flexibility



■ Dr Matt McCallum (above) says farming with two-centimetre accuracy allows growers to adjust farming practices to the season.

Promises of yield increases and cost savings from precision agriculture are nothing new, but agronomist Matt McCallum may have delivered the most compelling argument yet for adopting the system.

Speaking at a grower update on precision farming specially convened by the Grains Research and Development Corporation at Lockhart in southern NSW, the South Australian-based agronomist talked up the system's flexibility. Farming with two-centimetre accuracy, he said, allowed growers to adjust farming practices to the season.

Quoting trial work from NSW and South Australia, Dr McCallum compared yields from cereal crops sown in the same row as the last cereal crop with those sown between rows. Where soil borne diseases such as take-all, crown rot and CCN were a factor, sowing between last season's rows boosted yields by 6-9%.

That's not to say Dr McCallum would always recommend inter-row sowing, far from it. Faced with the prospect of dry sowing or sowing after a failed crop, his recommendation was to sow in the same row.

Growers would get a more even seed bed by running their tynes in last year's loose soil in the seed furrow. They would save fuel by not having to break open hard ground and they would increase their potential to recapture any residual nutrition. Most important was the potential to get that extra bit of moisture available in last year's row, he said.

Stressing the now-accepted advantages of precision farming, such as better stubble handling and establishment of canola when sown on the inter-row, Dr McCallum said one of his clients had found it easier to harvest lentils sown on the inter-row, with the crop using the standing stubble as a trellis.

He also proposed wide row cropping, as much as a metre's space between rows, to provide broader weed control options and more cost-effective weed control.

The aim was to use expensive grass herbicides only on the crop row and to control inter-row weeds with knockdown herbicides. The potential savings amounted to $30-70 per hectare. The strategy also allowed growers to concentrate pesticide treatments for such pests as red-legged earth mite in canola crops on the row only, a distinct advantage in a program of integrated pest management.

At a time when zone management of cropping country is becoming an accepted practice, Dr McCallum said the marriage of precision agriculture with zone management offered the prospect of fine tuning such things as fungicide or fertiliser application. Reducing urea applications by 50kg/ha and better targeting fungicide applications promises savings of up to $28/ha, he said.

While a number of his clients were working with guidance systems accurate to 10-20cm, Dr McCallum said that 2cm accuracy was preferred.

He said his clients found that guidance accurate to 10-20cm is about 70% accurate year on year. Guidance to 2cm accuracy pushed it out to 90% accuracy year on year.

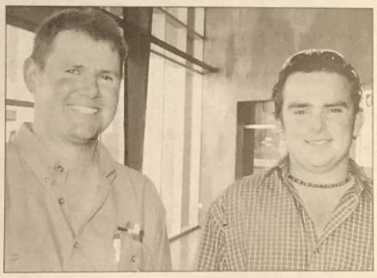
PRECISION AGRICULTURE STOCK JOURNAL ■ July 15, 2004

Straight talking at SPAA conferenc

MORE than 50 people enjoyed the chance to talk about the latest in precision agriculture at Friday's Southern Precision Agriculture Association annual grower conference at Mawson Lakes.

Profiting from Precision Agriculture was the theme for the day, which drew interested farmers from throughout the State and over the border.

Stock Journal's **MARY-JANE ANGUS** and **KATE DOWLER** caught some of the crowd on camera.



CHIT-CHAT: SPAA committee member Matthew McCallum, Ardrossan, swaps information with Warnertown farmer Heath Tiller.

Wide rows cut chemical costs

BY KATE DOWLER

Key Points

- Changes in canola seeding rate
- YP trial focus on chickpeas and beans
- Plants have better access to fertiliser
- Glyphosate used instead of grass-selective herbicides.

THE YP Alkaline Soils Field day attracted more than 100 farmers, reflecting a surge of interest in the group's work.

A survey of those attending showed that 60 per cent of respondents thought the information presented was very useful and 92pc gave the field day an overall rating of very good or excellent.

Changes in canola seeding rate, adoption of wide row spacing or controlled traffic were noted as the most likely changes for the future.

One of the most popular trials was Bill Long's Ag Consulting Co wide row spacing demonstration.

"Research in Western Australia has shown that by doubling row spacings on lupins, yields can be increased to 17 per cent," he said.

"The exact reason for the yield increase is not known, there are a number of factors, and we are following that up with a SAGIT and GRDC trial repeating the work this year."

The Yorke Peninsula trial is looking at chickpeas and beans, crops better suited to that region than lupins.

"This year the interest from farmers in wide row spacings has been huge," Bill said.

Farmers' are interested in the concept because of the severe diseases dense crops have been suffering.

These canopies become very humid - producing ideal conditions for diseases like botrytis in bean crops.

Another problem with very dense crops is the amount of energy that goes into plant material trying to access light at the expense of pods.

Wider row spacings improves light penetration into the canopy, allowing leaves to contribute to grain fill.

"Hopefully, we will see more pods on each stem and less lodging - it really is an exciting area," he said.

The rows have been increased from conventional 150 millimetres spacings to 300mm.

Another major benefit of this sowing method is the increased height of the lowest pod on the plants. Bill's trials found the pods were 3-5cm higher on wider row spacings than conventional, resulting in less harvest front losses.

The plants also have better access to fertiliser.

Wider row spacings can be incorporated into GPS farming where rows are 0.5 to 1m apart and shrouded sprayers can be used in the inter-row.

This enables the farmer to use glyphosate instead of using more expensive grass-selective herbicides.

"Depending on row spacing width, fungicide costs can be reduced significantly," Bill said.

"At 1m row spacing width, banded spraying can reduce fungicide inputs by two thirds.

"With five fungicide applications in chickpeas using chlorothaloni at \$25/ha this results in a saving of \$83/ha."

Other topics of interest at the field day included nitrogen management in cereals, using lower seeding rates, growth regulants and precision agriculture.

• See future issues of Stock Journal for more stories on the YP alkaline Soils Group's work.

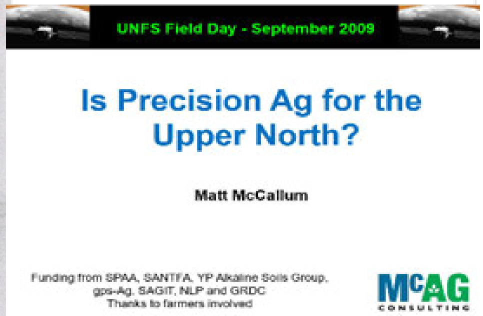
VARIABLE SPREADER: Yakka farmer Colin Mitchell demonstrates the Bogballe variable rate spreader with Craig Taylor, Bute, and Jamie Smith, Maitland at the YP Alkaline Soil Field Day.

GREAT CROP: GRDC/CSIRO's Mark Peoples, ABB Grain chairman Trevor Day, SAFF Grains Council chairman Greg Schulz and YP Alkaline Soils Group chairman Richard Murdoch.

CATCHING UP: Were Curramulka farmer Peter Stone and Bill Maloney, Arthurton.

SPREADING THE WORD (above): Agriculture consultant Sam Holmes of ACC Ltd spoke at the field days about nitrogen seeding rates in canola.

BEST BUY (right): Ag Consulting Co.'s Matt McCallum gave growers a buyers guide to GIS equipment.



Grower groups ensure topical on-farm work

GROWER groups across SA are acting as a valuable link between researchers, farmers and advisers to ensure applied research occurs in their region.

That is how Upper North Farming Systems executive officer Ruth Sommerville sees it.

"UNFS doesn't have to do the work ourselves, but we facilitate the work in the region," she said.

"We make sure we get the questions and issues of farmers to the researchers.

"We work on both national priorities, but also dig down to locally-relevant projects and ensure industry and government is investing in relevant, game-changing research for our farmers."

UNFS has several research and extension projects from a range of funding bodies, including the GRDC's Stubble Initiative Project.

The five-year project, concluding in June next year, assesses a broad range of agronomics within retained stubble, including seeder setup, pests, weeds, nutrition and harvesting height.

"We know retaining stubble is good for the system and helps the environment, but we also know it can come at an economic or operational cost, so we are looking at how we can make it a more profitable option for farmers," Mrs Sommerville said.

The SA Grains Industry Trust recently awarded \$3 million to 26 projects for 2017-18, from the 30 cent a tonne levy collected on the state's grain crop.

UNFS was one of the successful candidates, and also has an ongoing time of sowing trial from 2016.

It is assessing five wheat varieties sown at three different dates near Booleroo Centre to assess yield loss from heat and frost stress.

Winning the AgEx Alliance Grower Group award last month has also enabled UNFS to seek out suitable improved pasture options for Upper North farmers to use as a break crop, with PIRSA funding.

Mrs Sommerville says the project builds on a GRDC-funded Crop Sequencing project completed in 2015.

"We identified there were significant economic gains with rotating crop types to have a two-year break between cereals, offering a disease and weed break," she said.

"This is amplified where the break also results in nitrogen fixation. With the livestock industry as it is, one of the most profitable options is an improved pasture."

Sites will be established at Melrose and Booleroo Centre, and will include varieties due for release in 2018.

Matt McCallum, Booleroo Centre, says UNFS is undertaking some great practical research and a diverse range of projects.

"You can read information about what is being completed in our areas, but there is nothing like seeing the work done in your own soil types and conditions," he said.

– CATHERINE MILLER

PRACTICAL APPROACH: Upper North Farming Systems member Matt McCallum, Booleroo Centre, (pictured with project officer Hannah Mikajlo) says the group has some great research projects.


2019 UNFS Research Trial Sites
Legend
Trial Site
Dryland Legumes Trial
Barley Grass Trial
Micronutrients - Lentil Trial
Micronutrients - Wheat Trial
Cover Crops & Crown Rot Trial
Fodder Options & Barley TOS Trials
Melrose
Micronutrients - Wheat Trial
Peterborough
Pasture Options Demonstration
Jamestown
Gladstone
Laura
Crystal Brook
Vetch Trials
Port Pirie
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
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30 km
N

Understanding trial results and statistics

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

The average (or mean)

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

The LSD test

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

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

Results from replicated trial

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

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

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

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

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

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

On-farm testing – Prove it on your place!

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

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

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

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

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

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

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

Some useful conversions

Area

1 ha (hectare) = 10,000 m^2 (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

Decision Support Tools

UPPER NORTH FARMING SYSTEMS

Automatic Weather Station Network

Better Decisions from Better Information

Author: Ruth Sommerville
Funded By: SAFECOM
Project Title: Upper North Fire Danger Index Alerting Weather Station Network
Project Duration: 2019
Project Delivery Organisations: Agbyte

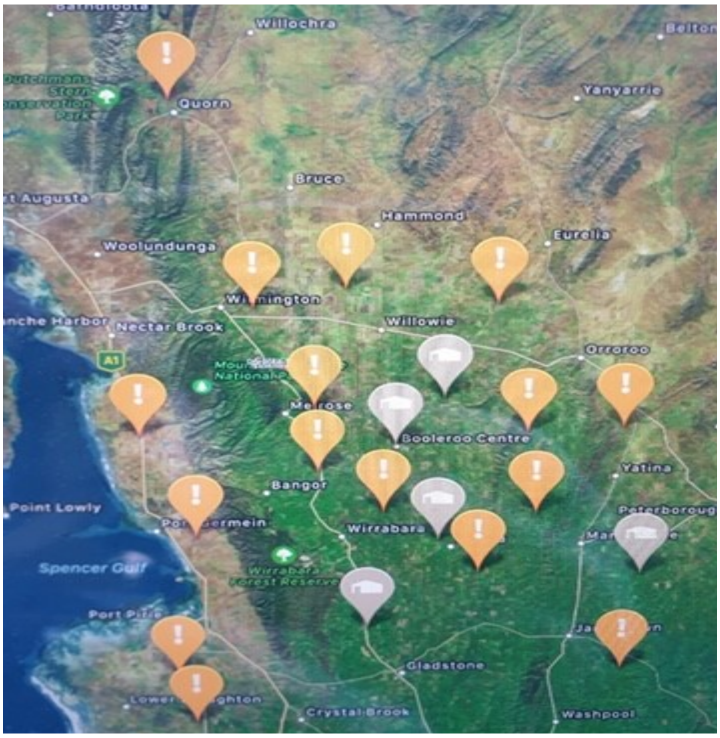
Overview: Installed in 2019 the Upper North Farming Systems Automatic Weather Station Network was funded through SAFECOM and aims to provide farmers in the Upper North Region of South Australia with timely and accurate weather data to enable better decision making on farm. The system will enable farmers 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. The addition of soil moisture probes is also being investigated.

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 weather condition verification.



Government of South Australia
South Australian Fire and Emergency Services Commission

agbyte

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

Government of South Australia

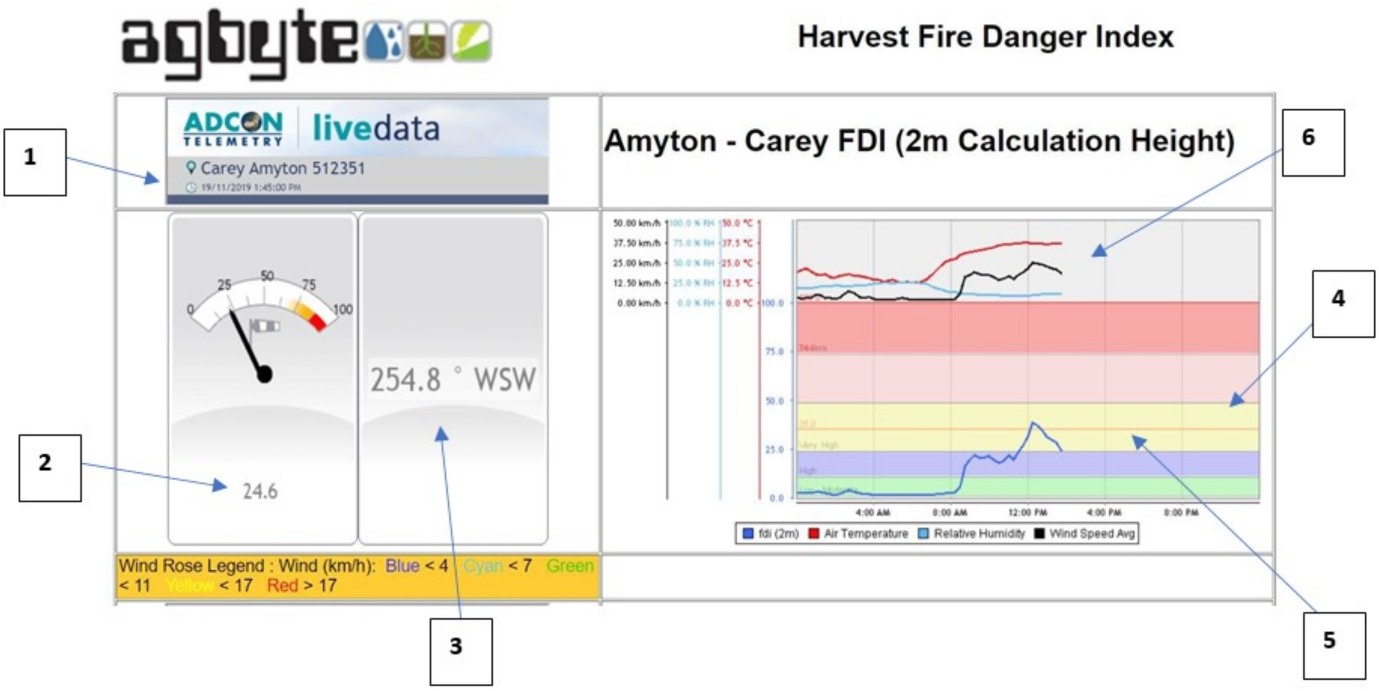
CFS

SOUTH AUSTRALIAN FARMERS FEDERATION

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"

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.

Upper North Farming Systems would like to acknowledge Leighton Wilksch, Agbyte, for installing and managing the weather station sites and the landholders who have partnered in this venture to make this a regional asset for all farmers and for the greater good of the community.

UNFS Weather Station Data – Booleroo Centre 2019

UNFS has a weather station located north west 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 2019 and can be referred to as a reference for the 2019 trial sites near Booleroo Centre.

It is important to note that the Bureau of Meteorology for the Booleroo BOM Station 019006 is an average annual rainfall of 390.7mm. This is the result of 136 years of data and has been recorded since 1884.

Figure 1 – Weather Station Data for Weather station – UNFS Booleroo 863071 installed by Agbyte.

2019 Booleroo Weather Station Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
AVG (°C)	29.7	26.2	23.3	18.2	11.7	8.1	8.9	8.3	13.5	19	20.2	27.6	
MIN (°C)	7.9	6.5	5.4	1.2	0.5	-3.8	-2.2	-3.5	-2.5	-0.5	0.6	4	
MAX (°C)	59.3	55.6	52.3	43.3	31.3	25.2	22.5	24.6	33.9	43.8	48.7	59.4	
SUM (mm)	5.8	6.8	3.8	4.8	31.8	44.5	12	20.5	10.5	0.8	9	8.5	158.5
AVG (% RH)	38.2	43.4	49.1	50.1	69.7	72.9	76.4	-	-	-	-	-	
MIN (% RH)	7.7	12.7	13.7	11.3	28.3	33.2	24.9	-	-	-	-	-	
MAX (% RH)	94	90.5	96.9	95.7	98.6	99.2	99.3	-	-	-	-	-	
Weather Station - UNFS Booleroo 863071 - installed by Agbyte													
Data for 2019 Calender year.													

The above data is a summary of the monthly recordings taken from the weather station installed by Agbyte.

These recordings cover:

- Average temperature (Cº)
- Minimum temperature (Cº)
- Maximum temperature (Cº)
- Total Monthly rainfall (mm)
- Relative Humidity Average (%)
- Minimum Relative Humidity (%)
- Maximum Relative Humidity (%)

The Growing Season Rainfall (April – October) for this weather station was 124.9 mm. The total rainfall recorded on this station was 158.5mm.

This location has soil moisture probes and Figure 2 shows that at on May 1st 2019 the 0-15cm reading was 15.5mm. The stored soil moisture from 15cm – 125cm varied from 27.6mm (25cm) to 38.9mm (125cm). The top of Figure 2 shows the rainfall events and throughout 2019 there was very little moisture reached greater than 35 cm.

Figure 3 shows the cumulative stored soil moisture for 2018 through to 2019, the cumulative graph shows that the soil moisture towards the driest ever with no major increase in soil moisture from November 2017. 2019 profile moisture floated around 400mm and only briefly got to 420mm.

On 21st April 2020, the profile was reading approximately 440mm so is already at an advantage over 2019.

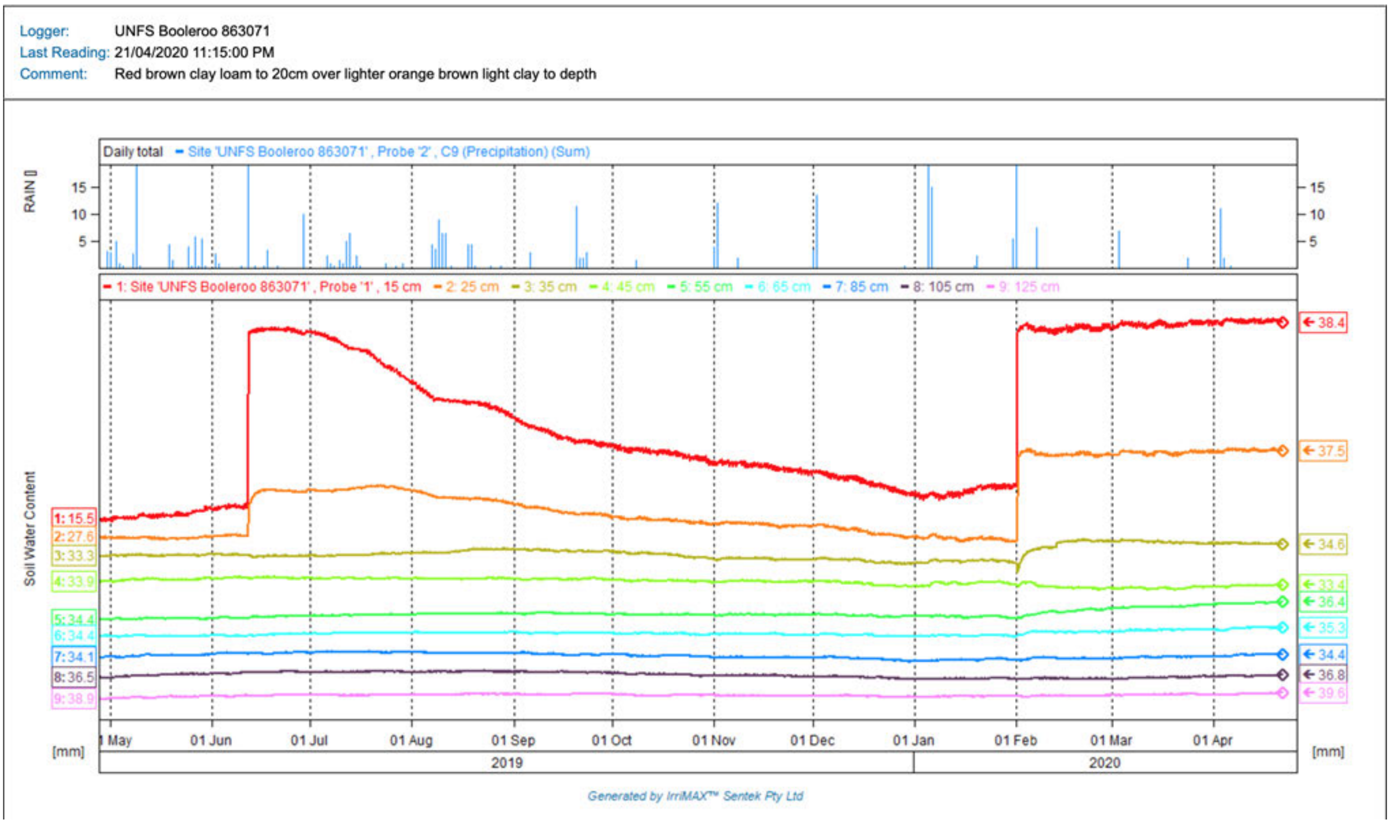


Figure 2 Soil Moisture Probe – Booleroo Agbyte Site 863701 – May 2019 – May 2020

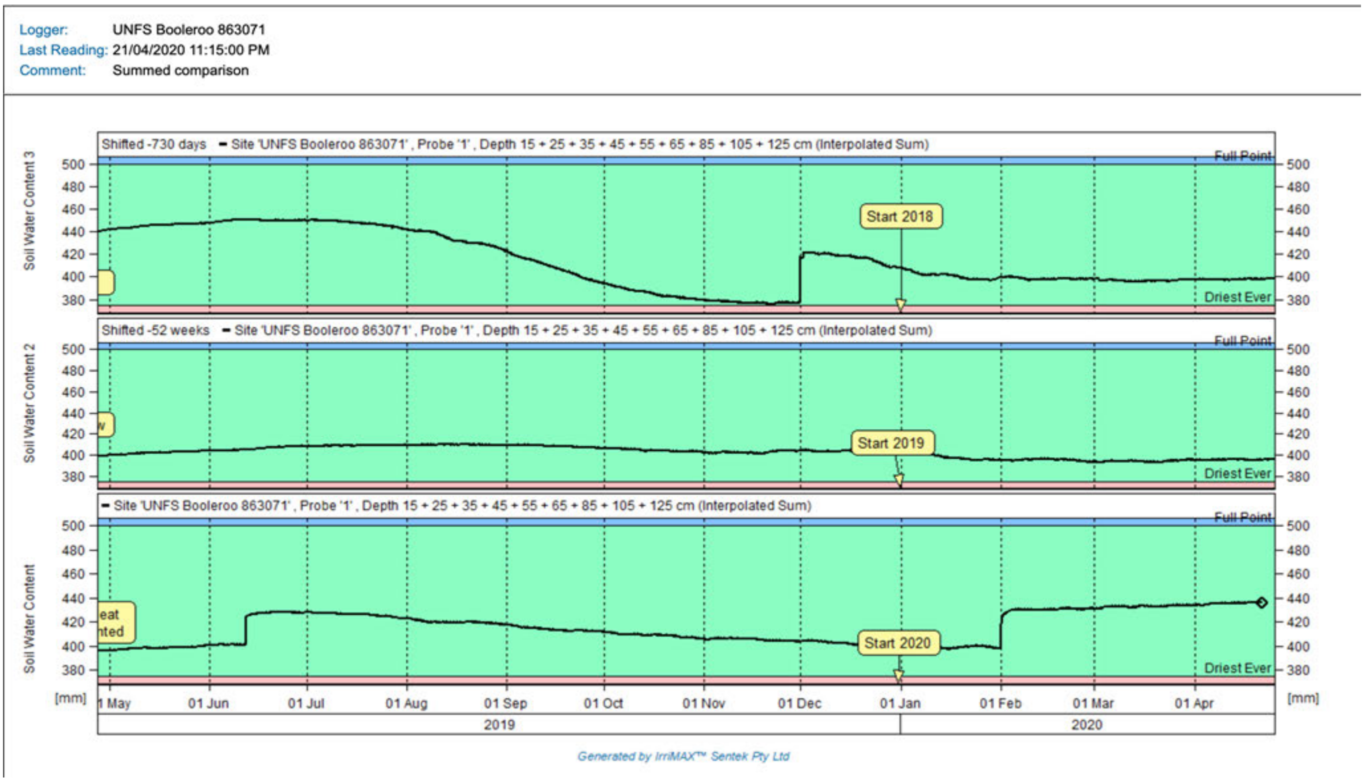


Figure 3: 2019 Summary soil moisture probe data. Actual date range: May 2018 – April 2020

Fast and Slow Thinking- an agricultural perspective

Barry Mudge, Barry Mudge Consulting

Take Home Messages

- **Optimising choices and judgements in agricultural systems is challenging in a complex decision-making environment**
- **Slowing down and thinking through the potential outcomes (or "imagining the future with rigour") can support the decision-making process**
- **Analysing the expected range of outcomes (rather than focussing on a specific point) can provide an increased level of robustness**
- **Seasonal Outlook forecasts can be useful in providing additional information to be used in the decision-making process, but their application needs to be carefully considered**
- **Use of a support mechanism such as a *Decision Matrix* can be of value in large decision**s

Background

"…most of our judgements and actions are appropriate most of the time…….But not always." (Kahneman, 2011)

In his excellent internationally best-selling book, "Thinking Fast and Slow", psychologist Daniel Kahneman investigates human rationality and irrationality and identifies a number of areas where errors in judgement and choice can lead to sub-optimal outcomes. While we may believe what is going on in our minds, many of our thoughts and impressions arise without us consciously knowing how they have actually got there. He argues that a more accurate diagnosis and understanding may limit the damage that bad judgements and choices often cause.

For a range of reasons, the specialised area of agricultural decision making can be quite complex. This is largely associated with the variability and risk that are inherent in agricultural systems.

In line with the above quote from Kahneman's book, most farmers operate pretty well most of the time. But many studies have identified the profitability gap which exists between the top 20% of farmers and the middle majority. And while clearly, profitability is not necessarily the only driver of decision making, these studies have identified an implementation gap which, in some cases, is limiting farm performance. Fundamentally, the difference between operators lie not necessarily in what they do, but in how well they do it. Interestingly, scale was not the driver of profitability which many people think it is. But effectiveness in making *good* choices and judgements remains the key.

Kahneman identifies a number of influences which can contribute to sub-optimal decisions making. These include:

- Risk aversion - not thinking like a trader
- WYSIATI (What you see is all there is)
- Recency Bias
- Affect heuristic
- Effect of stress, tiredness
- The law of small numbers
- Anchoring effect
- The illusion of validity (vs expert intuition)
- Poor acceptance of the value of simple analysis
- Overweighting of small probabilities

I have not attempted to progress all these in this paper, but it is easy to identify agricultural examples of these influences acting is a way which may restrict best judgements. This paper does not attempt or pretend to cover all aspects of complex decision making. What it does is look at some specific concepts around tactical decision making which have been fundamental to my own understanding of the subject and then provide some practical suggestions of mechanisms which I have found useful in the harsh practical world of farm decision making. A great outcome would be if this can be part of further discussion and hopefully implementation of more robust decision-making systems.

Profitability Drivers in mixed Farming Systems

A recent GRDC project (RDP00013 'The integration of technical data and profit drivers for more informed decisions') identified some key profit drivers. These were:

- Gross Margin Optimisation
- Operating a Low-Cost Business Model
- Managing people
- Managing risk

There are excellent methodologies available to manage and address these profit drivers, particularly the first three which are largely about establishing the correct strategic settings to aid long term viability. Examples include benchmarking, machinery economics, some cost of production calculations and perhaps some restructuring incorporating the use of an advisory board. This paper addresses the fourth factor of managing risk by looking at tactical decision making under uncertainty. I discuss some methodologies to potentially improve choices and judgements in this area.

Characteristics of Successful Farm Decision Makers

Two people whose opinion I respect have provided context of what they consider as characteristics of successful farm decision makers:

1. **Professor Bill Malcolm** from The University of Melbourne describes his interpretation of the process of decision making as "Imagining the future with rigour"
2. Highly respected and now retired Farm Consultant **Allan Mayfield** from South Australia identified successful farmers as being shrewd (knowing when to move or not) most of the time and bold (e.g. to grow the business) some of the time

So, here is an insight of what those top 20% of farmers might be doing- they are "imagining the future with rigour" and are "shrewd" in their understanding of the situation. Boldness then becomes the actions taken (or not taken) based on the information. The question then becomes whether it is possible to adopt techniques which improve our ability to "imagine the future with rigour"- and is "shrewdness" innate or can it be learned? I will return to this later in this paper.

A Definition of Decision Making

"*The thought process of selecting a logical choice from the available options.*

When trying to make a good decision, a person must weight the positives and negatives of each option and consider all the alternatives. For effective decision making, a person must be able to forecast the outcome of each option as well, and based on all these items, determine which option is the best for that particular situation." (http://www.businessdictionary.com/definition/decision-making.html)

Farmers are clearly faced with an array of decisions, the outcome of which can be heavily dependent on circumstances which only become known after the decision point- e.g. weather/climate, final price. As farmers, we take responsibility for these decisions and being comfortable with the decision-making process is an important psychological hurdle to overcome. Decisions can range from simple to complex- usually the complexity is increased as the time scale increases. For example, consider the situation around managing Nitrogen in an intensive cropping rotation. Decisions will include:

• Short term operational decisions e.g. are weather conditions suitable to apply urea? Relatively simple and could be heavily influenced by short term weather forecasts or radar.

• Medium term tactical decision of how much N to apply. We have knowledge of existing soil water status, N supply etc. but the decision is complicated by the fact that we don't know what the balance of the season will look like.

• Longer term changes in farm program aimed at altering long term N supply. e.g. from high return/ high risk grain legumes to lower return but lower risk legume pasture-based systems. A complex decision due to the potential longer-term rotational influences and consequences of changing crop types.

Kahneman identifies two mechanisms by which we make choices and judgements. The default position ("Fast Thinking"- he calls it System 1 or the automatic system) has been identified by others as *Intuitive decision making*- instinctive, subjective and subconscious in nature*. Rational decision-making* ("Slow Thinking"- Kahneman System 2-effortful) is almost the opposite and consists of a sequence of steps designed to rationally develop a desired solution. System 1 requires very little effort and is used extensively- System 2 require much more effort and is only used when forced. We can't turn off System 1 (and we don't want to) but we may be able to learn to recognise situations where better informed and transparent decisions could result in improved profitability or at the very least, reduced personal regret.

Weighing the positives and negatives

Effective decision making could be seen as having an understanding and knowledge of three areas:

1. Recognition of the current state (the "known knowns"). There is an enormous amount of information contained within our knowledge of current circumstances. We know (or should know) a lot about current soil moisture levels, crop stage, weed and disease levels, input/output price relationships, varietal performance etc. We also have an appreciation of our own (or our clients) attitude to risk.

2. The likelihood and consequence of the various states which may occur after the decision is made (the "unknown knowns")

3. A methodology to combine the information contained above, along with personal preferences and other potential externalities (the "unknown unknowns") into a process to arrive at a "decision".

Consider a relatively common decision problem which involves the choice between doing nothing and doing something. An example could be deciding whether or not to apply post-seeding nitrogen to a moderately N responsive crop. We expect that the seasonal conditions which apply after the decision point will determine whether the decision is ultimately regarded as right or wrong- if seasonal conditions are good, the crop will benefit from the additional N and we will be **satisfied** we applied the urea- on the other hand, poor seasonal conditions post application is likely to result in perhaps the possibility of a yield reduction, or at least insufficient yield gain to cover the cost of the application. **Regret** will be a likely outcome.

A common approach with the post seeding nitrogen question is to fertilise to a target yield we are satisfied with. But the one fact we do know is that this target yield is unlikely to be achieved- final crop yield is likely to be more (or less) depending on the seasonal outcome. So, one way of providing a level of "rigour" to this process is to describe the decision problems in terms of a **range** of outcomes against likelihood of occurrence. We find that the use of 5 points (say Very Good, Above Average, Average, Below Average and Very Poor) will provide an effective range. Table 1 provides an example of the calculations. The results can then be graphed to provide a visual representation as shown in Figure 1.

Table 1. Comparison of the net result across subsequent seasonal rainfall deciles of applying 46 kg N with no application of N to a moderately N responsive crop.

Season Rainfall Decile	Yield (no N) (t/Ha)	Price ($/t)	Gross ($)	Applic Cost ($/Ha)	Net Result ($)	Yield (46 Kg N) (t/Ha)	Price ($/t)	Gross ($)	Applic Cost (incl urea) ($/Ha)	Net Result ($)
1	1.3	250	325	0	325	1.3	250	325	53	272
3	1.7	250	425	0	425	1.8	250	450	53	397
5	2.2	250	550	0	550	2.7	250	675	53	622
7	2.6	250	650	0	650	3.4	250	850	53	797
9	3	250	750	0	750	4.2	250	1050	53	997

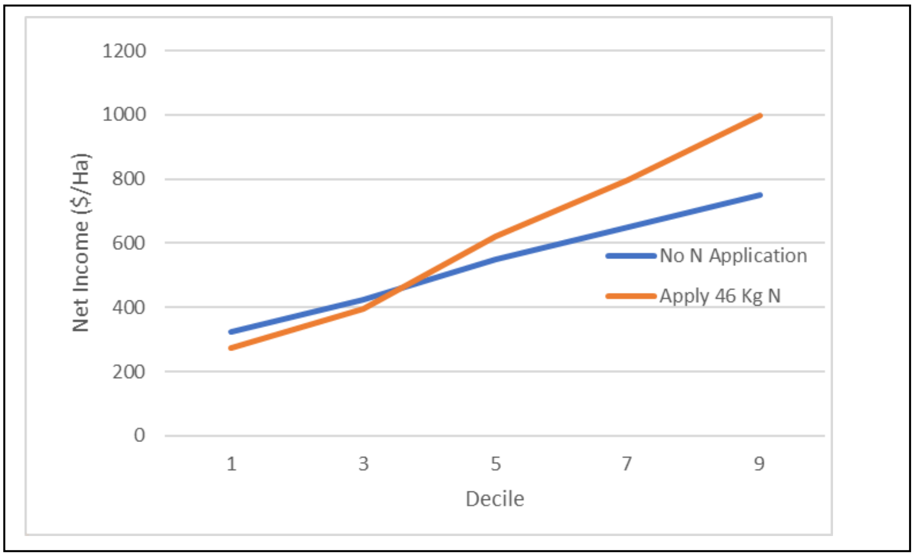


Figure 1. Graph of the comparison of the net result across subsequent seasonal rainfall deciles of applying 46 kg N with no application of N to a moderately N responsive crop.

As suggested above, there is a lot of knowledge captured in the information presented. The yield estimates may have been derived from a program such as Yield Prophet. If this site has been correctly parameterised, then information about the current state (soil water, current N levels, etc) is caught in the models estimates of yield. Likelihood and consequence of different climate states occurring after the decision point are shown in the decile vs yield estimates. And if the numbers are considered robust and accepted by the decision maker, then we are able to "weigh the positives and negatives'' as a robust aid to the decision process.

System 1 thinking will recognise there is a range of possible outcomes but usually will only focus on one. It requires some System 2 thinking to actually put some numbers on the range of possibilities. And it would require mental agility of the highest order to do this without committing some numbers to paper or a simple spreadsheet.

I have used the simple Nitrogen case as an example, but the same methodology can be used for any decision which has an expectation of **regret** or **satisfaction**, depending on the conditions which apply after the decision point. Appendix 1 contains a couple of actual examples which have been relevant to my farming business. Our experience is that people with a good understanding of farming systems (e.g. advisors and farmers) can undertake the calculations and create the graphs quite quickly (we suggest 20 minutes or less). It usually just involves taking information out of the head and putting it down on paper. The caveat to this is that it is very difficult to come up with numbers for more complex situations which may involve inter-seasonal effects which may be difficult to quantify. More about those situations later.

So, what is the correct decision in the above Nitrogen case? System 1 (the fast thinking, automatic one) might have been telling us " I think I have enough N out there already for my target yield" or "We always apply 100 kg of urea and it seems to work out", or "the crop looks a bit yellow- I think we should put some urea on" or "They are forecasting an El Nino, so I think we should back off on the urea". We have a "fast" decision. On the other hand, System 2 (slow) thinking has provided us with the graphs although they have come at the cost of some mental effort. In this case, we can observe that the upside wedge is much larger than the downside- while net benefit from urea application is not guaranteed, probability weighted average suggests that the N should go out.

Adding in Seasonal Climate Outlooks

An interesting further development of the "fast graphs" is the ability to analyse the potential influence of seasonal climate outlooks on some decisions (specifically those whose outcomes are seasonal climate dependant). Dr Peter Hayman from SARDI Climate Applications has developed an interesting Excel based program which allows users to examine the effect of changes in probabilities of different climate outlooks on expected outcomes. While this is not meant as a decision support tool, it does allow discussion on how much the patterns on the chocolate wheel would need to change before a decision might realistically be altered. In the nitrogen example used above, increasing the chance of the driest tercile from 33% (historic climatology) to 50% increases the size of the downside "wedge" but it is still outweighed by the potential gains if the (less likely) better seasons occur. A decision maker here could still be well satisfied with the decision to apply urea, due to an unwillingness to forego the potential for substantial gains.

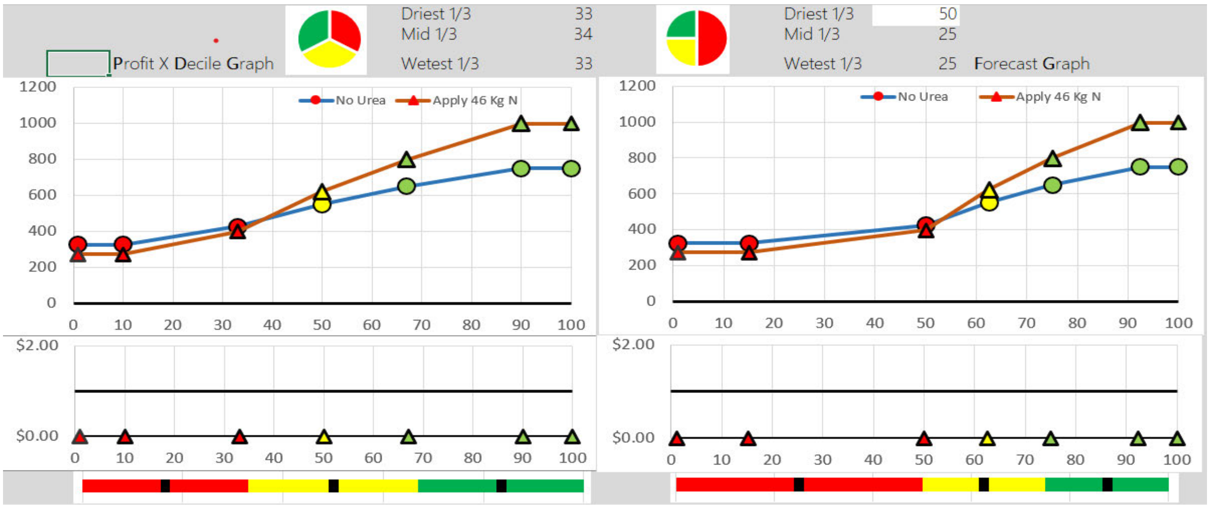


Figure 2. Graphs comparing the effect of changes in seasonal outlooks on the range of outcomes from choosing to apply urea or not. The two graphs represent two different seasonal outlooks- no change from historical recordings compared with an increased chance of drier outcome. Increasing the chance of the driest tercile from 33% (historic climatology) to 50% increases the size of the downside "wedge" but it is still outweighed by the potential gains if the (less likely) better seasons occur.

"Fast graphs for slow thinking"

The real value in developing the "fast graphs" lies in our ability to then interrogate and ask questions of the output (i.e. the slow thinking). For example

- How confident are we that we have reasonably captured the essence of the decision problem i.e. are the numbers robust?
- How does the upside and downside risk compare (the wedges)?
- what externalities would/could change the graphs?

On the assumption that 20 minutes of effort has enabled us to reasonably capture the essence of the decision problem, we can then return to the Malcolm/Mayfield discussions. I would argue that taking the numbers out of our heads and putting them down on paper (and producing the graphs) has, in fact, improved our ability to "imagine the future with rigour". We have potentially become "shrewder". We can then work through the decision process with this additional information available. However, I have rarely seen this simple approach being advocated or used.

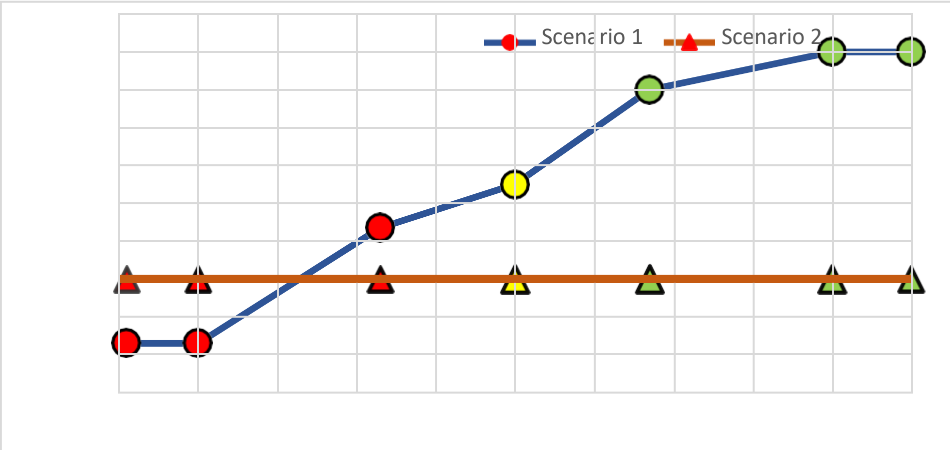
What about the "wedges"?

Most difficult choices we make in life involve some trade-off between the upside and downside risk- a win/loss situation. This is the "crossover" in the Figure 1 graph. A win/win situation would see no crossover- assuming we had the numbers right, one choice would always be superior to the other. Mathematicians would call this "stochastic dominance".

In the win/loss situation, the wedges in the graphs give us a visual picture of the decision question.

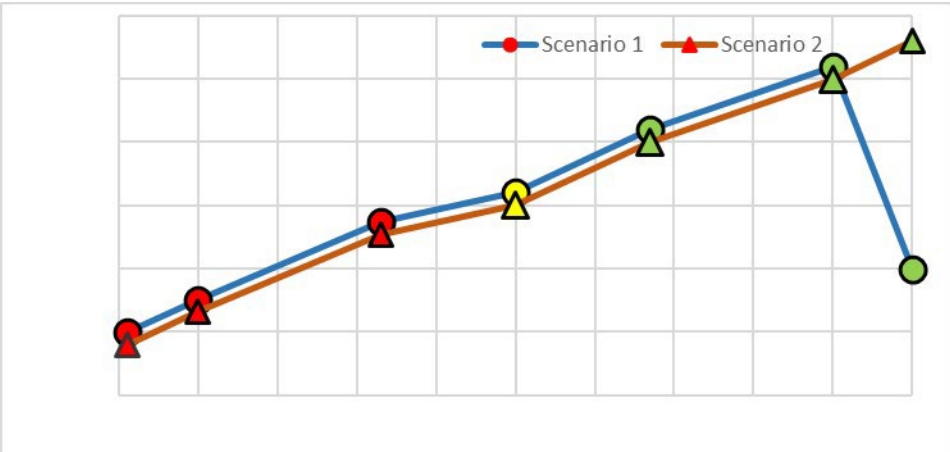
We use every day phrases to refer to a range of different choice judgements. Consider the following stylised graphical representations with the common articulation (note- in these graphs, the x-axis represents some level of changing (increasing?) risk, while the Y axis represents some measure of outcome):

a. The “No Brainer- just do it”. The upside wedge is much bigger than the downside wedge because the payoffs in the good years easily cover the relatively small costs in bad years.



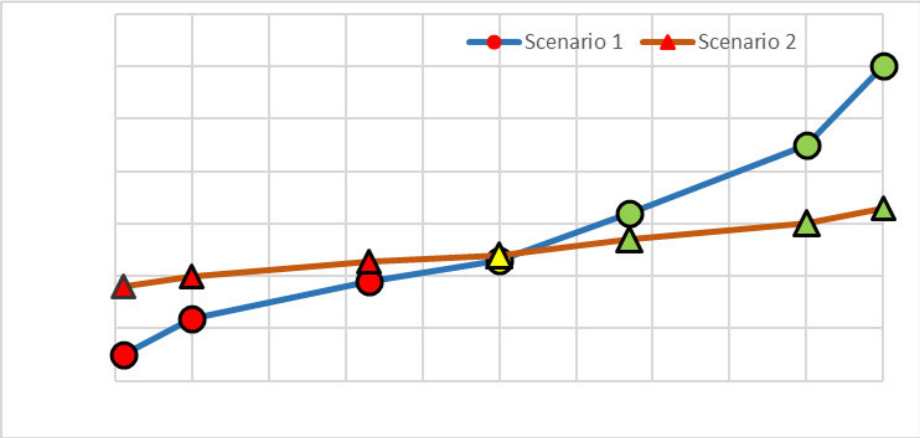
Possible examples- Summer weed control or applying N to a responsive crop.

b. “Insurance”. The blue line is the optimist who doesn’t insure. They are better off by a small amount most of the time but occasionally worse off.

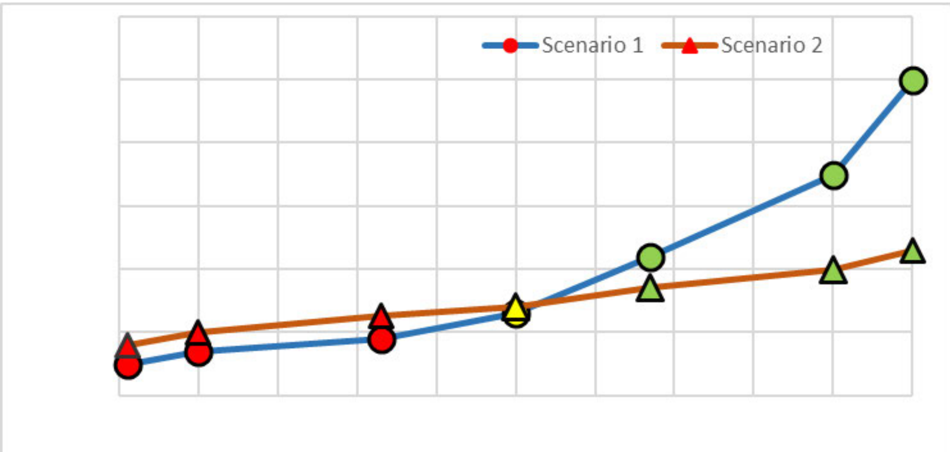


Possible examples- Hail and fire insurance, extra capital to deal with wet harvest, a fungicide for a disease that will have a major impact only in very wet years

c. “Not worth the risk”. While the upside wedge is slightly bigger than the downside wedge, because most of us care more about losses than gains, we need a bigger gain.



d. Possible examples- Growing canola in a low rainfall environment, topdressing N where the grower is worried about haying off and not convinced about carryover of N for later crops.“Probably worth a punt”. Losses might occur in about half of the years but the downside wedge is relatively small compared with the benefit in good years.



Possible Example- Growing Durum wheat in a low rainfall environment? Topdressing N where the grower is not worried about haying off and is confident about carryover.

Some of the influences which Kahneman’s identifies as potentially leading to sub-optimal choices can be seen in the above graphs. **Risk aversion** (not thinking like a trader) results from too much weight being put on the downside wedge. **Overweighting of small probabilities** is the “insurance” graph- we are comfortable meeting a modest premium, even though the payoffs are rare.

More Complex Decisions- the Decision Matrix

As suggested earlier, it is often hard to quantify consequences of actions, particularly in a complex biophysical agricultural system. An obvious example is the difficulty in identifying the effect which significant changes in crop sequences (rotations) may have on long term productivity and profitability. In these cases, it is very difficult to construct the “fast graphs” identified earlier. These are still tactical decisions- they involve choices and judgements which alter depending on our assessment of the current situations.

Some examples could include:

- Identifying appropriate annual stocking rate based on surface cover, feed availability and seasonal outlook
- Identifying appropriate annual cropping mix (or crop/livestock mix)
- Appropriate levels of hay and grain reserves to meet expected seasonal demands
- More complex late season Nitrogen application decisions
- Tactical changes in the level of opportunity cropping in marginal country
- Amount of crop area to dry sow when opening break is delayed

System 1 will again provide us with "fast" decisions which we may or may not be comfortable with. This fast thinking will always incorporate some of the important components of the decision problem- such as some subjective assessment of feed on hand, or soil water levels etc. But there is a strong possibility it will also include some sub conscious components- such as recency bias given inappropriate weight, for example, to what happened last year, or an over emphasis on risk aversion giving too much focus on downside risks which may be actually manageable in other ways.

One way of putting some objectivity into such complex decisions is to use a decision matrix or index system. These are reasonably common in business or finance, but I have rarely seen them adopted in agricultural systems. It again uses some System 2 thinking to identify the critical factors affecting the decision (which have usually been already thought of in System 1) but then uses some analysis to rank the factors and provide some consistency in the judgement. This ranking and weighting of priorities is something that as humans we do all the time and is part of what we admire in experienced and successful farmers and advisers. Getting it out of our mind and onto paper has advantages. Appendix 2 contains a guide to developing a decision matrix for agriculture.

Conclusion

"The 'Law of Least Effort' asserts that if there are several ways of achieving the same goal, people will eventually gravitate to the least demanding course of action". Kahneman, 2011.

Slow thinking is demanding in terms of mental requirements- by default we will look to take the easy way out. Taking mental shortcuts is efficient and we are all aware of people who get caught in analysis paralysis. Decision frameworks such as fast graphs and the decision matrix come at cost- many people may believe that benefit from implementing such systems does not justify these costs.

My own experience is that using these systems has been of significant value. They are particularly useful when there is more than one person involved in the decision-making process- they can significantly improve communication and storytelling which are important parts of the process. They also allow more effective review of past decisions- most people are more comfortable being judged on the wisdom of the decision rather than the luck of the outcome.

In a grain enterprise these could be applied to decisions where there are at least tens of thousands at stake.

Box 1 An example of using a Decision Matrix to assist with dry seeding decisions.

Decision: Should we dry seed a particular paddock?

Critical success factors	Conditions	Points	Max points	Paddock A	Paddock B
Current season stage	Two weeks earlier than optimum	0	4	2	2
	Early optimum	2			
	Late optimum	3			
	> 2 weeks past optimum	4			
Seeding capacity compared with intended seeding area	High- can complete in2 weeks	2	6	4	4
	Average- completion in 2-4 weeks	4			
	Low- more than 4 weeks required	6			
Weed burden	Low- easily controlled	6	6	0	6
	Medium	4			
	Heavy- would prefer knockdown	0			
Rain forecast for next two weeks	Very little forecast	0	4	2	2
	Moderate probability of rain	2			
	High probability of rain	4			
	Maximum Points		**20**		
			Total	**8**	**14**

Points	**Decision**
>14	Sow paddock ASAP
8 to 14	Proceed but with gentlemen's hours
<8	Don't sow (yet)

Acknowledgements

I have been fortunate in my farming and business career to have had the pleasure of being able to discuss, cultivate and progress ideas and concepts with a range of highly intelligent and committed people. All these discussions have contributed to the thoughts contained within. I would like to specifically acknowledge the input from Dr Peter Hayman from SARDI Climate Applications and Cam Nicholson, Nicon Rural.

More Information

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Appendix 1. Actual Examples of “Fast Graphs for Slow Thinking”

Lentils vs Vetch- A decision about which crop to plant. Context- Getting late in the seeding program and choice was between lentils for grain (but initially assessed as too risky) and vetch for pasture. We would expect the lentils to perform well if seasonal conditions were good- but vetch would prove “safer” if the season was poor. ***Satisfaction*** *or* ***regret*** *would likely apply after the decision is made, depending on the season.*

In this case, we needed to value the different benefits of the two crops e.g. the value of vetch revolves around its use as a grazing proposition combined with its expected higher nitrogen fixation and expectation of higher residual soil water (given that it would be brown manured). This made it more complicated but the discussion of the numbers proved very beneficial. After 20-30 minutes work, we were comfortable we had something that reasonably resembled reality.

Table 2. Comparison of the net result across seasonal rainfall deciles of sowing lentils for grain or vetch for pasture in a low rainfall environment.

Lentils harvested as grain						Vetch used for pasture then brown manured					
Decile	Yield (t/Ha)	Price ($/t)	Gross ($/Ha)	In-crop expenses ($/Ha)	Net Result ($/Ha)	Grazing Value	Addit Nitrogen Benefit ($/Ha)	Value of retained moisture ($/Ha)	Gross ($/Ha)	In-crop Expenses ($/Ha)	Net Result ($/Ha)
1	0	450	0	120	-120	0	0	50	50	90	-40
3	0.5	450	225	220	5	45	12	75	132	97	35
5	1	450	450	240	210	90	25	100	215	97	118
7	1.5	450	675	270	405	90	37	130	257	97	160
9	2	450	900	310	590	90	50	160	300	97	203

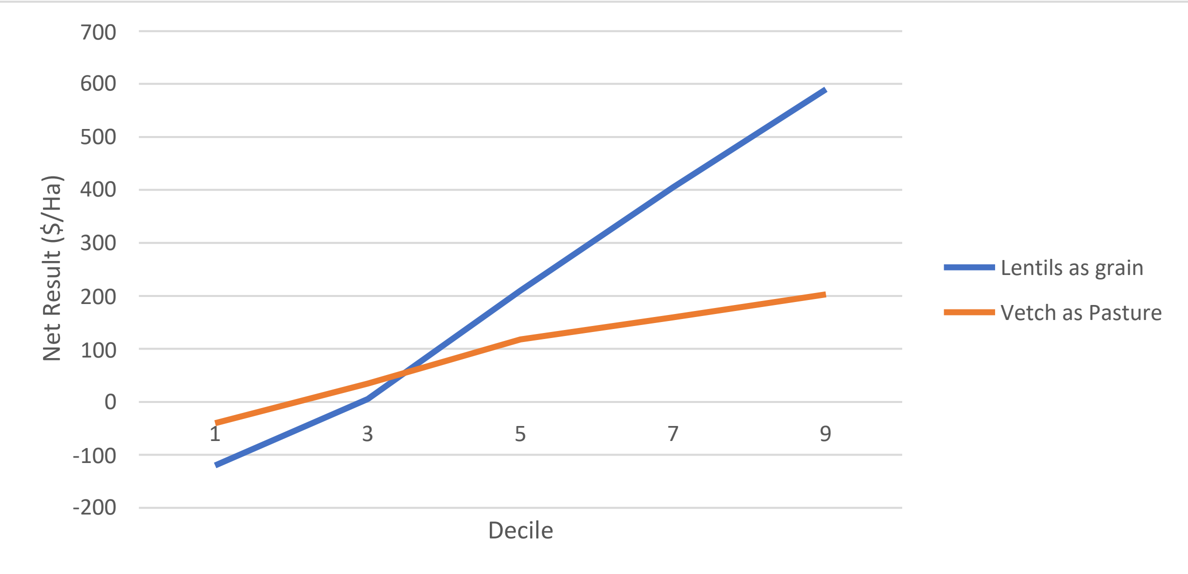


Figure 3. Graph of the comparison of the net result across seasonal rainfall deciles of sowing lentils for grain versus vetch for pasture in a low rainfall environment.

Result- Substantial upside benefit evident from growing lentils in seasons above Decile 3. The original System 1 judgement that "lentils are too risky" was not well supported by System 2 thinking. Decision was made to plant lentils.

Timing of purchase of replacement breeding stock. Context- The value of replacement ewes in April, 2019 was at modest levels due to seasonal uncertainty. If a good season was to prevail, replacement ewe hogget prices were likely to rise- it would be better to purchase them earlier. On the other hand, if a poor season prevailed, then any additional purchases would need to be hand fed, and it was likely that replacements could be purchased later (say, October) at a lower price. ***Satisfaction*** *or* ***regret*** *would likely apply after the decision is made, depending on the season.*

Table 3. Comparison of the net result across seasonal deciles of buying replacement ewes in April vs October (April purchases already were carrying an estimated $35 net wool- October purchases were likely to be bare shorn)

Buy Now									Buy in Oct					
Season onwards	Purchase Price	Less wool	Weeks fed	Kg /week	Cost / kg	Feed $	Int 5%pa	Total ewe cost	Purchase Price	Weeks fed	Kg /week	Cost / kg	Feed $	Total ewe cost
Very Poor	220	65	25	5	0.35	43.75	5.5	204.25	150	8	5	0.35	14	164
Below av	220	65	18	5	0.35	31.5	5.5	192	220	4	5	0.35	7	227
Av	220	65	9	5	0.35	15.75	5.5	176.25	250	0	5	0.35	0	250
Above av	220	65	0	5	0.35	0	5.5	160.5	300	0	5	0.35	0	300
Very Good	220	65	0	5	0.35	0	5.5	160.5	320	0	5	0.35	0	320

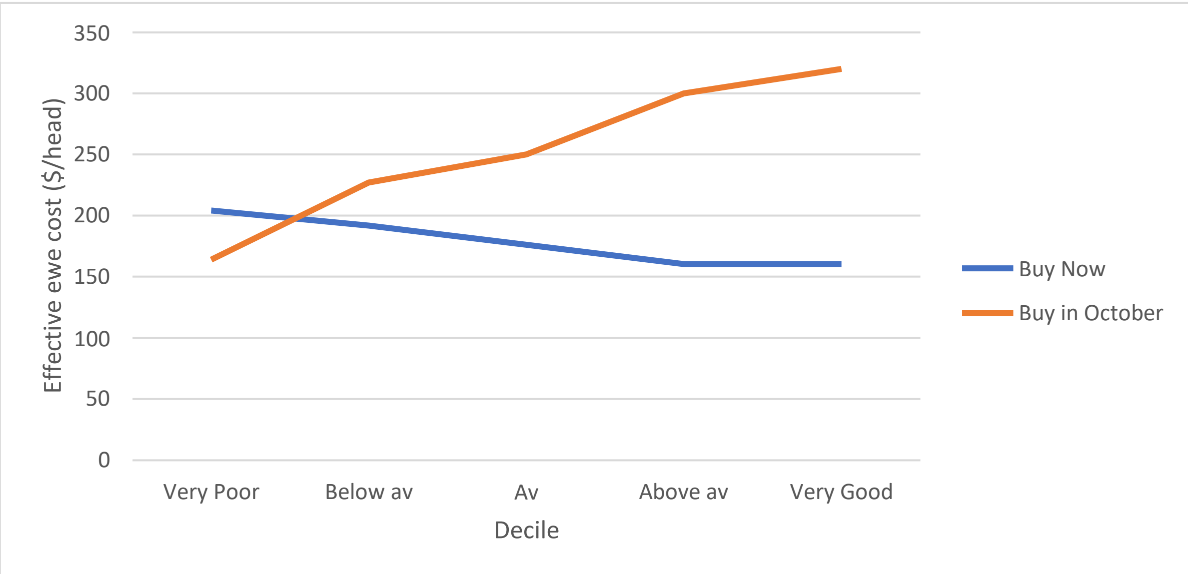


Figure 4. Graph of the comparison in effective ewe cost from purchasing in April vs October

Result- At a purchase price of $220 in April, expectations were that we would be well in front compared with purchasing in October (primarily due to the gain in wool income) providing we did not encounter a very poor season. An alternative interpretation was that we could afford to increase our offer price in April.

Appendix 2. Guide to developing a decision matrix
(Courtesy Cam Nicholson)

1. Identify an **important decision** you need to make. This is usually something that occurs on a regular (annual) basis e.g. how much crop to sow, do I apply additional nitrogen to a crop, how much fodder should I conserve etc.

2. List the **big considerations** you know should influence the decisions. These become your critical success factors. Usually there are only 4 to 8 critical success factors.

3. Take each big consideration (critical success factor) and ask “at what point would I think a bit differently about my decision”? This will split each critical success factor into two or more **conditions**. Repeat for each critical success factor.

4. Once all critical success factors have conditions described, **assign scores**. Tip - assign all the lowest conditions as 0. Then consider the highest described condition and give them a score relative to the other highest conditions. i.e. if you decide the highest condition in critical success factor 1 is twice as critical as the highest condition in critical success factor 2, then the first needs twice the points. Once the top and bottom are established, it is relatively easy to fill in the remaining condition scores.

5. Add up the **maximum score** if all conditions were at their highest.

6. Describe the **key decision** you would make under the maximum possible score and the worst possible score. Then fill in a couple of possible decisions you could make in between the two extremes.

7. Think of an **extreme historic example** (usually a year, season or known scenario) calculate the score for that example *at the time the decision needed to be made.* Using hindsight, what was the appropriate response for that set of circumstances. Use this to inform a key decision score for that extreme. Repeat with another extreme, but opposite example. Then estimate the scores in between the extremes.

8. Test with a series of **more recent examples** (so you get a score) and fine tune the score if required.

*Note: The original idea was derived from Barry Mudge, farmer and consultant in South Australia and appeared in the publication, **Farm Decision Making – The interaction of personality, farm business and risk to make more informed decisions**.* www.grainandgraze3.com.au/resources/Farm_Decision_Making.pdf

1

Important decision: Which lease land should I take on?

3

2

4

Critical success factors	Condition	Points	Max points	Example 1	Example 2
Length of lease	5 yrs + 5 yr option	10	10	8	4
	5 yrs	8			
	3 yrs	4			
	1 yr	0			
Proximity to home	< 10 km	5	5	5	1
	10 -30 km	2			
	> 30 km	0			
Soil condition (fertility & pH)	< maint req'd	8	8	8	2
	Main only req'd	5			
	Some capital inputs req'd	2			
	heaps of capital inputs	0			
Weed control	All weeds under control	4	4	2	2
	Some weed control required	2			
	Weeds a disaster	0			
Infrastructure to graze livestock	Yes	4	4	4	0
	No	0			
Paddock sizes	< 15 ha & obstacles	0	5	3	5
	15 ha to 50 ha	3			
	> 80 ha	5			
		TOTAL	**36**	**30**	**14**

5

7

6

Decision description	
> 28 points out of 36	Great option (willing to pay > $140/acre)
20 - 28 points	Good option (willing to pay $120 - $140/acre)
16 - 20 points	Fair option (willing to pay $100 - $119/acre)
< 16 points	Not worth pursuing

8

Cereal Agronomy

BARLEY TIME OF SOWING

Author: Alex Burbury
Funded By: South Australian Grains Industry Trust
Project Number: SAGIT Project UNF119, UNFS Project number 232
Project Title: Effects of Barley Time of Sowing: Frost/Heat Stress Effects.
Project Duration: 2019 - 2022
Project Delivery Organisations: Upper North Farming Systems, YPAG/NRAG

Key Points:

- **Time of sowing 2 (mid-May) had the most frost damage due to flowering coinciding with a frost event.**
- **The first time of sowing (mid-April) had the best overall biomass and grain yield results due to the extremeĚ dry finish.**
- **Spartacus CL, Fathom, Maximus and Banks in Time of Sowing 1 (TOS1) had the highest biomass.**
- **The highest yielding varieties were Maximus, Spartacus CL and Fathom all sown at TOS1.**

Background

The Barley Time of Sowing trial was conducted on Todd Orrock's property, just south of Booleroo Centre, South Australia. The trial aims included:

- Evaluate how heat stress at the end of the season affects grain fill,
- Capture how frost stress during flowering affects grain development.
- Identify phenotype differences within barley varieties that may enable farmers in the Upper North to manage their seeding window and variety choices to minimise risk/maximise yield across their barley crop.

Methodology

There were three times of sowing (TOS), with TOS1 being watered with approximately 10mm to allow different germination times between each time of sowing.

- TOS1: 13^{th} April (artificial rain)
- TOS2: 14^{th} May
- TOS3: 31^{st} May

The trial was sown with 4 replicates in a complete randomised block design with the UNFS Plot seeder – plots were 15m long x 2.5m wide (*refer to attachment Appendix 1 – 2019 Barley Time of Sowing Trial Plan)*

All Time of Sowing treatments were sown with 50Kg DAP/Ha (Nitrogen 9Kg/Ha, Phosphorus 10Kg/Ha) and 20 Kg/Ha Urea (Nitrogen 9.2Kg/Ha). The trial site was sown to lentils in 2018. Pre-emergent chemicals were applied at Time of Sowing 1 (13^{th} April 2019) and were Boxer Gold (2.5L/Ha) and Gramoxone (1.2L/Ha). On July 16^{th} Lontrel and LVE MCPA was applied to all treatments for broadleaf weed control.

The following varieties were sown at each sowing timing:

- Spartacus
- Fathom
- Maximus CL (entered in the trial as IGB1705T)
- Banks
- Urambie

Variety Summary

Spartacus CL:

Spartacus CL is a malting accredited imidazolinone-tolerant barley developed by Intergrain and released in 2016 with a similar plant type and flowering behaviour to Hindmarsh and La Trobe. Within SA NVT during 2014–17, Spartacus CL has also exhibited similar agronomic performance for grain yield and disease resistance profile including resistance to CCN and susceptibility to loose smut. It has shown increased susceptibility to net form net blotch in 2019. Yields have averaged similar to Compass across most districts and slightly higher in higher yielding districts. Spartacus CL has consistently averaged more than 15 per cent above the widely grown imidazolinone-tolerant Scope CL and has improved grain size. Seed is available for sowing from local resellers and Intergrain Seedclub members.

Fathom :

Fathom is an early-maturing feed quality variety developed using wild barley to improve stress tolerance and water use efficiency. Fathom has averaged very high yields similar to Hindmarsh, based on NVT data, since 2010 and shows good early vigour and weed competitiveness. Fathom typically flowers three to four days later than Hindmarsh with early May sowing and flowers similar to Hindmarsh with later sowings. Fathom has good levels of resistance to CCN, Powdery mildew and Spot form net blotch. Fathom has shown susceptibility to net form net blotch, scald and Leaf rust. Seed is available from Seednet.

Banks:

Banks is a mid-late maturing barley that is feed quality. Banks has been developed by Intergrain and targeted for the medium to high-rainfall environments. Banks is rated R-MRMS for net form net blotch resistance and is MS-S to Spot form net blotch. Its long-term yield performance has been four to seven per cent above Commander in most SA districts. Seed is available for planting in 2020 from Intergrain Seedclub members and resellers.

Urambie:

Feed Barley**.** It is best suited to grain and grazing situations. Two-row barley, adapted to early sowing, having early maturity combined with a cold requirement to initiate heading. Sowing window is early May to mid-June; earlier if grazed. Consistent yields across seasons, but low grain quality. Seed available from Waratah Seeds.

Maximus CL (IGB1705T):

Maximus was entered in the 2019 trial as IGB1705T and was named early in 2020. MAXIMUS CL is a high yielding, early to mid-flowering, potential malt, imidazolinone (IMI) tolerant barley. MAXIMUS CL has CCN resistance and for other disease resistance traits it represents an overall improvement compared to SPARTACUS CL with improved:

- Net form net blotch resistance (RMR-MRMS)
- Spot form net blotch (MRMS-S)
- Scald resistance (R-MRMS)

Similar to SPARTACUS CL, MAXIMUS CL has an erect plant type, strong lodging tolerance and a low-medium head loss risk. The variety also has very good physical grain qualities, including excellent grain retention (grain plumpness) (higher than SPARTACUS CL) and good hectolitre weight. The variety has a short coleoptile and it is recommended that sowing depth be considered carefully when planting this variety. MAXIMUS CL has been accepted into the Barley Australia malt accreditation program, with earliest potential accreditation in March 2021. Commercial availability likely in 2021 from Intergrain Seedclub members and resellers.

Information supplied by SARDI Sowing Guide 2020, Winter crop Variety Guide 2019 – NSW DPI & Intergrain

Image 1 – Barley Time of Sowing site at Booleroo showing the variability in time of sowing and the different plant growth, Urambie in the foreground has a prostrate plant growth habit – Photo 23rd July 2019, Steph Lunn, NRAG

During the season frost assessments and biomass cuts were performed and assessed. The trial was then harvested, grain yields were analysis via ARM software (YPAG/NRAG). Frost assesments were taken on October 9th 2019. Visual assesments were taken as a percentage % of head damage due to frost, based on the amount of frost damage that occurred on the barley head. Based on the amount of head damage in 25% increments. This was then scored on the overall plot.

Biomass cuts were taken as 4 x 50cm rows from the middle of each plot, this was sampled on 25th September 2019. The samples where dried in a drying oven and weighed for Dry Matter weights.

Results and Discussion

The earliest sown treatments (TOS 1) had the highest yields, with Maximus CL (IGB1705T), Spartacus CL and Fathom yielding significantly higher than all other treatments.

Urambie and Banks are longer season varieties and the shortness of the season had a significant impact on their performance.

	2019 Booleroo Weather Station Data													
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	AVG (°C)	29.7	26.2	23.3	18.2	11.7	8.1	8.9	8.3	13.5	19	20.2	27.6	17.8
	MIN (°C)	7.9	6.5	5.4	1.2	0.5	-3.8	-2.2	-3.5	-2.5	-0.5	0.6	4	-3.8
	MAX (°C)	59.3	55.6	52.3	43.3	31.3	25.2	22.5	24.6	33.9	43.8	48.7	59.4	59.4
	SUM (mm)	5.8	6.8	3.8	4.8	31.8	44.5	12	20.5	10.5	0.8	9	8.5	158.5
	AVG (% RH)	38.2	43.4	49.1	50.1	69.7	72.9	76.4	-	-	-	-	-	56.8
	MIN (% RH)	7.7	12.7	13.7	11.3	28.3	33.2	24.9	-	-	-	-	-	7.7
	MAX (% RH)	94	90.5	96.9	95.7	98.6	99.2	99.3	-	-	-	-	-	99.3

Table 1 – Weather Station data – 2019 – Booleroo Weather Station by Agbyte

The weather station data (Table 1) shows the minimum temperatures from June to October, these occurred during the plants reproductive phase and had the potential to cause severe damage to head development and flowering. Plants are sensitive to temperatures below <0º C during the reproductive phase and >30ºC when in the flowering phase. The weather station recorded the following –

	Days Below 0ºC	Coldest Minimum ºC - Date	
June	11	-3.8	24th June
July	7	-2.1	31st July
August	17	-3.5	5th August
October	6	-2.5	10th October
November	1	-0.5	9th November

Table 2: Frost Event Summary 2019

The maximum temperatures > 30ºC were recorded as follows
September 11 days > 30ºC – hottest 33.9ºC, 15th September
October 15 days > 30ºC – hottest 43.8ºC, 31st October

The maximum temperatures for August and September while they didn't reach extreme levels (>35ºC) the timing of the heat could impact plant flowering window along with the minimal rainfall in the months of July, August, September and October. This would have had an impact on plant head development and plant health. The Growing Season Rainfall was 124.9mm and total annual rainfall of 158.5mm for 2019. The long term annual average rainfall for Booleroo is 390.7mm (BOM Data).

Flowering was spread out across the 3 time of sowing treatments. Flowering occurred as follows for TOS1 - Spartacus and Maximus flowering on 20th August; by 26th August all varieties were flowering apart from Urambie. Urambie flowered on 11th September. For TOS2 all varieties but Urambie flowered on 11th September. TOS3 flowering was not recorded but was approximately the end of September for all varieties.

TOS1	TOS1		TOS1	Tipping	One quarter	Half	Three quarter
BBCH	V4	1/2, 50%, 1/4, 40%, tipping 10%	V4	10	40	50	0
	V3	1/4,15%, tipping 50%	V3	50	15	0	0
	V2	tipping 10%	V2	10	0	0	0
	V1	1/4 30%, tipping 50%	V1	50	30	0	0
	V5	1/4 20%, tipping 70%	V5	70	20	0	0
TOS2	TOS2		TOS2	Tipping	One quarter	Half	Three quarter
BBCH	V2	Frost damage to 1/4 of head, 90% of plot	V4	0	90	0	0
	V3	Frost damage 1/10,80% 1/2, 15%	V3	80	0	15	0
	V4	Frost 3/4, 20%, 1/2 30%, 1/5 40%	V2	0	40	30	20
	V1	1/2, 30%, 1/10,50%	V1	50	0	30	0
	V5	1/4, 30%	V5	0	30	0	0
TOS3	TOS3		TOS3	Tipping	One quarter	Half	Three quarter
BBCH	V2	Frost tipping 85%	V4	85	0	0	0
	V4	Frost tipping 90% heads. 1/4-1/2	V3	90	0	0	0
	V5	Frost tipping 10%	V2	10	0	0	0
	V3	1/2, 45%, 1/4, 40%, tipping 10%	V1	10	40	45	0
	V1	1/2, 10%, 1/4, 30%, tipping, 40%	V5	40	30	10	0

Table 3: Frost Assessment Data- October 9th 2019. Varieties: 1 – Spartacus CL, 2 – Fathom, 3 – Maximus CL, 4 – Banks, 5 - Urambie

Visual assessments for frost damage (Table 3) were undertaken of each plot and the number of heads that were frost damaged was assessed. This was based on the amount of visual damage to the head as per the following description - Tipping – just the tip of the head, ¼ - quarter of the head, half – half of the head, ¾ - 3 quarters of the head damaged. The overall plot was assessed based on this criteria with a percentage (%) given to each section of frost head damage.

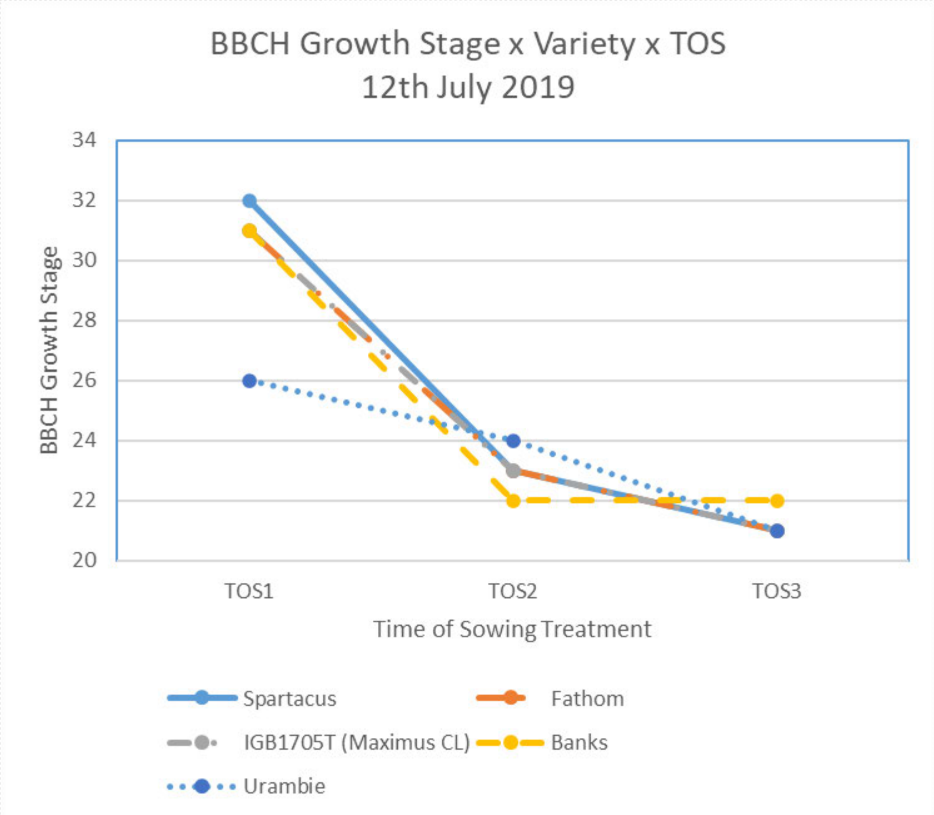


Figure 1 Growth stage by Time of Sowing by variety

Maturity and growth stage assessments were conducted on a weekly basis from 14th May through to 21st October 2019. There are maturity differences between the 3 time of sowing treatments across all 5 varieties (Fig 1) highlighting the importance of time of sowing on end of season outcome regardless of the variety sown.

In mid July, Time of Sowing 1 is more mature and varieties are showing a slight maturity difference with Urambie being the slowest to mature. As the sowing time gets later the maturity spread between varieties closes in with less spread and variation between varieties.

The amount of days with minimum temperatures <0ºC were greatest in August with 17 days having temperatures <0ºC, the coldest being -3.5ºC. This frosty period occurred while plants from TOS 1 and TOS 2 were in the reproductive phase and were either flowering or about to flower. This is when the plant is most sensitive to frost damage.

Time of Sowing 3 was subjected to heat shows stresses with September having 11 days > 30ºC, the hottest day being 33.9ºC on September 15th. Figure 7 shows that these heat stresses combined with the extreme dry finish have had a bigger impact on yield than the frost from earlier sowing.

The maturity spread for each variety and the influence on seeding time can be seen in the below series of graphs for each variety from Fig.2 to Fig.6. This series of graphs clearly shows the phenelogical behaviour differences in each variety and on the individual basis being a lot closer in maturity. The later the sowing date the closer the plant growth stages are for each variety. The crops were rated using the BBCH growth stage.

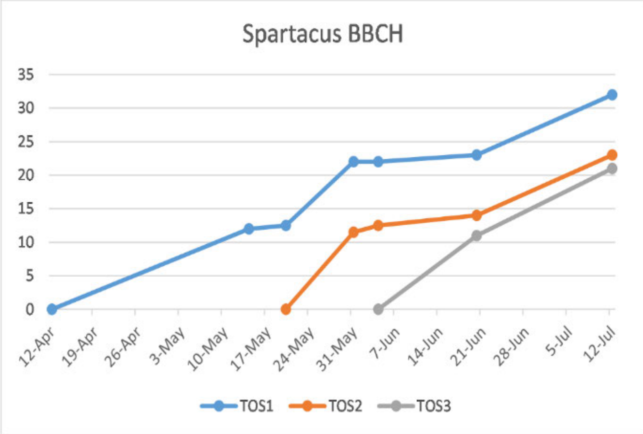


Figure 2: Spartacus Growth Stages

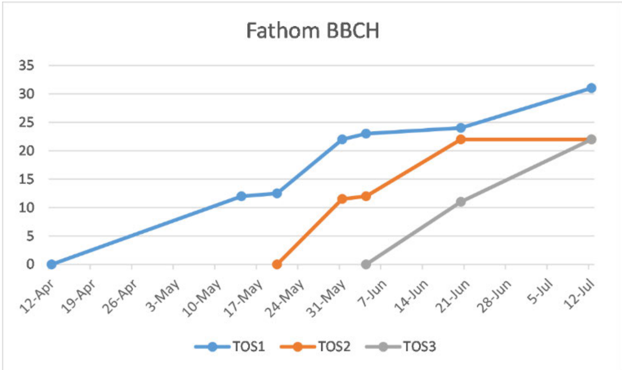


Figure 3: Fathom Growth Stages

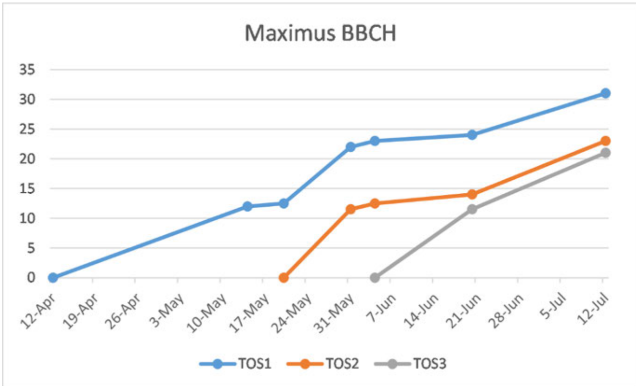


Figure 4: Maximus (IGB1705T) Growth Stages

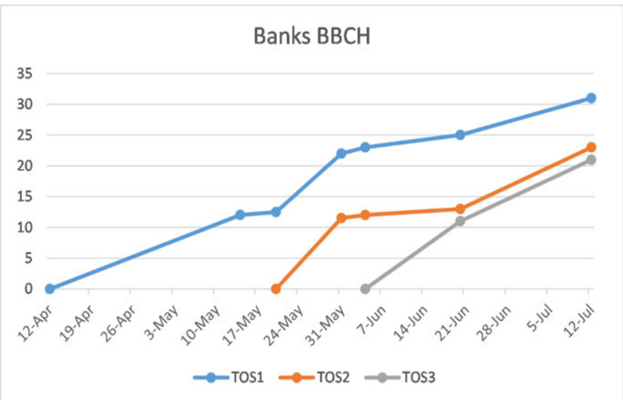


Figure 5: Banks Growth Stages

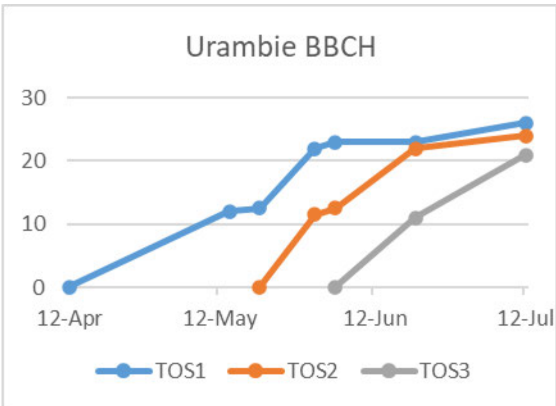


Figure 6 : Urambie Growth Stages

Table 4: Means Table of Yield and Biomass

No.	Name	Biomass T/Ha		Yield T/Ha	
1	Early Spartacus CL	7.01	a	2.57	ab
2	Early 'Fathom	6.39	a	2.56	abc
3	Early Maximus CL - IGB1705T	6.27	a	2.65	a
4	Early Banks	5.83	ab	2.18	d
5	Early Urambie	4.48	c	1.4	f
6	Mid Spartacus CL	4.5	c	2.19	cd
7	Mid Fathom	4.69	bc	2.23	bcd
8	Mid Maximus CL - IGB1705T	4.68	bc	2.05	de
9	Mid Banks	4.59	bc	1.71	ef
10	Mid Urambie	3.22	de	1.01	g
11	Late Spartacus CL	3.96	cd	1.69	ef
12	Late Fathom	3.6	cde	1.66	f
13	Late Maximus CL - IGB1705T	3.74	cd	1.68	f
14	Late Banks	3.19	de	1.35	fg
15	Late Urambie	2.38	e	0.58	h
	Means followed by same letter or symbol do not significantly differ (P=.05, LSD).				

Figure 7 and Table 4 showing the yield and biomass (tonnes/Hectare) shows the differences between the time of sowing and biomass production. All varieties showed declining yield and biomass production as a result of delayed time of sowing, however these responses were not equal due to the phenology of each variety. The decline in yield and biomass as a result of delayed sowing time is likely due to a number of factors including soil temperature during establishment, impacts of frosts and the combined interactions of growth stages, biomass and severe moisture and heat stress at the end of the season.

Barley biomass is important not only for yield but for production as an alternative to graze or cut for fodder adding to the adaptability of barley within the cropping system. The greater the biomass produced the better returns can also be achieved for grazing or fodder.

The early sown treatment resulted in the largest biomass production in all va. As the time of sowing delays the biomass and yield has reduced with TOS 2 showing a reduced biomass and yield. This is not all due to frost and heat stress but also as the soil temperature is cooling it slows the physiological development of the plant.

This is Year 1 of a 3 year trial and further years should cover seasonal variation to be able to look at plant behaviours across different seasons. This will allow conclusions to be drawn as to the success of early planting specific barley varieties.

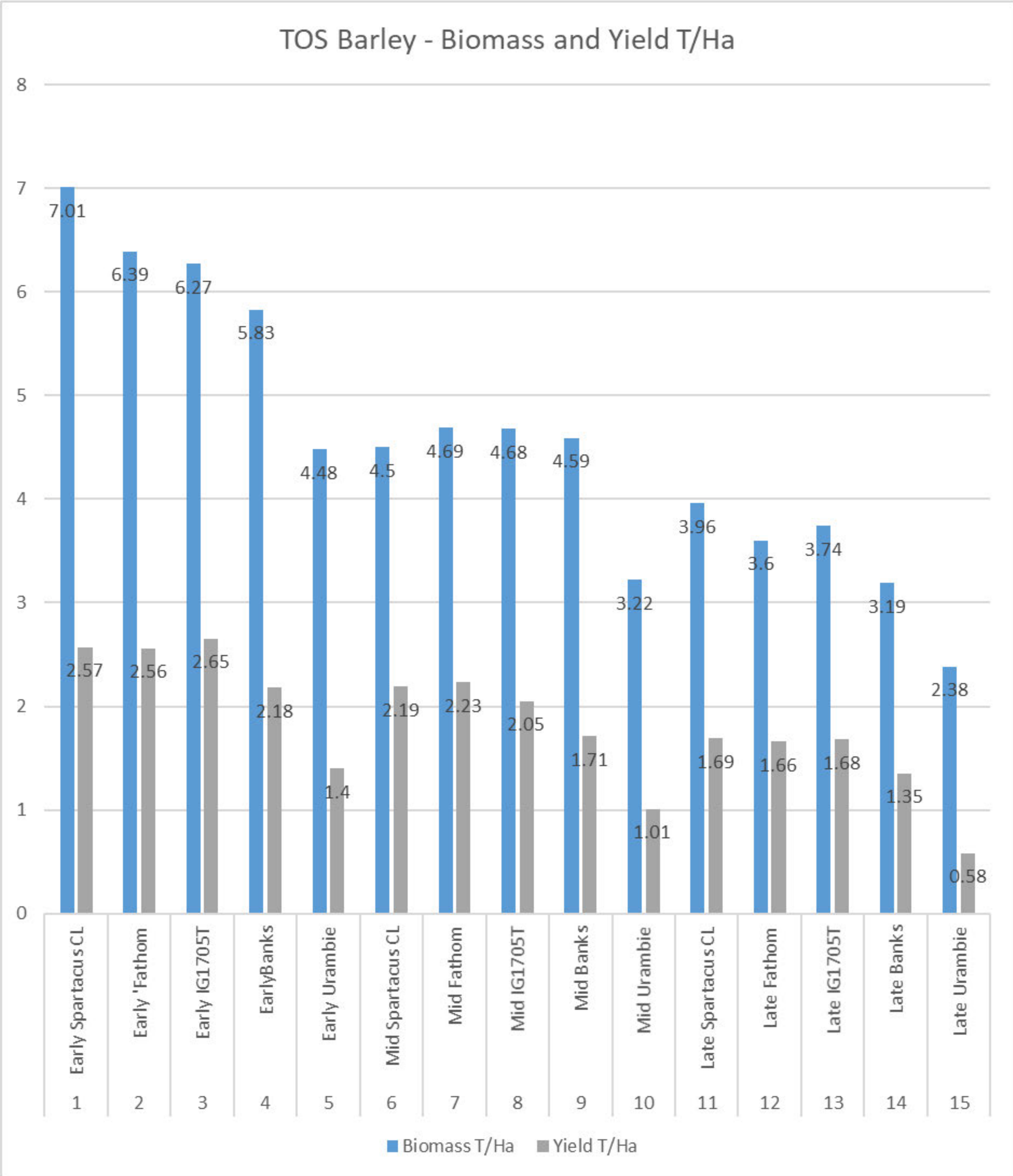
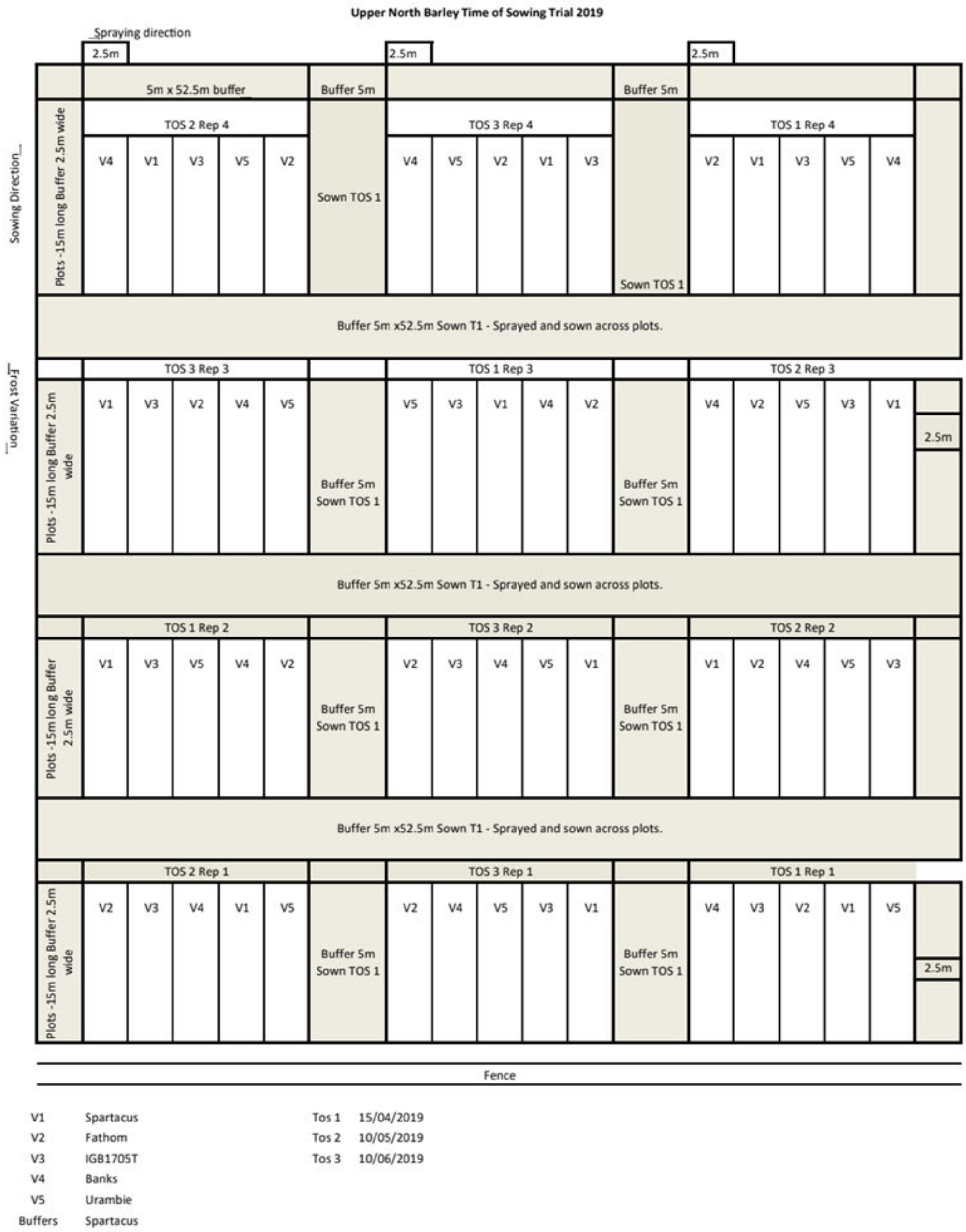


Figure 7: Barley Biomass and Yield results *(graphical representation of Table 4)*

Appendix 1 – 2019 Barley Time of Sowing trial plan.



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- **Todd and Brooke Orrock, Orrock Farming, for providing significant support to the trial and managing the site as the research co-operator**
- **Joe Koch for assisting with seeding**
- **SAGIT for funding the trial.**
- **SARDI Clare for trial harvesting**
- **Special thanks to Intergrain, Seednet and local growers that supplied the trial seed**
- **NRAG/YPAG as the trial contractors that took all in crop measurements**

Management of flowering time and early sown slow developing wheats

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Key messages

- **Different winter varieties are required to target different optimum flowering windows.**
- **Best yields of winter wheats sown early are similar to Scepter sown in optimal window.**
- **If sowing early use the right winter cultivar for the right yield and flowering environment.**
- **Highest yields for winter wheats come from early – late April establishment.**
- **Mid - slow developing spring varieties are less suited to pre 20 April sowing.**

Why do the trials?

Timely operations are key to maximising farm profit, and sowing is one of the most time-critical operations. This is because there is only a short period (~10 days) in spring during which crops can flower and yields be maximised. This period is referred to as the optimal flowering period and its timing and length varies with location and climate. During the optimal flowering period, combined yield loss from drought, heat, frost and insufficient radiation are minimised, and yield maximised. Increasing farm sizes and cropped area and declining autumn rainfall have made it increasingly difficult to get crops flowering during the optimal period.

Sowing early with appropriate cultivars is one management strategy to increase the amount of farm area that flowers during the optimal period and thus farm yield can be maximised. Sowing earlier requires cultivars that are slower developing to take advantage of early establishment opportunities. They are ideally sown into a moist seed bed following breaking rain or preceding a convincing forecast of enough rain to allow germination. This should not be confused with dry sowing which will typically use fast developing cultivars sown into dry seed beds that will establish when breaking rains fall.

Winter wheats for early sowing

For sowing prior to 20 April, winter cultivars are required, particularly in regions of high frost risk. Winter wheats will not progress to flower until their vernalisation requirement is met (cold accumulation), whereas spring cultivars will flower too early when sown early. The longer vegetative period of winter varieties also opens opportunities for grazing. Winter wheat cultivars allow wheat growers in the southern region to sow much earlier than currently practiced, meaning a greater proportion of the farm can be sown on time.

Management of Early Sown Wheat experiments

The aim of this series of the GRDC Management of Early Sown Wheat experiments is to determine which of the new generation of winter cultivars have the best yield and adaptation in different environments and what is their optimal sowing window. Prior to the start of the project in 2017 the low–medium rainfall environments had little exposure to the new winter cultivars, particularly at really early sowing dates (mid-March). Three different experiments have been conducted in the southern region in low–medium rainfall environments during 2017 and 2019, including collaboration in NSW for additional datasets presented in this paper.

How was it done?

Experiment 1: Which wheat cultivar performs best in which environment and when they should be sown?

- Target sowing dates: 15 March, 1 April, 15 April and 1 May (10 mm supplementary irrigation to ensure establishment).
- Locations: SA - Minnipa, Booleroo Centre, Loxton, Hart. Vic - Mildura, Horsham, Birchip and Yarrawonga. NSW - Condobolin, Wongarbon, Wallendbeen.
- Up to ten wheat cultivars - The new winter wheats differ in quality classification, development speed and disease rankings (Table 1).

Table 1. Summary of winter cultivars, including Wheat Australia quality classification and disease rankings based on the 2020 SA Crop Sowing Guide.

Cultivar	Release Year	Company	Development	Quality	Disease Rankings			
					Stripe Rust	Leaf Rust	Stem Rust	YLS
Kittyhawk	2016	LRPB	Mid winter	AH	RMR	MS	MRMS-S	MRMS
Longsword	2017	AGT	Fast winter	Feed	RMR	MSS	MR	MRMS
Illabo	2018	AGT	Mid-fast winter	AH/APH*	RMR	S	MS	MS
DS Bennett	2018	Dow	Mid - Slow winter	ASW	RMR	S	MRMS	MRMS
ADV15.9001	?	Dow	Fast winter	?	-	-	-	-
Nighthawk	2019	LRPB	Very slow spring	?	RMR	MSS	RMR	MS
Cutlass	2015	AGT	Mid spring	APW/AH*	MS	RMR	R	MSS
Trojan	2013	LRPB	Mid-fast spring	APW	MR	MRMS	MRMS	MSS
Scepter	2015	AGT	Fast spring	AH	MSS	MSS	MR	MRMS

**SNSW only*

What happened?

Different winter cultivars are required to target different optimum flowering windows

Flowering time is a key determinant of wheat yield. Winter cultivars are very stable in flowering date across a broad range of sowing dates, this has implications for variety choice as flowering time cannot be manipulated with sowing date in winter wheats like spring wheat. This means that different winter varieties are required to target different optimum flowering windows. The flowering time difference between winter cultivars are characterised based on their relative development speed into three broad groups fast, mid-fast, mid and mid-slow for medium-low rainfall environments (Table 1 and Figure 1).

For example at Birchip each winter variety flowered within a period of 7-10 days across all sowing dates, whereas spring cultivars were unstable and ranged in flower dates over one month apart (Figure 1). In this Birchip example the fast–mid developing winter wheats with development speeds similar to Longsword and Illabo are best suited to achieve the optimum flowering period 10-20 September for Birchip.

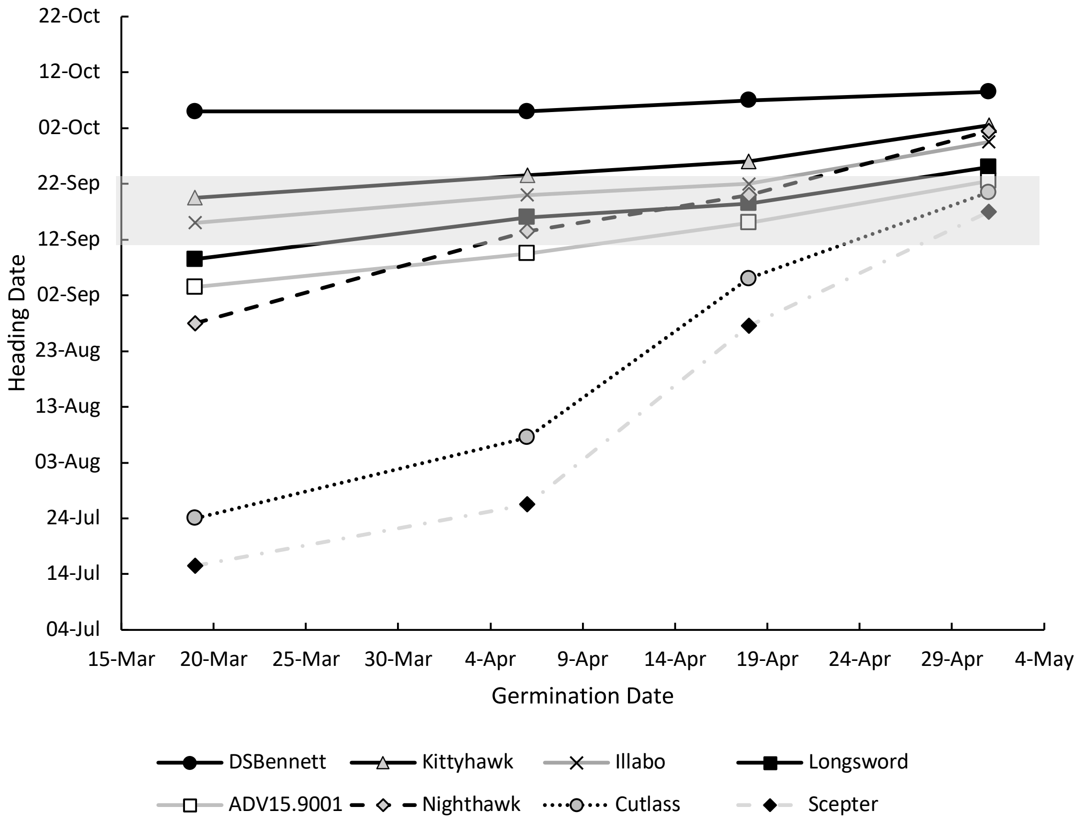

Figure 1. Mean heading date responses from winter and spring cultivars at Birchip in 2018 and 2019 across all sowing times, grey box indicates the optimal period for heading at Birchip.

In other lower yielding environments such as Loxton, Minnipa and Mildura the faster developing winter cultivar ADV15.9001 and Longsword was better suited to achieve flowering times required for the first 10 days in September.

Best yields of winter wheats sown early are similar to Scepter sown in optimal window.

- Across all experiments the best performing winter wheat yielded similar to the fast developing spring variety Scepter sown at the optimal time (last few days of April or first few days of May, used as a best practice control) in 21 out of 28 sites, greater in 5 and less than in 2 environments (Figure 2).
- The best performing winter wheat yielded similar to the best performing slow developing spring variety (alternative development pattern) at 24 sites, greater at 2 and less than at 2 sites.

The best performing winter cultivar depends on yield environment and development speed

The best performing winter wheat cultivars depended on yield environment, development speed and the severity and timing of frost (Table 1). The rules generally held up that winter cultivars that are well-adjusted to a region yielded similar to Scepter sown in its optimal window, these results demonstrate that different winter wheats are required for different environments and there is genetic by yield environment interaction.

- In environments less than 2.5 t/ha the faster developing winter wheat Longsword and ADV15.9001 was generally favoured (Figure 3).
- In environments greater than 2.5 t/ha the mid–slow developing cultivars were favoured; Illabo in the Mid North of SA, and DS Bennett at the Vic and NSW sites (Figure 4).

The poor relative performance of Longsword in the higher yielding environments was explained by a combination of flowering too early and having inherently greater floret sterility than other cultivars irrespective of flowering date.

Sites defined by severe September frost and October rain included Yarrawonga, Mildura and Horsham in 2018, in this scenario the slow developing cultivar DS Bennett was the highest yielding winter wheat and had the least amount of frost induced sterility. The late rains also favoured this cultivar in 2018 and mitigated some of the typical yield loss from terminal drought (i.e. Birchip 2019). Nonetheless the ability to yield well outside the optimal flowering period maybe a useful strategy for extremely high frost prone areas for growers wanting to sow early.

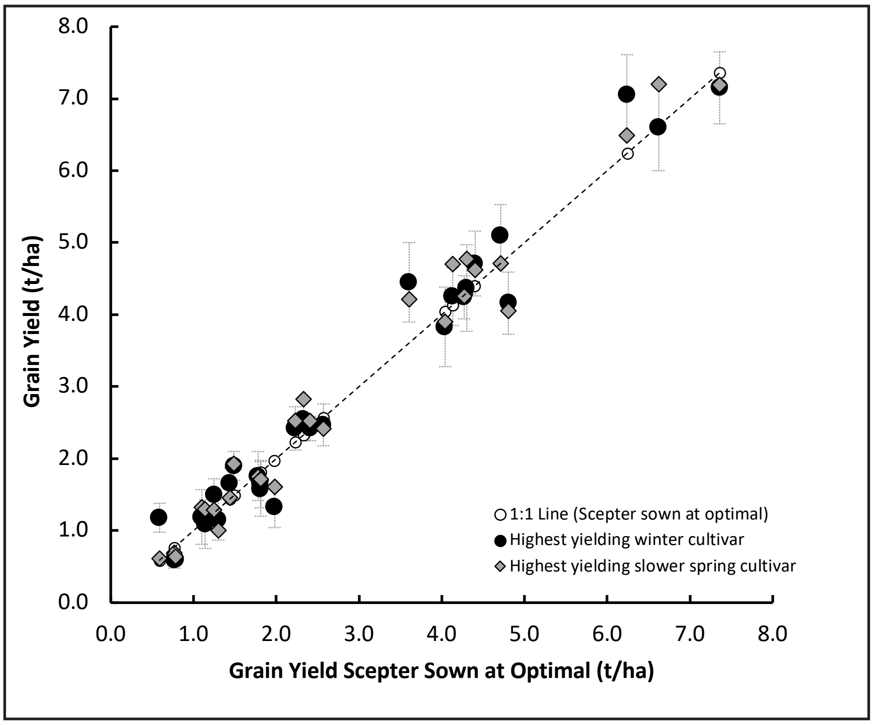

Figure 2. Grain yield performance of Scepter wheat sown at its optimal time (late April-early May) in 28 environments (2017–2019) compared to the performance of the best performing winter wheat. Error bars indicate LSD (P<0.05).

Table 2. Summary of grain yield performance of the best performing winter and alternate spring cultivar in comparison to Scepter sown at the optimum time (late April-early May). Different letters within a site indicate significant differences in grain yield.

Site	Year	Grain yield of Scepter sown ~1 May (t/ha)	Highest yielding winter cultivar			Highest yielding slower spring cultivar		
			Grain yield (t/ha)	Cultivar #	Germ date	Grain yield (t/ha)	Cultivar #	Germ date
Yarrawonga*	2018	0.6 b	1.2 a	DS Bennett	16-Apr	0.6 b	Cutlass	16-Apr
Booleroo	2018	0.8 a	0.6 a	Longsword	4-Apr	0.7 a	Trojan	2-May
Booleroo	2019	0.8 a	0.6 a	ADV15.9001	05-Apr	0.6 a	Cutlass	01-May
Loxton	2018	1.1 a	1.2 a	Longsword	19-Mar	1.3 a	Cutlass	3-May
Loxton*	2019	1.1 a	1.1 a	ADV15.9001	15-Mar	1.3 a	Cutlass	01-May
Minnipa	2018	1.3 a	1.5 a	Longsword	3-May	1.3 a	Trojan	3-May
Mildura	2019	1.3 a	1.2 a	ADV15.9001	29-Apr	1.0 a	IGW6566	15-Apr
Mildura*	2018	1.4 b	1.7 a	DS Bennett	1-May	1.5 ab	Nighthawk	1-May
Mildura	2017	1.5 b	1.9 a	Longsword	13-Apr	1.9 a	Cutlass	28-Apr
Minnipa	2019	1.8 a	1.8 a	ADV15.9001	05-Apr	1.7 a	Cutlass	05-Apr
Horsham*	2018	1.8 a	1.6 a	DS Bennett	6-Apr	1.7 a	Trojan	2-May
Hart	2019	1.8 a	1.6 a	Illabo	05-Apr	1.7 a	Nighthawk	18-Apr
Booleroo	2017	2.0 a	1.3 b	DS Bennett	4-May	1.6 b	Cutlass	4-May
Minnipa	2017	2.2 a	2.4 a	Longsword	18-Apr	2.5 a	Cutlass	5-May
Loxton	2017	2.3 a	2.6 ab	Longsword	3-Apr	2.8 b	Nighthawk	3-Apr
Hart	2018	2.4 a	2.4 a	Illabo	17-Apr	2.5 a	Nighthawk	17-Apr
Condobolin	2018	2.6 a	2.5 a	DS Bennett	19-Apr	2.4 a	Trojan	7-May
Yarrawonga	2019	3.6 b	4.5 a	ADV15.9001	15-Mar	4.2 a	Nighthawk	05-Apr
Birchip	2018	4.0 a	3.8 a	Longsword	30-Apr	3.9 a	Trojan	30-Apr
Hart	2017	4.1 a	4.3 a	Illabo	18-Apr	4.7 b	Nighthawk	18-Apr
Yarrawonga	2017	4.3 a	4.2 a	DS Bennett	3-Apr	4.3 a	Cutlass	26-Apr
Wongarbon	2017	4.3 a	4.4 a	DS Bennett	28-Apr	4.8 a	Trojan	13-Apr
Tarlee	2018	4.4 a	4.7 a	Illabo	17-Apr	4.6 a	Nighthawk	17-Apr
Birchip	2019	4.7 a	5.1 a	DS Bennett	01-May	4.7 a	Nighthawk	01-May
Horsham	2019	4.8 a	4.2 b	Longsword	05-Apr	4.1 b	Nighthawk	05-Apr
Wallendbeen	2017	6.2 b	7.1 a	DS Bennett	28-Mar	6.5 b	Cutlass	1-May
Birchip	2017	6.6 b	6.6 b	DS Bennett	15-Apr	7.2 a	Trojan	15-Apr
Horsham	2017	7.4 a	7.2 a	DS Bennett	16-Mar	7.2 a	Trojan	28-Apr

**stem and/or reproductive frost substantially affected yield*
#Cultivars Trojan and ADV15.9001 were not included at all sites

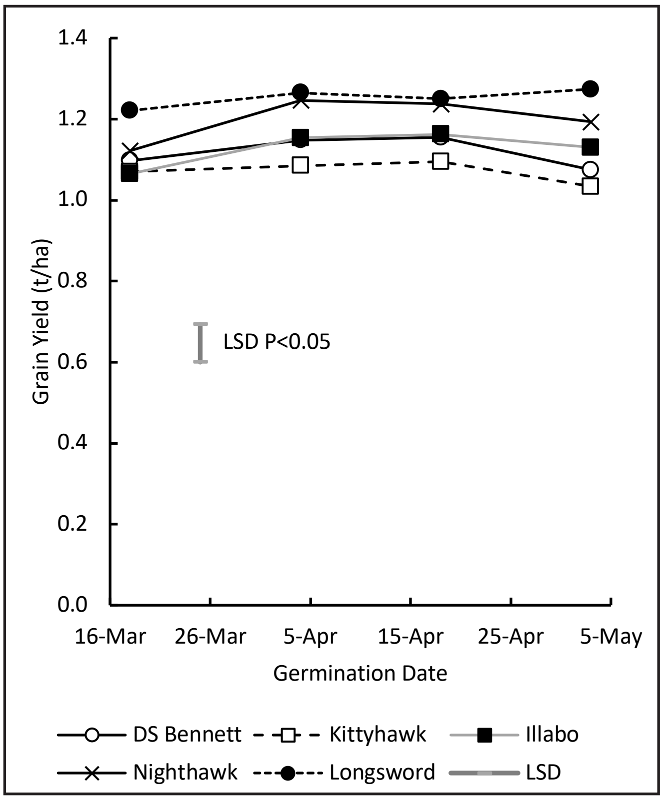

Figure 3. Mean yield performance of winter wheat in yield environments less than 2.5 t/ha (16 sites in SA/Vic)

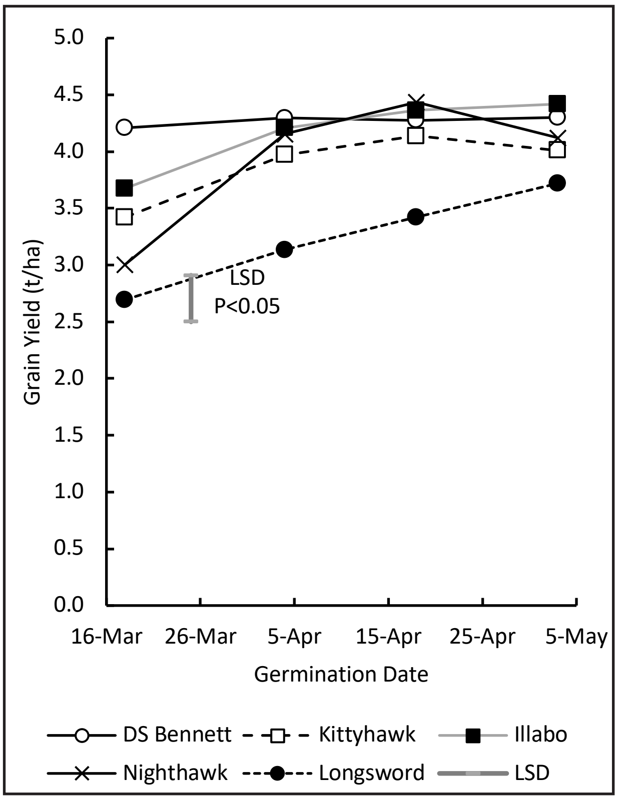

Figure 4. Mean yield performance of winter wheat in yield environments greater than 2.5 t/ha (5 sites in SA/Vic)

Highest yields for winter wheats come from early–late April establishment

- Across all environments the highest yields for winter wheats generally came from early-late April establishment and results suggested that the yields may decline from sowing dates earlier than April and these dates may be too early to maximise winter wheat performance (Table 2, Figure 3 and Figure 4). The cultivar DS Bennett maintained it's better than other cultivars from March establishment.
- Mid-slower developing spring wheat cultivars (i.e. Cutlass) performed best from sowing dates after 20 April, and yielded less than the best performing winter cultivars when sown prior to 20 April. This reiterates slow developing spring varieties are not suited to pre 20 April sowing in low-medium frost prone environments.
- The very slow developing spring Nighthawk yielded similar to the best performing winter cultivar in both yield environments from mid-April establishment dates.

More details on experiment one can be found here: http://agronomyaustraliaproceedings.org/images/sampledata/2019/2019ASA_Hunt_James_173.pdf

What does this mean?

Growers in the low-medium rainfall zones of the southern region now have winter wheat cultivars that can be sown over the entire month of April and are capable of achieving similar yields to Scepter sown at its optimum time. However, grain quality of the best performing cultivars leaves something to be desired (Longsword=feed, DS Bennett=ASW). Sowing some wheat area early allows a greater proportion of farm area to be sown on time. Growers will need to select winter wheats suited to their flowering environment (fast winter in low rainfall, mid and mid-slow winter in medium rainfall) and maximum yields are likely to come from early–mid April planting dates.

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

LA TROBE UNIVERSITY

Effect of sowing time x seed rate x herbicides on ryegrass management in barley

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[1]University of Adelaide, School of Agriculture, Food and Wine; [2]SARDI, Minnipa Agricultural Centre

Location
McEvoy Road, paddock N20
Rainfall
Av. Annual: 282 mm
Av. GSR: 202 mm
2019 Total: 235 mm
2019 GSR: 216 mm
Paddock history
2019: Self-regenerating medic pasture, barley in trial
2018: Mace wheat
2017: Self-regenerating medic pasture
2016: Mace wheat
Yield limiting factors
Annual Ryegrass

Key messages

- **There were large weed control benefits of delayed sowing of barley at Minnipa. However, when a highly effective pre-emergent herbicide was applied the benefit of delayed sowing was negligible.**
- **In barley a three week delay in sowing time did not significantly reduce grain yield as it did in the previous year in wheat. Lower yield penalty in barley from delayed sowing may be related to its earlier maturity and more competitive nature compared to wheat.**

Why do the trial?

Change in sowing time can have multiple effects on crop-weed competition. Delayed sowing can provide opportunities to kill greater proportion of weed seedbank before seeding the crop, but weeds that establish in late sown crops can be more competitive on a per plant basis. This is one of reasons why farmers who have adopted early seeding have reported excellent results in crop yield and weed suppression. Therefore, it is important to investigate sowing time in combination with other practices across different rainfall zones. The review of Widderick *et al*. (2015) also recommended research on sowing time in many crops. Delayed sowing can also reduce crop yield so the gains made in weed control may be completely nullified by the yield penalty.

There has been some research already on crop seed rate on weed suppression but none of these studies have investigated the benefits of higher crop density in factorial combinations with sowing time and herbicide treatments. Crop seed rate is an easy tactic for the growers to adopt provided they are convinced of its benefits to weed management and profitability. Furthermore, growers in the low rainfall areas tend to be reluctant to increase their seed rate due to concerns about the negative impact of high seed rate on grain screenings.

This field trial at Minnipa was undertaken to investigate factorial combinations of sowing time, seed rate and herbicides on the management of annual ryegrass in barley.

How was it done?

This field trial investigated combinations of the management tactics in Table 1.

All data collected during the growing season was analysed using the Analysis of Variance function in GenStat version 19.0.

In 2019, annual rainfall received at Minnipa was 17% below the long-term average but the growing season rainfall was 7% above the long-term average. The rainfall received in May, June and September was greater than the long-term average with all other months being well below the long-term average (Table 2).

What happened?

Barley plant density

There was a significant interaction between sowing time and wheat seed rate (Figure 1). As a general trend seedling establishment efficiency reduced as seed rate increased. Only in the high seeding rate, barley establishment differed significantly between TOS 1 and TOS 2.

Annual ryegrass plant density and seedbank

The average seedbank of annual ryegrass (ARG) at the site was 4168 ± 411 seeds/m^2. ARG plant density was significantly influenced by the time of sowing (P=0.002), herbicide treatment (P<0.001) and the interaction between the time of sowing and herbicide (P=0.001).

There was a large impact of the 3 week delay in seeding barley on ARG plant density (Figure 2). This was particularly evident in the untreated control in which ARG density decreased from 676 plants/m^2 in TOS 1 to 379 plants/m^2 in TOS 2 (44% reduction).

Table 1. Key management operations undertaken at Minnipa trial site in 2019.

Operation	Details
Location	Minnipa, SA
Seedbank soil cores	11 April
Plot size	1.5 m x 10 m
Seeding date	TOS 1: 4 May TOS 2: 24 May
Fertiliser	At sowing – DAP (18:20:0:0) @ 60 kg/ha
Variety	Compass barley
Seeding rate	100 seeds/m^2 150 seeds/m^2 200 seeds/m^2
Herbicides	4 May and 24 May (applied just before seeding) Boxer Gold 2.5 L/ha IBS Trifluralin 1.5 L/ha IBS Control (knockdown treatment only)
Trial design	split plot design with three replicates
Measurements	pre-sowing weed seedbank, crop density, weed density, ARG spike density, ARG seed production, wheat grain yield

Table 2. Rainfall received at Minnipa in 2019 and the long-term average for the site.

Month	Rainfall (mm)	
	2019	Long-term rainfall
Jan	4.0	11.2
Feb	1.2	13.2
Mar	0.2	18.9
Apr	11.0	15.5
May	57.2	28.2
Jun	56.4	37.1
Jul	15.6	35.0
Aug	19.2	38.7
Sep	53.6	27.5
Oct	3.4	19.9
Nov	7.0	16.9
Dec	6.4	18.9
Annual total	235.2	282.3
GSR total	216.4	201.9

This large response of ARG density to delayed sowing is most likely related to rainfall events in May, which would have caused weed emergence (Figure 2). The reduction in ARG plant density due to delayed seeding was also apparent in the herbicide treatments (Figure 2) with both herbicide treatments providing greater efficacy in TOS 2. However in the most effective herbicide treatment (Boxer Gold), high level of ARG control was also achieved in TOS 1, making any benefits from delayed sowing redundant.

Annual ryegrass spike density and seed production

ARG spike density was significantly influenced by the time of sowing ($P=0.019$), herbicide treatment ($P<0.001$) as well as the interaction between the TOS and herbicide treatment ($P=0.006$). However, there was no effect of barley seed rate on ARG spike density ($P=0.237$). When averaged across the seed rates and herbicide treatments, the three week delay in seeding at Minnipa reduced ARG spike density from 194 spikes/m^2 to 123 spikes/m^2 (37% reduction). Herbicide treatments were also more effective in TOS 2, with Boxer Gold treatment resulting in the production of only 27 ARG spikes/m^2 (Figure 3). These results clearly highlight the ability of Boxer Gold to manage moderate levels of ARG seedbank under adequate soil moisture conditions, reducing ARG seed production (spikes/m^2) by 83% and 87% for TOS 1 and TOS 2, respectively.

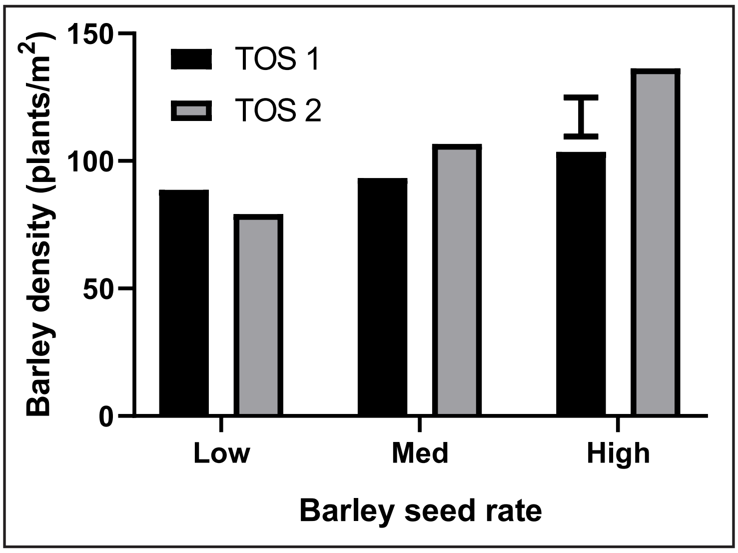


Figure 1. The effect of seed rate on barley plant density in time of sowing 1 (TOS 1) and time of sowing 2 (TOS 2). The vertical bar represents the LSD (P=0.05).

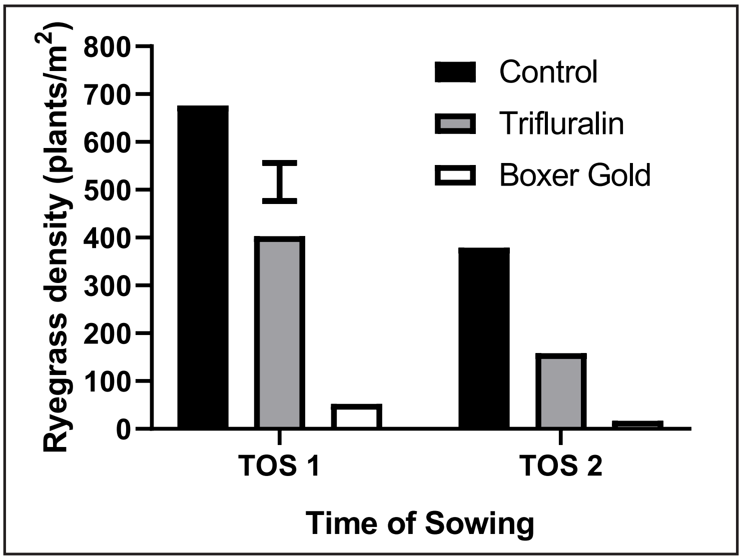


Figure 2. The interaction between the time of sowing and herbicide treatments (P=0.001). The vertical bar represents the LSD (P=0.05).

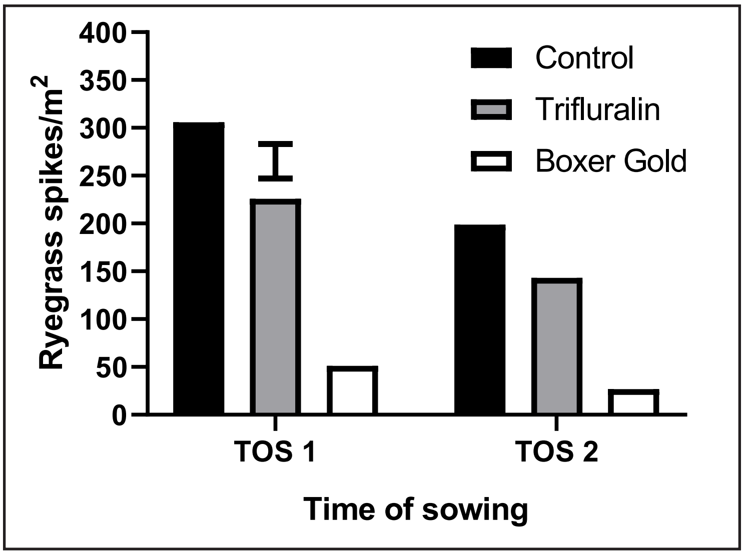


Figure 3. The effect of interaction between the time of sowing and herbicide treatments (P=0.006) on ARG spike density. The vertical bar represents the LSD (P=0.05).

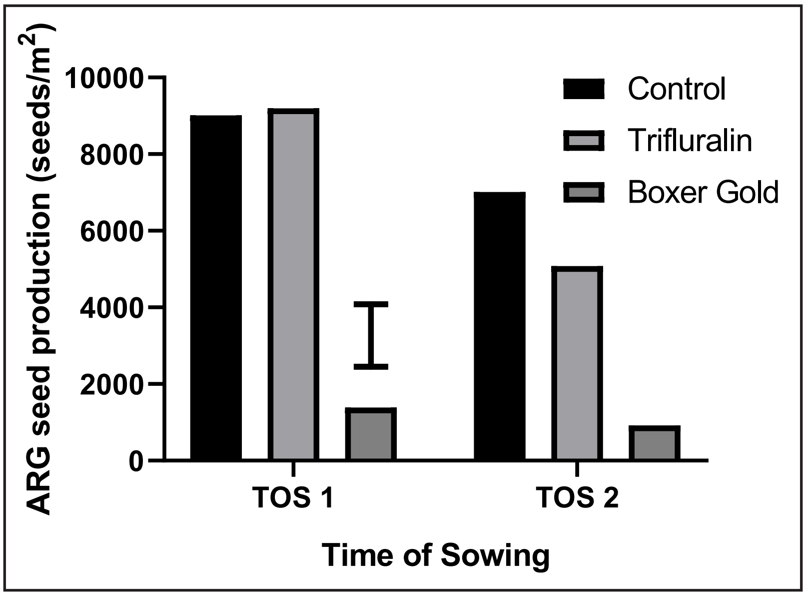


Figure 4. The effect of interaction between the time of sowing and herbicide treatments (P=0.021) on ARG seed production. The vertical bar represents the LSD (P=0.05).

Barley grain yield

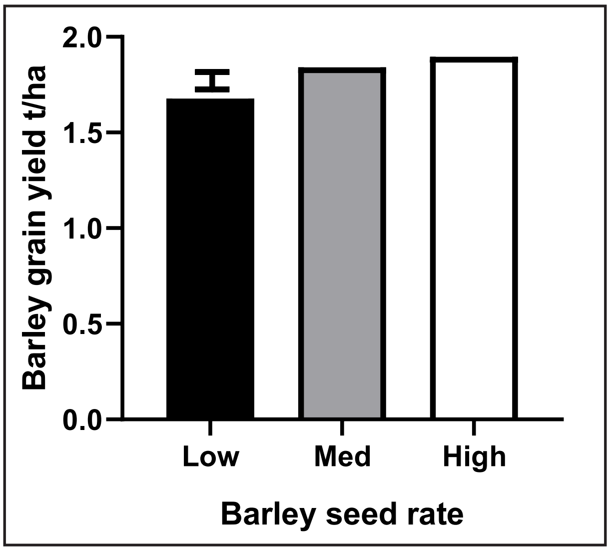


Figure 5. The effect of barley seed rate treatments (P<0.001) on barley grain yield. The vertical bar represents the LSD (P=0.05).

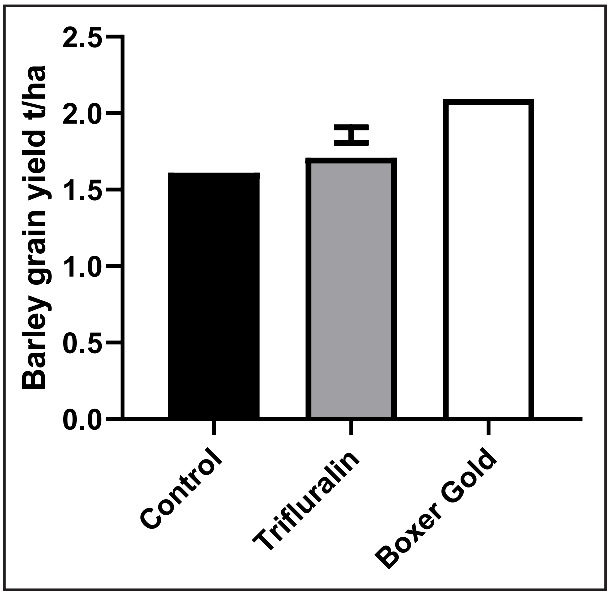


Figure 6. The effect of herbicide treatments (P<0.001) on barley grain yield. The vertical bar represents the LSD (P=0.05).

Barley grain yield at Minnipa was not significantly influenced by the time of sowing (P=0.644). However, crop seed rate (P<0.001), and herbicide treatment (P<0.001) had a significant effect on grain yield. Averaged across all treatments barley produced a grain yield of 1.81 t/ha (site mean yield). Barley yield increased as seed rate increased from low (1.68 t/ha), to medium (1.84 t/ha) and high (1.90 t/ha) (Figure 5). Even though the increase in barley yield as seed rate increased from low to high was only 13%, it was statistically significant. This increase in barley grain yield with increased seed rate was identical to the trend seen in wheat in 2018. Increased seed rate had no influence on percentage of barley screenings, however percentage of barley screenings reduced with increased control of annual ryegrass with herbicides.

Herbicide treatment had a significant effect on barley grain yield with Trifluralin (1.71 t/ha) increasing grain yield by 6% and Boxer Gold (2.09 t/ha) by 30% compared to the control (1.61 t/ha) (Figure 6). These yield gains equate to approximately a 2:1 return on the cost of trifuralin and a 3.75:1 return on Boxer Gold.

What does this mean?

Consistent with the trends observed for ARG spike density, ARG seed production was also significantly influenced by the time of sowing (P=0.023), herbicide treatments (P<0.001) and the interaction between the TOS and the herbicide treatments (P=0.021). Pre-emergence herbicides performed better in TOS 2 where the density of ARG plants had been reduced by the delay in seeding (Figure 4). The Trifluralin treatment produced 9192 ARG seeds/m^2 for TOS 1 and 5078 ARG seeds/m^2 for TOS 2. However in the most effective herbicide treatment (Boxer Gold), high level of ARG control was also achieved in TOS 1, making any benefits from delayed sowing redundant. While these Boxer Gold treatments all set less seed than the 2019 ARG soil seed bank, a substantial ARG infestation would be expected in 2020. In contrast to ARG plant density and spike density, trifluralin in TOS 1 produced a similar amount of ARG seeds to the untreated control. This means that the plants that survived the trifluralin tillered well and adequately compensated for the reduced plant density.

The three week delay in sowing barley did not significantly reduce its grain yield (P=0.64). This is in complete contrast to a similar wheat trial in 2018 where a 6 week delay in sowing reduced wheat grain yield by 36%. This could partially be explained by the longer sowing delay due to drier May and June in 2018. However, this lack of impact on barley yield from this delay in sowing was most likely related to the greater early vigour of barley and its earlier maturity than wheat. This is also evident by how much an effective herbicide improved grain yield with the most effective herbicide improving wheat yield in 2018 by up to 44% and 30% for barley in 2019 despite much heavier weed pressure.

These results give some confidence in using a short delay in sowing barley to achieve ARG control compared to wheat, however the cost of that delay would be dependent on seasonal conditions and the variety of barley grown. Compass barley grown in this trial is quite weed competitive and well adapted to a shorter growing season. If a long season barley like Planet or less competitive barley like Spartacus was grown the cost from the delay in seeding could be larger.

Acknowledgement

The authors thank Bruce and Kathryn Heddle for hosting the site. Malinee Thongmee and Hue Thi Dang (University of Adelaide), Fiona Tomney, Steve Jeffs, Bradley Hutchings and Katrina Brands (SARDI) for their technical input to the trial. We also acknowledge the investment from GRDC for the research into ‘Cultural management for weed control and maintenance of crop yield’ (9175134).

Demonstrating integrated weed management strategies to control barley grass in low rainfall zone farming systems

Amanda Cook[1], Gurjeet Gill[2], Ian Richter[1], Neil King[1], Jake Hull[1], Wade Shepperd[1] and John Kelsh[1]
[1]SARDI, Minnipa Agricultural Centre; [2]University of Adelaide.

Location
Minnipa Agricultural Centre, paddock S3
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Soil type
Red sandy loam
Paddock history
2019: Compass barley
2018: Scepter wheat
2017: Volga vetch
Rainfall
27 m x 620 m x 3 reps (3 paddock seeder strips (27 m each) wide)

Key messages

- **In 2019 the IMI system had the lowest barley grass plant numbers.**
- **The Cultural Control strategy did not achieve the desired outcome of having a more even seed spread and increased competition in the inter row for barley grass weed control.**
- **The medic pasture produced low dry matter compared to the cereal systems, had the highest barley grass population and the lowest competitive ability with the barley grass.**
- **The loss of Group A herbicides to control barley grass within local pasture systems has the potential to change rotations and decrease farm profitability.**

Why do the trial?

Barley grass possesses several biological traits that make it difficult for growers to manage it in the low rainfall zone, so it is not surprising that it is becoming more prevalent in field crops in SA and WA. A survey by Llewellyn *et al*. (2015) showed that barley grass has now made its way into the top 10 weeds of Australian cropping in terms of area infested, crop yield loss and revenue loss.

The biological traits that make barley grass difficult for growers to manage in low rainfall zones include:

- early onset of seed production, which reduces effectiveness of crop-topping or spray-topping in pastures,
- shedding seeds well before crop harvest, reducing harvest weed seed control effectiveness compared to weeds such as ryegrass which has a much higher seed retention,
- increased seed dormancy, reducing weed control from knockdown herbicides due to delayed emergence, and
- increasing herbicide resistance, especially to Group A herbicides, used to control grass weeds in pasture phase and legume crops.

Barley grass management is likely to be more challenging in the low rainfall zone because the growing seasons tend to be more variable in terms of rainfall, which can affect the performance of the pre-emergence herbicides. Furthermore, many growers in these areas tend to have lower budgets for management tactics, and break crops are generally perceived as more risky than cereals. Therefore, wheat and barley tend to be the dominant crops in the low rainfall zone. This project is undertaking coordinated research with farming systems groups across the Southern and Western cropping regions to demonstrate tactics that can be reliably used to improve the management of barley grass.

How was it done?

On 27 March 2019 a meeting was held between seven growers, four MAC staff, one consultant and Dr. Gurjeet Gill to discuss the issue of barley grass in upper EP farming systems. A three year broad acre management plan (2019-21) was developed to be implemented with five different strategies to be tested and compared in a replicated broad acre farm trial on the MAC farm (Table 1).

These management strategies will be tested over the three year rotation with the focus on barley grass weed management and weed seed set.

Three replicated broad acre strips of three seeder widths (27 m wide) were sown in MAC paddock S3 on 17 May. Barley was sown at a seeding rate of 65 kg/ha, with GranulockZ fertiliser at 50 kg/ha, and 1.2 L/ha glyphosate, 1.5 L/ha trifluralin and 400 g/ha diuron. The 'Higher cost' chemical strategy hay cut barley was sown at 95 kg/ha, and the 'Cultural control' double seeding rate was inter row sown with a final seeding rate of 120 kg/ha and was only sprayed with 1.2 L/ha glyphosate. The IMI strategy with Scope barley was sprayed on the 16 July with 700 ml/ha Intervix.

The self-regenerating medic pasture was sprayed on 17 May with propyzamide @ 1 L/ha, followed with Targa Bolt @ 190 ml/ha, Broadstrike @ 25 g/ha and clethodim @ 250 ml/ha on 2 July. Due to high levels of barley grass escapes it was also sprayed with paraquat @ 1.2 L/ha on 3 September. The hay cut occurred on 26 September prior to which it was sprayed with 1.8 L/ha Weedmaster DST on 3 September.

Crop establishment, dry matter, barley grass numbers, barley grass seed set, grain yield and quality were assessed during the growing season. The dry matter hay cut was taken on 26 September and the other dry matter cuts a week later on 3 October. Late barley grass samples were taken and panicles sent to Roseworthy for the assessment of barley grass seed set and herbicide resistance testing. The 27 m strips were harvested with the plot header (3 times) per treatment on 28 October and grain quality was assessed.

What happened?

There were differences in plant establishment with the higher seeding rates resulting in an increase in barley plant numbers, as shown in Table 1. The highest plant establishment was in the Higher cost chemical strategy (sown at 95 kg/ha for a hay cut), and the Cultural Control strategy (sown at 120 kg/ha).

The Cultural Control strategy was a double sown system, with 60 kg/ha barley seed spread on top of the ground and 60 kg/ha sown over the top to give a total seeding rate of 120 kg/ha. Although this strategy had higher plant numbers, the seeding system did not achieve the desired outcome of greater seed distribution to increase competition with weeds, due to seed being buried in a dry part of the raised furrow reducing the germination. The cultural control strategy resulted in similar barley grass weed control as the district practice.

Barley grass weed numbers increased between 25 June and 28 August, indicating late germination patterns requiring a vernalisation (cold) are present in this population. Barley grass weed numbers were lowest in the IMI strategy. The medic pasture systems had the highest barley grass weed population with an average of 127 barley grass weeds/m2. Despite using propyzamide @ 1 L/ha on 17 May with 7.8 mm of rainfall in the following two days to activate the chemical, weed control in the pasture phase was disappointing. Some barley grass had already germinated before the application of propyzamide, which could have reduced its efficacy.

Table 1. The five different management strategies and crops for each season (2019-2021) at Minnipa Agricultural Centre, paddock S3.

Strategy	2019	2020	2021
District Practice	Compass barley	Self-regenerating medic pasture (Gp A)	Scepter wheat
IMI system	Scope barley (with IMI (Gp B) applied)	Sultan sown medic pasture (IMI tolerant)	Razor CL wheat (IMI tolerant)
Higher cost herbicide	Compass barley for hay cut sown at higher seeding rate	Scepter wheat (Gp K - Sakura) with harvest weed seed control (HWSC) chaff lines and burning	Spartacus barley (with IMI if needed)
Two Year Break	Self-regenerating medic pasture (Gp A)	TT canola (Gp C, Triazines)	Scepter wheat with harvest weed seed control (chaff lines and burning)
Cultural Control	Compass barley at double seeding rate	Self-regenerating medic pasture (Gp A)	Scepter wheat with no row spacing for competition and HWSC

IMI = imidazolinone herbicides (Gp B).

Table 2. Plant and barley grass weed numbers, dry matter, yield and grain quality in GRDC Low Rainfall Barley Grass Management farm trial, 2019.

Barley grass weed control strategy, barley variety and seeding rate (kg/ha)	Crop establishment 25 June (plants/m^2)	Early barley grass numbers 25 June (plants/m^2)	Late barley grass numbers 28 Aug (plants/m^2)	Late dry matter 3 Oct (t/ha)	Yield 28 Oct (t/ha)	Protein (%)	Screenings (%)
District Practice Compass (70 kg/ha)	134	2.3	8.5	6.0	2.08	14.2	4.4
IMI system Scope (70 kg/ha)	128	1.7	0	5.0	1.06	15.1	10.5
Cultural Control Compass (120 kg/ha)	187	3.7	8.3	5.5	1.84	13.5	4.0
Higher cost herbicide (hay) Compass (95 kg/ha)	164	3.3	3.6	6.8*	-	-	-
Two Year Break Self -regenerating medic pasture	146	123.5	129.5	0.9	-	-	-
LSD (P=0.05)	*28*	*29.6*	*8.0*	*0.9*	*0.4*	*1.1*	*1.2*

**Sampled on 26 August*

The pasture system also received Targa Bolt @ 190 ml/ha, Broadstrike @ 25 g/ha and clethodim @ 240 ml/ha on 2 July, with poor barley grass weed control. Poor efficacy of the Group A herbicides is likely to be associated with resistance to this group. Paraquat @ 1.2 L/ha was sprayed in the pasture phase on 3 September to prevent weed seed set.

Compass barley sown at 95 kg/ha for a hay cut produced the greatest dry matter, with the Scope barley producing significantly lower dry matter and grain yield than Compass. Grain protein in Scope barley was higher than Compass, which was most likely due to its lower yield and higher screenings. The medic pasture produced lower dry matter compared to the cereal systems and had a lower competitive ability with barley grass compared to barley.

What does this mean?

Barley grass seed germination occurred between late June and August indicating a late germinating population that avoids early weed control with pre-sowing herbicide applications. Germination patterns of the barley grass populations from different low rainfall regions has been assessed at Roseworthy as part of this research project.

The Cultural Control strategy with a double inter row sown system @ 120 kg/ha did not reduce the barley grass numbers compared to the district practice system, as it did not achieve the desired outcome of having a more even seed spread and increased competition in the inter row for barley grass weed control.

The IMI system had the lowest barley grass weed numbers indicating the Group B system is still working at MAC, and is an effective strategy. However, the IMI herbicide system tends to be quite prone to evolution of resistance in weeds. Therefore strategic use of the IMI herbicide system must be used to maximise the effectiveness and long term use of this system. Growers also need to be aware of herbicide breakdown and plant back periods, especially in low rainfall seasons to avoid bare paddocks.

The medic pasture produced lower dry matter compared to the cereal systems. It also had the highest barley grass weed population and the lowest competitive ability with the barley grass compared to the barley systems. The high levels of barley grass escapes when sprayed with Group A herbicides indicated herbicide resistance is becoming a major issue on MAC and in this region. The loss of Group A chemicals within our pasture break system has the potential to totally change farming systems. Currently farmers on upper EP rely on self-regenerating medic based systems with a profitable livestock enterprise, with grass control applied to prevent weed seed set in spring. The loss of the ability to control barley grass weeds using Group A herbicides will result in medic pasture having to be sprayed out using glyphosate in spring. This will reduce the feed base and carrying capacity, incur later sowing times in the cropping phase to gain weed control or more cropping dominate systems with other break crops (canola, vetch, lentils) and alternative herbicide groups which will increase risk and impact on profitability.

To ensure Group A resistance is kept in check, farmers may want to make sure any suspected resistant plants are dealt with in pasture systems by following up with a knockdown herbicide as early as possible to prevent seed set. Always have follow up options to control any survivors and to preserve Group A herbicides. Using alternative chemical groups by including canola or introducing Clearfield systems as a different rotational break may also be an option. The loss of Group A herbicides within current farming systems may result in high barley grass seed bank carry over. Reducing the weed seed bank is pivotal to managing all grass weeds.

If barley grass herbicide resistance is suspected, the first step is to test the population to know exactly what you are dealing with. This project has the ability to test barley grass populations for suspected herbicide resistance over the next two seasons, so contact Amanda Cook if you would like an Eyre Peninsula population tested. This paddock scale MAC research is ongoing for the next two seasons to assess the different barley grass weed management strategies.

Acknowledgements

This research was funded by GRDC 9176981. Thank you to Katrina Brands and Steve Jeffs for processing samples.

THE UNIVERSITY OF ADELAIDE AUSTRALIA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Barley Grass Management Options

Author: Matt McCallum, Jamie Wilson
Funded By: Grains Research & Development Corporation
Project Code: GRDC Project 9176981
Project Title: Demonstrating and validating the implementation of integrated weed management strategies to control barley grass in the low rainfall zone farming systems
Project Duration: 2019 - 2022
Project Delivery Organisations: UNFS on behalf of The University of Adelaide. Site management by Matt McCallum.

Key Points:

- Late sown treatment resulted in lower barley grass plant numbers
- Late sown treatment delayed barley grass seed set
- Dry year and high barley grass pressure reduced barley yield by up to 50%

Background

The trial site, situated in Matt McCallum's paddock on Whim road (Booleroo Centre) and sown with Spartacus barley in 2018, was chosen for the demonstration trial due to the presence of an uncontrolled barley grass missed spray strip from 2017. This strip is one boom-spray width wide (36 m) by 120 m long. Barley grass levels in this strip were high and relatively even in distribution. The paddock surrounding the uncontrolled strip had low levels of barley grass infestation. The trial aims to demonstrate effective management options for reducing barley grass numbers and impact within a barley and pasture rotation. This encompasses 2 times of sowing and alternative harvest and chemical treatment options to look at the impact on barley grass numbers and at the effects on the crop growth and yield.

Methodology

The site was chosen to investigate the impact (and interaction) of locally relevant cropping tactics on barley grass levels across a rotation:

1. Impact of dry seeding cereals vs waiting for the opening break and seeding after a knock-down herbicide has been applied.

2. Effect of cutting a crop for hay vs taking it through to grain.

The treatments have been overlayed on the two levels of initial infestation- high and low.

Strategies

Year	S1	S2	S3	S4
2019	Spartacus barley, dry sown, harvested as grain	Spartacus barley, dry sown, cut for hay	Spartacus barley, sown after break, harvested for grain	Spartacus barley, sown after break, cut for hay
2020	Natural regen pasture, spring topping	Natural regen pasture, spring topping	Natural regen pasture, spring topping	Natural regen pasture, Group A plus spring topping
2021	Barley	Barley	Barley	Barley

Notes:

A. 2019 herbicides- All-Pre-emergent Trifluralin 1.5 l/Ha, Avadex 2 l/Ha. Post break sown would receive Glyphosate 540 knock-down at 1.2 l/Ha
B. 2020 herbicides- Group A- Clethodim 500ml/Ha plus Verdict 520 @38ml/Ha. Topping Glyphosate 450 @ 360 ml/Ha
2021 herbicides- All- Pre-emergent Trifluralin 1.5 l/Ha, Avadex 2 l/Ha

Trial Plan 2019

Dimensions	High BG Infestation (36m)	Low BG Infestation (36 m)
12 m wide	Buffer	Buffer
	Buffer	Buffer
Rep 1	Barley Dry Sown- Grain	Barley Dry Sown- Grain
	Barley Dry Sown- Hay	Barley Dry Sown- Hay
	Barley After break-Grain	Barley After break-Grain
	Barley After break-Hay	Barley After break-Hay
Buffer	Barley After Break- Buffer	Barley After Break- Buffer
	Barley After Break- Buffer	Barley After Break- Buffer
Rep 2	Barley After break-Hay	Barley After break-Hay
	Barley After break-Grain	Barley After break-Grain
	Barley Dry Sown- Hay	Barley Dry Sown- Hay
	Barley Dry Sown- Grain	Barley Dry Sown- Grain
Buffer	Barley Dry Sown Buffer	Barley Dry Sown Buffer
	Barley Dry Sown Buffer	Barley Dry Sown Buffer
Rep 3	Barley Dry Sown- Grain	Barley Dry Sown- Grain
	Barley Dry Sown- Hay	Barley Dry Sown- Hay
	Barley After break-Grain	Barley After break-Grain
	Barley After break-Hay	Barley After break-Hay
Buffer	Buffer	Buffer
	Buffer	Buffer

Plot Size- 36 by 6 m (half airseeder)
The plots were sown at 2 different times with the below treatments.

Barley Grass low numbers – photo Matt McCallum -12th June 2019

Dry sown barley
Sown 16/4/2019
Barley 60kg/ha
MAP 35kg/ha (Nitrogen 3.5kg/Ha; Phosphorus 7.7kg/Ha)
Trifluralin 1.5L/ha
Avadex 2L/ha

Wet sown barley
Sown 22/5/2019
Barley 60kg/ha
MAP 35kg/ha (Nitrogen 3.5kg/Ha; Phosphorus 7.7kg/Ha)
Trifluralin 1.5L/ha
Avadex 2L/ha
ARGO 1.5L/ha

All barley was sown at 60kg/Ha and resulted in the high density barley grass areas having 160 barley plants/M^2 and the low density barley grass areas having 154 barley plants/M^2 in the dry sown and 147 barley plants/M^2 in the wet sown plots.

Results and Discussion

The 2 times of sowing both had barley grass emergence measurements taken (Figure 1). The delayed sowing in both areas (low and high barley grass populations) lead directly to reduced barley grass numbers as well as a delay in barley grass seed set. The delayed seeding has resulted in control of barley grass from the knockdown herbicide roundup and better efficacy of the pre-emergent herbicides – trifluralin and avadex.

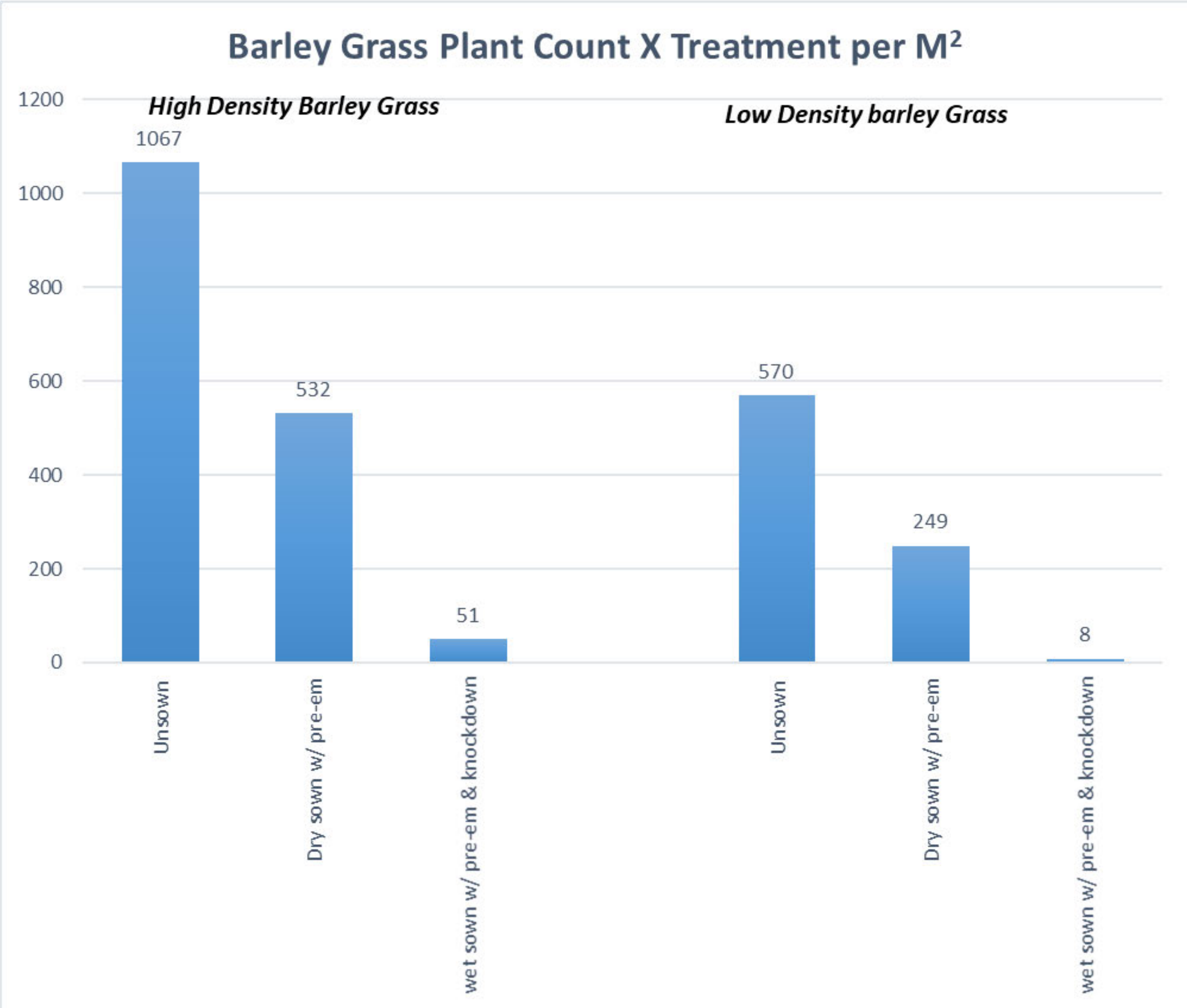


Image 1 (Right): Barley Grass wet sown Left & Dry Sown Right- 12th June 2019. Photo: Matt McCallum

Image 2: Barley Grass high numbers - Dry Sown (left), Wet sown (right)–, photo taken by Matt McCallum 28th June 2019

Image 3: Barley Grass low numbers – Dry Sown (left), Wet Sown (right) – photo taken by Matt McCallum 28th June 2019

Seasonal condition in 2018 meant that this paddock did not produce sufficient biomass to be cut for hay, nor sufficient plant height to be harvested with a plot header. The plots were instead hand harvested by Matt McCallum to assess Barley Grain Yield. This data will be presented in the final results for the trial in 2021.

For 2020, the paddock is due to be left out for pasture and the treatments will be monitored for the effect of each treatment with barley grass number plant counts taken for each treatment

Image 4: Barley Grass Trial early/dry sown –high barley grass numbers – photo 28th august 2019 – photo Matt McCallum

Appendix 1: 2019 Measurements & Observations

26/6/19 – Plant Counts – Table 1

High density barley grass strip:	Lower density barley grass strip:
Unsown 1067 barley grass plants/m2	Unsown 570 barley grass plants/m2
Dry Sown (with pre-emergent chemical) 532 plants/m2 – 50% control	Dry Sown (with pre-emergent chemical) 249 plants/m2 – 56% control
Barley (crop) 160 plants/m2	Barley (crop) 154 plants/m2
Wet Sown (with pre-emergent chemical and knock-down) 51 plants/m2 – 95% control	Wet Sown (with pre-emergent chemical and knock-down) 8 plants/m2 – 99% control
Barley (crop) 160 plants/m2	Barley (crop) 147 plants/m2

Table 2 (Right): Rainfall measurements to 28/6/2019 compared to average. Full seasonal data for Booleroo Centre can be found in the Weather Station Report for Booleroo Centre in this Compendium.

	2019	Average
Jan	8	19
Feb	8	19
Mar	4	14
Apr	4	22
May	39	32
Jun	37	35
Jul		34
Aug		35
Sep		33
Oct		29
Nov	30	25
Dec	15	21
GSR	80	219
Year	100	318

9/8/2019; **Plant Growth Stages**

70% of the dry sown barley plants had reached flag leaf emergence on the main tiller, and 70% of the wet sown treatment had reached GS30.
In the dry sown treatment, early head emergence has begun in the barley grass.

29/8/19 – Dry Matter Cuts

Hand-cuts for hay undertaken.

- dry sown – barley grass is fully emerged
- wet sown treatments barley grass only 10% emerged.

Trial site has been mown and plots clearly marked.

Image 5: Barley Grass Trial wet sown – low barley grass numbers – photo 28th august 2019 – photo Matt McCallum

August 2019 – **Seasonal Review**

Significant lack of rainfall affecting the overall growth of the site, barley grass still growing well

October 2019 – Grain Harvest

Paddock harvested, plots biomass and height limited trial harvester success would have been achieved. Handcuts were taken for harvest – results TBC.

Acknowledgements:

- A special thank you to Matt McCallum and the McCallum family
- This report has been completed in memory of Matt McCallum – who undertook the trial and all operations and measurements. Sadly the passing of Matt McCallum in December 2019 has had a vast impact on his family and the community. The final results for this trial, including harvest details will be published at a later date when the collection and analysis is possible.
- Thank you to the GRDC for funding this project and to the University of Adelaide and Dr Gurjeet Gill for partnering with UNFS to deliver the project in the region.

UNFS Eastern Crop Walk – Matt McCallum & Gurjeet Gill – 11th September 2019

Survey of current management practices of barley grass in low rainfall zone farming systems

Amanda Cook[1], Gurjeet Gill[2], Naomi Scholz[1], Catherine Borger[3], Birchip Cropping Group (BCG), Central West Farming Systems (CWFS), Eyre Peninsula Agricultural Research Foundation (EPARF), Grain Orana Alliance Inc (GOA), Kellerberrin Demonstration Group, Lakes Information and Farming Technology, Mallee Sustainable Farming Systems Group (MSF), Mingenew Irwin Group (MIG), South East Premium Wheat Growers Association (SEPWA), Upper North Farming Systems Group (UNFS), WA No-till Farmers Association (WANTFA)

[1]SARDI, Minnipa Agricultural Centre; [2]University of Adelaide; [3]DPIRD, Northam WA

Key messages

- **The survey received 224 responses from growers aligned with the different farming systems groups participating in this project.**
- **39% of the grower respondents identified barley grass as having a medium to high impact on their cropping systems.**
- **40% of the grower respondents feel that barley grass emergence patterns have changed over the last 10 years and that it now emerges later in the season.**
- **51% of growers thought barley grass had become more common in their cropping paddocks. Some of the factors responsible for the increase in barley grass include delayed emergence and early seed-set, low efficacy of pre-emergence herbicides, particularly during dry starts to seasons, resistance to group A herbicides, continuous cereals in the system and wide crop row spacing.**

Why do the survey?

Barley grass is now one of the top 10 weeds of Australian cropping in terms of area infested, crop yield loss and revenue loss (Llewellyn et al. 2016). Barley grass has several biological traits that make it difficult for growers to manage it in the low rainfall zone, so it is not surprising that it is becoming more prevalent in field crops in SA and WA.

Through recent GRDC investment, the research project 'Demonstrating and validating the implementation of integrated weed management strategies to control barley grass in the low rainfall zone farming systems' (hereby referred to as GRDC Low Rainfall Barley Grass) has commenced. An initial grower survey of current practice and attitudes towards barley grass was undertaken in 2019 to be used as the baseline to assess changes in grower attitudes and any change in practices after the completion of the three-year project.

How was it done?

An electronic survey was developed by Amanda Cook, Naomi Scholz, Gurjeet Gill and Catherine Borger using Survey Monkey and distributed via email to the grower members of different farming systems groups collaborating in the GRDC Low Rainfall Barley Grass project. The survey was used to collect information on grower current management practices and attitudes towards barley grass.

The survey link was sent to grower groups on 4 July 2019 and closed on 20 September, giving farming systems groups 10 weeks to promote the survey to growers. The survey closed before the start of field days and crop walks, and before discussing the project and any outcomes from the 2019 GRDC Low Rainfall Barley Grass project.

What happened?

There were 224 grower respondents to the initial GRDC Low Rainfall Barley Grass survey through the farming systems grower groups across the southern and western cropping regions. The first survey question asked respondents which Farming Systems group they most commonly associated with. Respondents identified Birchip Cropping Group (BCG) 3%, Central West Farming Systems (CWFS) 4%, Eyre Peninsula Agricultural Research Foundation (EPARF) 27%, Grain Orana Alliance Inc (GOA) 8%, Kellerberrin Demonstration Group 4%, Lakes Information and Farming Technology 2%, Mallee Sustainable Farming Systems Group (MSF) 8%, Mingenew Irwin Group (MIG) 1%, South East Premium Wheat Growers Association (SEPWA) 4%, Upper North Farming Systems Group (UNFS) 11%, WA No-till Farmers Association (WANTFA) 10%, and 'other' 19%. Of the 'other' groups, 13% were Western Australian growers.

The second survey question asked growers how big an impact barley grass had in the cropping and pasture phase of the farming system. 10% of responses indicated barley grass had a high impact as a weed within their crop and 11% within the pasture phase (Figure 1). 29% indicated barley grass had a medium impact as a weed within their cropping phase, and 17% within the pasture phase. 17% indicated barley grass had a low impact as a weed within their cropping phase, and 8% within the pasture phase, and 8% indicated it was not an issue.

The third survey question asked growers about barley grass management strategies, and the level of effectiveness of current management strategies (low, moderate, high or don't use). The highest rating for effectiveness of management strategies for barley grass were rotation/break crops, two-year breaks, pasture or crop topping, spraying grasses out of crop and cereal choice e.g. barley. The management strategies for barley grass management which were not used were burning, narrower row spacing, harvest weed seed control or hay cutting. Other management strategies which may have been used (as a medium strategy) were crop competition by increasing seeding rate, sowing later or sowing early.

The fourth survey question asked growers about the level of effectiveness of current herbicides for barley grass management. Grass selective herbicides in pastures and other break crops had the highest level of effectiveness of current herbicides, followed by prosulfocarb (Sakura).

The fifth survey question asked if growers thought the barley grass germination pattern had changed over the last 10 years. 40% of growers thought barley grass now germinates later in crop, 19% thought the germination pattern was unchanged, 15% thought barley grass now germinated earlier in their farming systems and 26% were unsure.

The next question asked if barley grass had become more common in cropping paddocks. 51% of growers thought barley grass had become more common in their cropping paddocks, 43% said it was not more common, and 6% were unsure.

The next survey question asked if growers thought they may have herbicide resistance issues in barley grass. 23% of growers thought they may have herbicide resistance issues in barley grass, 53% thought they didn't have herbicide resistance issues, and 24% were unsure. Of the 23% of growers that thought they may have herbicide resistance issues, most were concerned about Group (Gp) A resistance, mostly fop's but also some dim's. Other herbicides growers were concerned about were Gp B (including IMI), Gp L (paraquat), Gp M (glyphosate) and Gp D (trifluralin).

The eighth question asked growers about their current row spacing and seeding system. Current row spacings for cropping ranged from 15-70 cm (6"-19.5") with 43% having 30 cm (12") wide rows, 23% having 25 cm (10") and 20% having 22.5 cm (9") row spacing. 88% of growers used direct drill knife point systems, and 9% used disc seeding systems, with 3% using conventional cultivation systems. Of the direct drill systems, five growers were using paired row or splitter systems to increase seedbed utilisation.

The final survey question asked growers the current wheat and barley seeding rates used. Wheat seeding rates ranged from 27 kg/ha to 120 kg/ha with 47% falling in the 60-70 kg/ha seeding rate range (60 kg/ha 18%, 65 kg/ha 12%, 70 kg/ha 17%). Barley seeding rates ranged from 34 kg/ha to 120 kg/ha again, with 47% falling in the 60-70 kg/ha seeding rate range (60 kg/ha 18%, 65 kg/ha 13%, 70 kg/ha 16%).

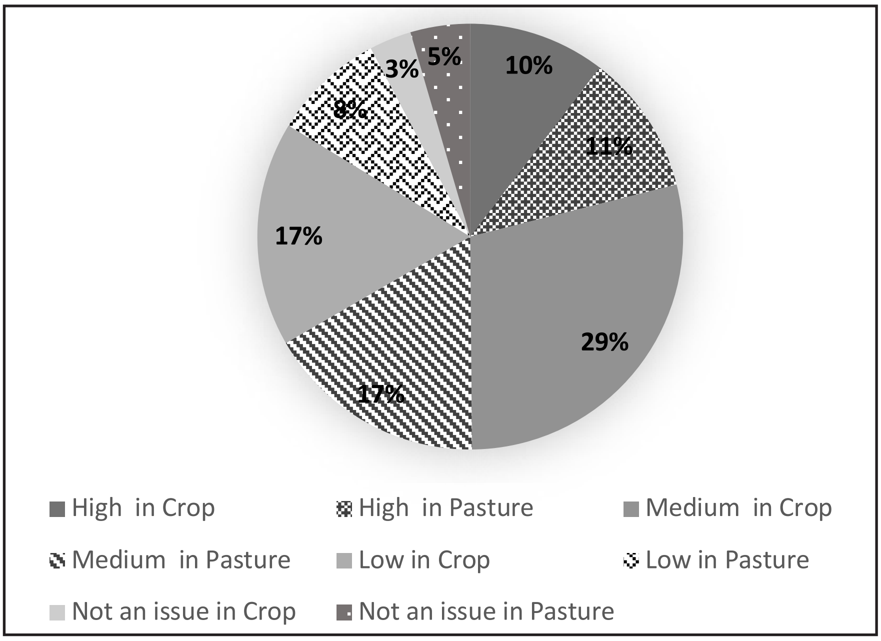


Figure 1. Growers response to the impact of barley grass as a weed within the crop or pasture phase.

The final question gave growers the opportunity to suggest possible contributing factors to the increase in barley grass on farms in the regions. Some of these responses have been presented below with the number of other similar responses indicted in brackets (number of growers):

- Pre-emergent chemical effectiveness and herbicide efficacy is limited in dry conditions (11 growers) and low rainfall starts presents a challenge to grass control in the cropping cycle. A pre-emergent chemical with good activity on barley grass in wheat and barley is needed.
- The diverse nature of its ability to set seed and its time of germination are making it hard to manage (4). There are many factors with non-wetting sand (4) that make this worse due to varied germinations (8) and lack of pre-emergent activation.
- Seems to be mostly a problem when sheep and pasture is in the rotation (7). Spray topping is not as effective (7), even with two applications, need a pre-emergent in wheat that is good on barley grass. Sakura is a costly option (4).
- Resistance to group A chemistry has developed from a year in year out pasture-wheat rotation (4).
- Failure from grass sprays in pasture phases are becoming more common in rotations, one year in one year out (4).
- Slowly turning into a major problem. Using double pasture breaks (3), canola and brown manure vetch (3) to get higher success in control. Requires vigilance and fussiness which includes at this stage spot-spraying resistant (tested and verified) patches as well as paddock hygiene.
- Easy to control with rotation or IMI system/Clearfield varieties (10), but developing IMI herbicide resistance will be an issue (3). We choose rotation because the IMI system reduces crop rotation options. Barley grass soon becomes a problem in continuous cereals. In dry seasons Clearfield varieties are a game changer.
- We have found patches of barley grass less tolerant to some knockdowns i.e. need more robust rates to achieve a good kill.
- It is persisting longer in the seed bank and coming up later than normal (4), this change has been quite quick over the last 5-7 years.
- Some newer barley varieties e.g. LaTrobe, Spartacus have more upright early growth, seem less competitive and have low early vigour - not as good for competing with weeds. Need wheat and barley varieties with good early vigour, and prostrate growth up to mid tillering.
- Weed seed collection not an option because it sheds seed too early, hay might be option or silage. Later germination hard because pre-ems not working, Sakura and Avadex too high a cost.
- Pre-ems are the only effective option where Group A has failed. Sets seed too early for anything else.
- Disc and wide rows results in more staggered germination of barley grass in season and following crops. Same method results in less early crop competition (2). Non wetting sands storing seed banks (4) especially through a run of dry seasons. Dry sowing has denied a pre-emergent knockdown (8).
- Without Sakura we would have real problems. But it will only work so long. Would like to be able to terminate pastures earlier but can’t because need livestock feed.
- Have only had problems recently due to dry sowing (8) most of the crop. In years where there is early rain, have no issues with barley grass. Also hay freeze pastures before barley grass seed set so have driven down numbers for a long time now. They are only creeping in from the edges when dry sowing.

What does this mean?

The initial grower survey of current practice and attitudes towards barley grass across the southern and western low rainfall zones was undertaken as the baseline to assess changes in grower attitudes, and any change in practices after the completion of the GRDC 'Demonstrating and validating the implementation of integrated weed management strategies to control barley grass in the low rainfall zone farming systems' project. Some of the major factors responsible for the increase in barley grass identified by the growers include: delayed emergence and early seed-set, low efficacy of pre-emergence herbicides particularly during dry starts to seasons and, resistance to group A herbicides, continuous cereals in the system and wide crop row spacing.

Each region has developed a three-year management plan for a farm based replicated demonstration to implement current strategies to manage barley grass in the local area. The outcomes from the research will be extended over the course of the project. A barley grass survey for herbicide resistance and germination patterns will also be undertaken within the project. Growers can contact their local farming systems group (listed above) if they have suspected barley grass resistance which they would like tested.

References

Llewellyn, *et al* (2016) Impact of weeds on Australian grain production.

Acknowledgements

This research was possible via GRDC investment in project UOA1904-004SAX. Thank you to the farming systems groups for distribution of the survey and growers for their responses.

National Hay Agronomy - what variety, when to sow and what N rate to use?

Alison Frischke[1], Genevieve Clarke[1] and Georgie Troup[2]

[1]BCG (Birchip Cropping Group); [2]DPIRD (Department of Primary Industries and Regional Development, Western Australia)

Location
Kalkee North
Rainfall
2019 (Nov-Oct): 363 mm
2019 (Apr-Oct): 254 mm
Soil type
Clay Loam
Paddock history
2018: Duram wheat
Nutrition
Available nitrogen (0-100cm) 30kg N/ha
Plot size
7 m x 1.8 m x 3 reps x 30 cm row spacing

Key messages

- **Hay yield was optimised by sowing either Mulgara, Wintaroo, Yallara or Brusher at the start of May.**
- **Delaying sowing from 1 May to 6 June reduced hay yield by 1.5 t/ha.**
- **WA hay varieties Williams and Carrolup were lower yielding when sown early, yet yielded similarly to Mulgara, Wintaroo and Brusher when sowing was delayed.**
- **Hay yield was optimised when 120 kg N/ha was applied.**
- **Stem thickness increased as applied N increased to 60 kg N/ha, before plateauing as N increased to 150 kg N/ha**

Why do the trial?

Hay can provide the highest gross margin crop in the program, while reducing business and production risk. Hay reduces risk by diversifying income across additional markets and selling periods and, due to the earlier harvest, hay crops can conserve moisture for subsequent crops. Deciding to cut hay can provide opportunities for frosted, water limited and heat-affected crops that are unlikely to fill grain, while reducing the weed seedbank at the same time.

Oaten hay accounts for almost 75 per cent of fodder exported from Australia each year. The National Hay Agronomy project is a four-year investment by the AgriFutures™ Export Fodder Program, led by Western Australia's Department of Primary Industries and Regional Development, with BCG, Agriculture Victoria, NSW DPI and SARDI. The project aims to improve understanding of how agronomic practices affect export oaten hay production and quality. This will help growers better manage oaten hay crops to meet export market specifications and develop a competitive advantage in our export fodder markets.

The aim of this research is to evaluate hay production and quality of oat varieties at different times of sowing and under different nitrogen (N) nutrition strategies.

How was it done?

A replicated field trial was sown with oats using a complete randomised block trial design. The treatments and sowing dates are listed in Table 1. The targeted plant density was 320 plants/m^2 and the trial had three replicates. The trial was sown using small plot equipment with knife points + splitter boot (70 mm split), press wheels and 30 cm row spacing. The fertiliser used was Granulock® Supreme Z + Flutriafol (200 mL/100 kg) @ 60 kg/ha at sowing, and seed treatments of Vibrance® @ 360 mL/100 kg and Gaucho® @ 240 mL/100 kg. The trial was managed as per best practice for herbicides, insecticides and fungicides.

Assessments included establishment counts, NDVI crop biomass, hay biomass at GS71, plant height, lodging, leaf greenness (SPAD chlorophyll measure) and stem diameter. NIR (including DairyOne calibration) was being analysed at the time of writing.

What happened?

Hay yield was influenced by variety selection, sowing date and rate of applied nitrogen. An interaction between sowing date and variety selection reflected the different maturity types within the trial - the ranking of varieties changed as sowing was delayed. An interaction between variety and nitrogen rate indicated that there were different sensitivities to applied N within the varieties in the trial.

Sowing in early May produced an additional 1.5 t/ha of hay than June sowing in 2019 (Table 2). All varieties yielded higher at TOS 1 except Carrolup.

The highest yielding TOS 1 varieties were Mulgara, Wintaroo, Brusher and Yallara, which averaged more than 8 t/ha (Table 2). The early finish to the 2019 spring meant the early-mid season variety Yallara finished better than expected.

Table 1. Treatments, time of sowing (TOS), oat variety and nitrogen rate (kg N/ha), Kalkee 2019.

Time of sowing	Oat variety	Nitrogen rate (kg N/ha applied as 2/3 at seeding, 1/3 at 6 weeks after germination)
TOS 1: 1 May TOS 2: 6 June	Brusher Carrolup Durack Forester Koorabup Mulgara Williams Wintaroo Yallara	10 (Mulgara, Wintaroo, Yallara only) 30 60 90 120 (Mulgara, Wintaroo, Yallara only) 150 (Mulgara, Wintaroo, Yallara only)

Table 2. Oaten hay yield (t/ha) response to TOS and N rate. Letters indicate significant difference.

Variety	Hay yield (t/ha)				
	Time of sowing		Nitrogen rate (kg N/ha)		
	TOS 1	TOS 2	30N	60N	90N
Brusher	8.1^{abc}	6.3^{hijk}	6.0^{ijkl}	7.9^{bc}	7.8^{bc}
Carrolup	7.1^{efg}	6.5^{ghi}	5.5^{l}	7.7^{bcd}	7.2^{cdefg}
Durack	7.8^{bcd}	5.8^{jk}	5.7^{kl}	6.9^{defgh}	7.7^{bc}
Forester	6.7^{gh}	5.7^{k}	5.7^{l}	6.5^{hijk}	6.5^{ghik}
Koorabup	7.5^{cde}	5.7^{k}	5.8^{jkl}	6.6^{fghi}	7.5^{bcd}
Mulgara	8.6^{a}	6.6^{gh}	6.0^{ijkl}	8.0^{ab}	8.5^{a}
Williams	7.4^{def}	6.4^{hij}	6.0^{ijkl}	7.2^{cdef}	7.4^{bcde}
Wintaroo	8.2^{ab}	6.8^{fgh}	6.7^{efghi}	7.9^{bc}	7.9^{bc}
Yallara	8.2^{abc}	5.9^{ijk}	6.2^{ijkl}	7.3^{bcdef}	7.6^{bcd}
Average	**7.7**	**6.2**	**6.0**	**7.3**	**7.6**
Sig. diff.	*<0.001*				
TOS Variety	*<0.001*				
TOS x Variety	*0.011*				
N	*<0.001*				
TOS x N	*ns*				
Variety x N	*0.05*				
TOS x Variety x N	*ns*				
LSD (P=0.05)	*0.37*				
TOS	*0.45*				
Variety	*0.25*				
TOS x Variety	*0.66*				
N	*-*				
TOS x N	*0.74*				
Variety x N	*-*				
TOS x Variety x N					
CV%	*9.2*				

The lowest yielding was late-maturing Forester (6.2 t/ha), which is well adapted for high rainfall and irrigated regions. In other low-medium rainfall regions Forester generally fails to finish for hay by starting to discolour before it reaches the hay cutting, watery ripe stage. This is the general experience right across southern Australia from WA to southern NSW.

A new variety Koorabup (formerly 05096-32) with early-mid to mid-season maturity, was expected to yield better from the shorter finish than it did.

Nitrogen response

Yield increased as N rate increased from 30 to 60 kg N/ha for all varieties, but only Koorabup and Durack responded to the increase to 90 kg N/ha (Table 2).

The largest yield responses to increasing N from 30 to 60 kg N/ha were by Brusher, Carrolup and Mulgara, and Koorabup. Mulgara yielded the highest with 90 kg N/ha. Forester's response to increasing N was low, again because its maturity is too late.

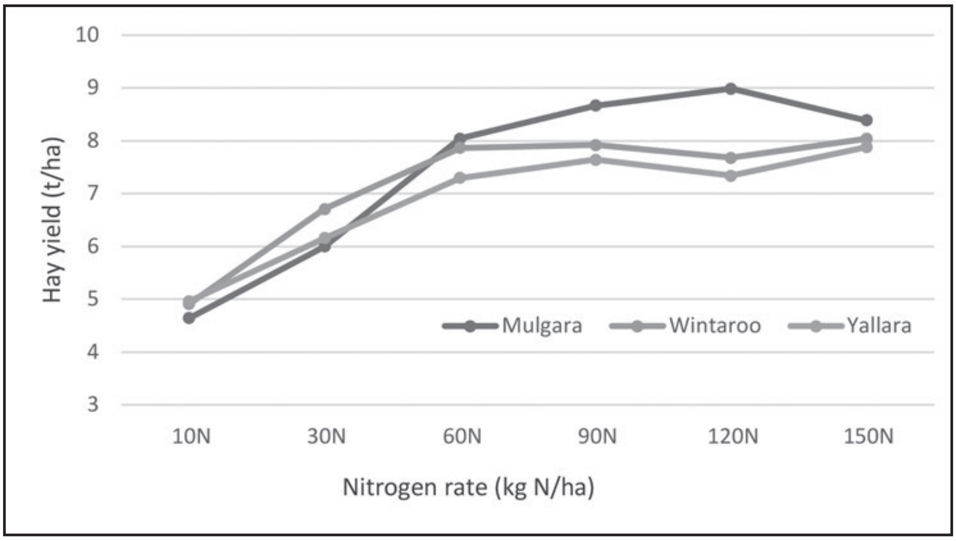


Figure 1. Mean oaten hay yield (t/ha) response to six nitrogen rates, Kalkee 2019 (P=0.024, LSD=0.79 t/ha, CV=9.7%).

Hay yield rose as N rate increased until 60 kg N/ha in Mulgara, Wintaroo and Yallara. Yield then plateaued and no further yield benefit was obtained from higher rates of N (Figure 1).

Hay quality

Plant height: The dry finish stalled plant height in general. Height responded to TOS x Variety x N (P=0.017). An earlier TOS allows plants to have a longer growing season before maturing and hence reach greater heights. May sown plants averaged 81.1 cm compared with early June sown plants at 67.8 cm. The tallest varieties were TOS 1 Mulgara, Durack, Wintaroo and Brusher above 88 cm. As N rate increased from 30 to 60 kg N/ha, plant height increased by 5 cm.

Lodging: There were no issues with lodging for any treatments in 2019.

Leaf greenness (SPAD chlorophyll measure): Greenness of hay is an indicator of plant health at cutting i.e. whether plants have been heat or water stressed, or if hay has been weather damaged, and forms part of the subjective analysis that determines hay price. Leaf greenness was highest for Williams, closely followed by Mulgara, Brusher and Koorabup, while Carrolup had the least colour. Later sown June varieties were greener than May sown (P<0.001), with the largest changes due to sowing time measured in Koorabup and Carrolup (P<0.01). Raising N from 30 to 60 kg N/ha increased greenness (P<0.05) for Brusher, Carrolup, Durack, Forester and Mulgara. There was no further response to 90 kg N/ha.

Stem thickness: Thinner stems (<6 mm) with lower fibre and higher water-soluble carbohydrates make better quality hay. Stem thickness responded to TOS (P<0.001), variety (P<0.001) and N rate (P<0.05). Later sowing reduced stem thickness from 4.73 mm to 3.98 mm. Varieties with the finest stems were Koorabup and Brusher, both under 4 mm. Raising N from 30 to 60 kg N/ha increased stem thickness from 4.22 to 4.41 mm. There was no further response to 90 kg N/ha.

What does this mean?

A combination of an adapted variety and the right agronomy will maximise the production and quality of oaten hay crops. Varieties with early-mid season maturity will perform best in the southern Mallee and Wimmera. Production of a late season variety, such as Forester, won't be optimised because it must be cut before peak biomass is reached in order to achieve hay quality.

Sowing early produces higher yielding hay crops. Better quality can be achieved when adequate N is applied in response to seasonal conditions, rather than large amounts applied early which are at risk of not being used if the season dries off. Despite good winter growing conditions, the dry finish meant 60 kg N/ha maximised yield and quality for all varieties, and the standard N rate of about 90-100 kg was more than adequate in a season like 2019.

This is the first year of a four-year research program. Results are indicative of the 2019 season and should be considered on the basis of growing conditions during this one season. The trial will be repeated in 2020 to evaluate these agronomic practices under a different set of seasonal conditions.

Acknowledgements

This research is part of the 'National Hay Agronomy project', funded by the AgriFutures™ Export Fodder Program. It is a national collaboration between DPIRD, SARDI, Agriculture Victoria, NSW DPI and grower groups including BCG.

Cereal Hay Options in the Upper North Farming Region

Author: Alex Burbury
Funded By: Balco Australia Pty Ltd
Project Number: UNFS 233
Project Title: Fodder Variety Trial – Investigate various cereals as alternative fodder hay variety options to improve rotations and profitability in the Upper North.
Project Duration: May 2019 to current
Project Delivery Organisations: Upper North Farming Systems, YPAG/NRAG

Key Points:

- The dry seasonal conditions meant that there were small variations in dry matter weights and yield.
- The AGT Wheat variety SUN945A had the highest dry matter weight (6.6mT/ha) but there were no significant differences between the varieties.
- SUN945A also had the highest grain yield (0.82mT/ha). This variety, along with SUN9440 and the Oat Variety Brusher the highest yields and but were not significantly different from each other.

Background

The Upper North region of South Australia is searching for suitable fodder varieties to provide a more flexible and resilient crop option with the possibility of producing either fodder as hay, green feed or grain production.

Methodology

The 2019 Fodder Variety Trial was sown on Todd Orrock's paddock, just south of Booleroo South Australia. The aim of the trial was to compare the biomass of different varieties of wheat (awnless), barley (awnless) and oats and assess whether they were suitable for grain production.

The trial was sown with the Upper North Plot Seeder, it was in a replicated randomised plot design (refer to Image 2) with 4 replicates.

The following varieties were sown:

WHEAT: SUN9440 and SUN945A (AGT)
BARLEY: Dictator 2 (Barenbrug)
OATS: GIA1701(Kingbale) & GIA1803 (Intergrain), Brusher (AEXCO)

The trial was sown on May 14th 2019 with 50Kg DAP/Ha (Nitrogen 9Kg/Ha, Phosphorus 10Kg/Ha) and 20 Kg/Ha Urea (Nitrogen 9.2Kg/Ha). The trial site was sown to lentils in 2018. Pre-emergent chemicals were applied at Time of Sowing 1 (13th April 2019) and were Boxer Gold (2.5L/Ha) and Gramoxone (1.2L/Ha). On July 16th Lontrel and LVE MCPA was applied to all treatments for broadleaf weed control. Biomass cuts were taken as 4 x 50cm rows from the middle of each plot, this was sampled on 25th September 2019. The samples where dried in a drying oven and weighed for Dry Matter weights. The plots were harvested at the end of the season by SARDI to assess grain yield and quality.

Variety Summary

KingBale(GIA17010-I)

KingBale is a mid-flowering IMI tolerant oaten hay variety with improved tolerance to soil residual imidazolinone herbicides. It is an ideal variety for use where there are IMI residue concerns from previous crops. KingBale is a tall variety with good early vigour and is suitable for planting in the major hay growing regions of Australia. Preliminary data shows that KingBale has a similar disease and agronomic profile to Wintaroo and indicates that it is resistant to CCN although rust (likely susceptible) will require proactive management. Yield information is currently limited. KingBale is a single gene IMI tolerant variety. The original breeding work was undertaken by Grains Innovation Australia (GIA) and the line is being commercialised by InterGrain. Commercial seed of KingBale will be available in 2021 subject to 2019 field testing results and an APVMA herbicide registration.

GIA1803O

GIA1803O is an early to mid-season heading dual purpose oat variety with a similar level of IMI herbicide tolerance to GIA1701O. This line is currently under evaluation and future progression is being assessed. The breeding work has been undertaken by Grain Innovation Australia (GIA)

Brusher

Brusher is an early to mid-season tall oat developed by SARDI and commercialised by AEXCO Pty Ltd. It is two to four days earlier to head than Wintaroo and this suits it well to low rainfall areas. Although Brusher has inferior hay yield when compared to Wintaroo, it is recommended to replace this variety where improved resistance to stem and Leaf rust or improved hay quality is desired. Grain yield and grain quality is similar to Wintaroo , Wallaroo and Kangaroo with higher grain protein. Brusher is moderately low in grain lignin.

Dictator 2 Barley

Dictator 2 is a long season barley suited to grazing, fodder and silage. It has vigorous early growth, early feed option, wide planting window, suitable for multiple grazing. Dictator 2 is a new awnless true forage barley. It is even faster establishing, has more early growth and is later maturing so has higher overall yield. Dictator 2 has a shorter growth habit so is less likely to lodge and has a wider planting window. It is a two row, early-mid maturing, black hulled, awnless (hooded) forage barley with medium green foliage and a medium plant height at maturity. From an autumn sowing, growth is extremely vigorous providing early feed and producing well through winter and into early spring. Late spring growth will be less than forage oats. Dictator 2 has an extended planting window and can be sown from mid-April through winter offering greater flexibility than forage oats. It will tolerate multiple grazing's until the production of the first node in late winter when it can be closed up for hay or silage production. Dictator 2 is produced by Barenbrug Seeds.

SUN 9440

SUN944O is an awnless long season spring wheat, flowering a few days earlier than Longsword and up to 10 days later than Scepter. SUN944O has excellent resistance to stem, stripe and leaf rust, with moderate yellow leaf spot resistance. AGT data from 2019 suggests that SUN944O is quite a tall line, up to 12cm taller than Scepter at maturity

SUN945A

SUN945A is an awnless long season spring wheat, flowering around 8 days later than Scepter, and 2 days earlier than SUN944O. SUN945A also has excellent resistance to stem, stripe and leaf rust. SUN945A is a very tall line, with AGT's 2019 height observations showing that this line is up to 18cm taller than Scepter.

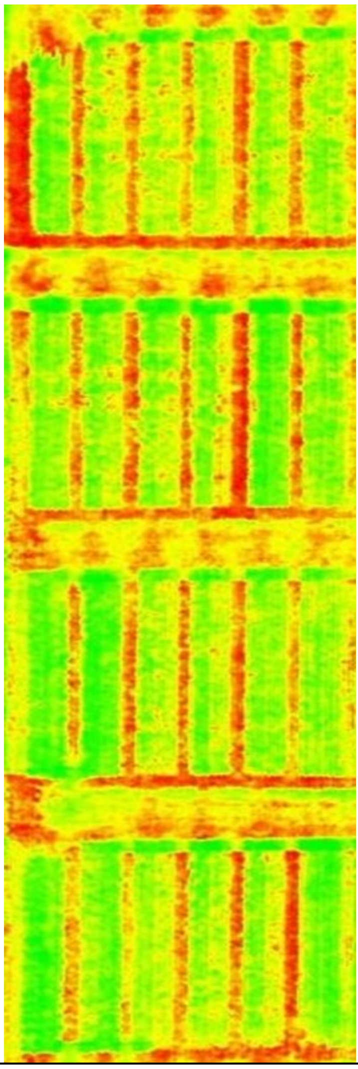
AGT entered two lines into UNFS fodder trials in 2019, both chosen for their potential for making wheaten hay due to awnless heads and straw length/biomass production, while also having excellent grain quality and grain yield. Both lines are therefore considered 'dual purpose' and if released, will offer growers a package of benefits that is regarded as uncommon in SA (awnless plus hard quality). These two lines will be entered into UNFS trials again in 2020, whilst also being nominated for NVT early break trials for the first time. If these lines progress through AGT's pipeline, they could potentially be released in spring 2021, with commercial availability in 2022. Neither of the two lines have quality classification yet, but preliminary testing shows that grain quality/ functionality for both is very good.

Note: Variety information supplied by SARDI Sowing Guide, Intergrain, Grain Innovation Australia and Barenbrug Seeds. All varieties are subject to Plant Breeders Rights.

Results and Discussion

The seasonal conditions had a major impact biomass and grain yields only receiving 124.9mm of Growing Season Rainfall (refer to appendix 1 on seasonal conditions). There was little to no difference between the barley, oats, and wheat in biomass or grain production. Three of the 6 varieties in the trial are undergoing field assessment and new to the market. These new varieties were GIA18030-I, SUN9440 and SUN945A. GIA1701-I was entered as an experimental variety but has now been named as Kingbale. Evaluation of new varieties compared to known commercial varieties in a range of environments is important for assessment of variety performance.

Table 1	Variety Table for Trial plan (**Image 2**) and Biomass and Grain Yield (**Figure 2**)
Variety 1	GIA18030 (oats)
Variety 2	SUN9440 (awnless wheat)
Variety 3	SUN945A (awnless wheat)
Variety 4	GIA1701.1 – Kingbale (oats)
Variety 5	Brusher (oats)
Variety 6	Dictator 2 (awnless barley)



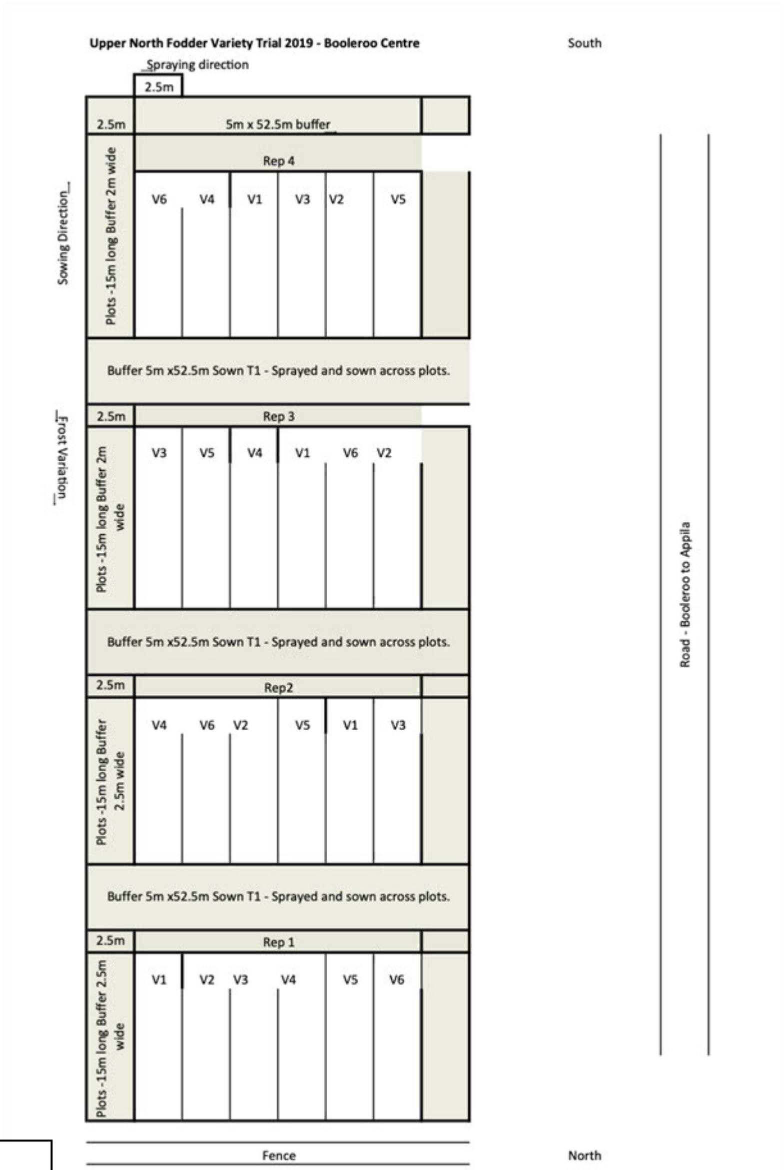


Image 1 – Chlorophyll content analysis taken by Agtech Services – 29th July 2019

Image 2 – Paddock Trial Plan

The trial is not only looking at fodder production through biomass production but also grain yield as a dual use crop. Dictator 2 barley is a fodder variety and as such has lower grain yields as it was bred for hay and grazing. Figure 1 below shows the varieties grain yield and biomass, there is little variation across varieties. Feed test analysis will be undertaken in 2020 to determine fodder value as a hay crop. The trial was harvested to gather grain yield data (Figure 2) however the oats and barley are bred as fodder varieties.

Further testing will be required to determine performance differences as one year of trials did not show statistical differences.

Image 1 is a chlorophyll map of the fodder trial site, chlorophyll is a measure of the amount of green leaf area on the plant and is a useful tool for looking at plant health and ground cover and therefore crop health and density. This early review of biomass and growth showed the varieties to be relatively uniform in their growth rates and production levels.

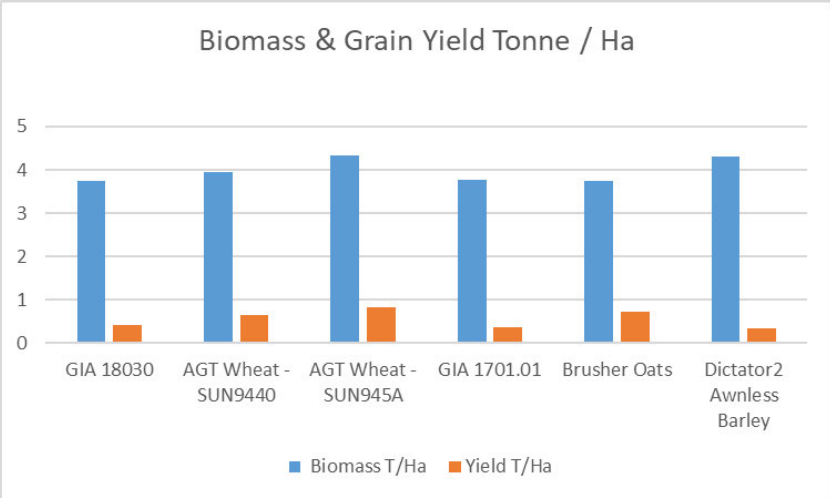


Figure 1 – Biomass and Grain Yield in tonnes per Hectare

Variety		Biomass T/Ha		Yield T/Ha	
1	GIA 18030	3.74	-	0.42	bc
2	AGT Wheat - SUN9440	3.96	-	0.64	ab
3	AGT Wheat - SUN945A	6.6	-	0.82	a
4	GIA 1701.01 (Kingbale)	3.78	-	0.36	c
5	Brusher Oats	3.74	-	0.72	a
6	Dictator2 Awnless Barley	4.3	-	0.33	c
	Means followed by same letter or symbol do not significantly differ (P=.05, LSD).				

Figure 2: Table of Yield and Biomass in Tonnes Per Hectare

All six varieties in the trial performed equally when analysed on Biomass/Dry Matter production in September. These biomass cuts were done at an appropriate growth stage for hay production. These results reflected the tough spring growing conditions experienced in 2019. As such the trial will be sown in 2020 to attempt to gain additional data on the varieties under less extreme growing conditions. The 2020 data will include Feed Quality analysis as well to evaluate the varieties suitability for export quality hay or domestic hay and standing crop feed. The grain yield data did show significant differences between the varieties, however quality data has not been analysed nor have the economic value comparison between varieties been completed. Without this comparing the different crops and varieties may not be relevant. Despite this the Brusher Oats and two Awnless AGT Wheats produced the highest grain yields (statistically equivalent) yielding a mean grain production of between 0.62 and 0.82t/ha. The other three varieties (2 IMI Oats and Dictator2 Barley) yielded the statistically equivalent mean grain production of between 0.33 and 0.42t/ha.

The varieties selected are fodder varieties and suitable for hay production due to their awnless head structure. This trial has aimed to investigate whether there are alternative options to oats for fodder production in the Upper North, that under the right seasonal conditions may be used for hay production, rept for grain or left as a standing grain crop for summer grazing or that may provide alternative weed management options within the crop and pasture rotation. Under the tough seasonal conditions of 2019, the varieties of Awnless Wheat, Awnless Barley and IMI tolerant oats all showed similar biomass production to the Brusher Oats, a standard hay variety for the region. Confirming this data in a better season is required to ensure that productivity potential is not compromised in the better seasons by selecting one of these alternative options. The viability of the varieties in this trial, under these seasonal conditions, as a viable option for yielding grain is unclear as the yields were low and economic comparison between crop types has not been undertaken.

Appendix 1 – Weather Station Data

2019 Booleroo Weather Station Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
AVG (°C)	29.7	26.2	23.3	18.2	11.7	8.1	8.9	8.3	13.5	19	20.2	27.6	17.8
MIN (°C)	7.9	6.5	5.4	1.2	0.5	-3.8	-2.2	-3.5	-2.5	-0.5	0.6	4	-3.8
MAX (°C)	59.3	55.6	52.3	43.3	31.3	25.2	22.5	24.6	33.9	43.8	48.7	59.4	59.4
SUM (mm)	5.8	6.8	3.8	4.8	31.8	44.5	12	20.5	10.5	0.8	9	8.5	158.5
AVG (% RH)	38.2	43.4	49.1	50.1	69.7	72.9	76.4	-	-	-	-	-	56.8
MIN (% RH)	7.7	12.7	13.7	11.3	28.3	33.2	24.9	-	-	-	-	-	7.7
MAX (% RH)	94	90.5	96.9	95.7	98.6	99.2	99.3	-	-	-	-	-	99.3

Weather Station - UNFS Booleroo 863071 - installed by Agbyte

Data for 2019 Calender year.

Acknowledgements:

- **Todd & Brooke Orrock, Orrock Farming – Trial Site Owner and Research Co-operator**
- **Joe Koch – Research Co-Operator**
- **Balco, major sponsor**
- **AGT, Intergrain, Grain Innovation Australia, Barenbrug and local growers for supplying seed for the trial**
- **AgTech Services for In-Crop Site Analysis Sponsorship**
- **YPAG/NRAG for working with UNFS to undertake the site assessments under contract.**

MIXED COVER CROPS

FOR SUSTAINABLE FARMING

Mixed Cover Crops for Sustainable Farming - Project Update

Background

Crop intensive farming systems are running down soil carbon levels, requiring increased inputs to maintain or increase yield without necessarily improving profitability. Mixed species cover cropping offers a new approach in the Australian context. It is a key component of some farming systems overseas but is yet to be adopted widely in southern Australia. In the context of this project, mixed species cover crops refers to a diverse mix of plant species grown at the same time but often outside the main growing season to build fertile and resilient soils.

Potential benefits of cover crops include improving soil organic carbon, structure and health, while decreasing weed and disease levels for following crops, but these must be balanced against the cost of growing the cover crop and the water and nutrients it will use.

The project has three components; Farm Demonstration Sites; Field Trial Cover Crop Evaluations; and Extension & Communications.

Farm Demonstration Sites

Cover cropping is being examined in demonstration trial sites on 20 farms across South Australia, Victoria and Tasmania. At each site replicated demonstration trials are being established from summer late 2018 and will be monitored until harvest in summer late 2021, providing up to 3 years of data. Treatment one will be a paddock sown with multiple species cover crops and will serve as a demostration paddock. Replicated areas within in the paddock will have two further treatments, one with no soil disturbance, no seed added (i.e. business as usual summer fallow), and another being sown with a single cover crop species.

Scientific support from the CSIRO will focus on measurements of nutrient cycling and stratification; soil organic matter and fractions; microbial biomass size and activity; soil physical parameters (bulk density, moisture content, qualitative water holding capacity); analysis of C and N in cover crop; biomass cuts and grain samples. This will take place in the final year of the project.

Assessment of invertebrate communities is occurring at five representative sites across the region.

Cover Crop Evaluation Field Trials

The performance of a broad range of cover crops will be evaluated in replicated field trials across the southern region to answer two key questions:

- What are the new and emerging plant species/varieties, summer and winter active, most suited to different environments across the region? (five sites)
- What are the most effective strategies and timings to terminate a cover crop for achieving the optimum benefits for subsequent crops and soil health? (nine sites)

Project Progress

This project is providing the space for constructive conversations around both the soil health benefits and the possible economic advantages of multispecies cover cropping. Discussions continue in relation to how multispecies might look in a larger cropping business (particularly mixed system), including how to best utilise the opportunities provided by a multispecies crop when the business is continuous cropping. Discussion with some landholders informed there is interest in the role of a multispecies crop as sheep feed and the project is gathering attention from other growers who have expressed interest to try mixed cover copping on a small scale.

Key learnings to date include:

- Multispecies generally work as a form of weed control however require the optimum species mix for the site. However, it has been noted the cereal crops are vigorous and outcompete legume components of mixed species.
- Demonstration trial sites produced some challenges with managing weeds in combination with the multispecies mixes.
- Considering split seeding options to allow for multispecies seeding following the early control of these problem weeds.
- Waiting for the 2019 winter harvest to finish before re-seeding the summer multispecies demonstration reduces rainfall opportunities to get the summer crop in the ground.
- With incredibly dry conditions getting a summer mix and single species crop sown at the correct time was challenging
- Significant differences were observed in the soil condition going into the spring summer period in the pre-existent multi-species site – there was an abundance of stored soil moisture and this was observed as being predominantly in relation to the proximity of the tillage radish tuber.

Project Web Site

The project website, hosted by the CSIRO, is providing the broader farming community with access to the project progress and reference materials on cover crop implementation and management. Find the site at https://research.csiro.au/mixedcovercrops/

Project Proponents

Ag Excellence Alliance   CSIRO   SANTFA

Project Funders

Australian Government   National Landcare Programme   GRDC

In Season Cover Crop Options for the Upper North: Reducing Soil Borne Disease and Improving Soil Health: Year One Project Report

Author: Jamie Wilson - UNFS
Funded By: National Landcare Program; Smart Farming Partnerships Initiative Rd 1. Subcontracted through Ag Ex Alliance - Project ID – I - UNFS
Project Title: Warm and cool season mixed cover cropping for sustainable farming systems in south eastern Australia.
Project Duration: 2019 - 2022
Project Delivery Organisations: Upper North Farming Systems, Elders Jamestown – Darren Pech

Key Points:

- Improving soil health and function through increased diversity of species through-out the paddock rotation is hoped to reduce the soil borne pathogen levels and improve the profitability and productivity of mixed farming operations in South Eastern Australia.
- In year one of the trial the mixed species plots performed well with limited rainfall
- Soil testing and Predicta B will be key in understanding the impact of a mixed species cover crop on improving soil health and productivity. This is year one of three years of different rotations.

Background

Crop intensive farming systems are running down soil carbon levels, requiring increased inputs to maintain or increase yield without necessarily improving profitability. Mixed species cover cropping offers a new approach in the Australian context. It is a key component of some farming systems overseas but is yet to be adopted widely in southern Australia.

Benefits of cover crops include improving soil organic carbon, structure and health, while decreasing weed and disease levels for following crops. Many potential cover crops exist and while growers are beginning to investigate these, they lack basic local knowledge to make informed decisions.

This site is part of a larger south eastern Australia project that aims to identify and demonstrate suitable cover crops across south eastern Australia. The impacts of cover cropping on soil health, nutrient cycling, organic carbon, and soil moisture will be measured, and the optimum timing and method to terminate the cover crops will be determined. This specific trial site has been selected for its history of high soil borne disease expression in crop and aims to investigate suitable cover crop options for the Upper North region and identify their impacts on soil disease loads, expression and overall soil health.

The paddock is located at Matt Nottle's on the eastern edge of Booleroo on the corner of White Cliffs and Miller roads in a paddock that has been underperforming while on a good soil type.

Methodology:

Trial Site Hypothesis:

1. Implementation of a higher level of crop type diversity into the rotation will have an effect on levels of Crown Rot (CR) and Root Lesion Nematode (RLN) *Pratylenchus thornei* in the soil and expression of symptoms in wheat.

2. Implementation of a higher level of crop type diversity into the rotation will improve soil condition parameters incl. microbial activity, organic carbon etc.

Location: Matt Nottle's property, Booleroo Centre

Paddock Trial Plan:

3 years, 3 treatments, 4 replicates, Plot lengths – 60-100m long. Sown with growers' seeder. In 2019, the site was sown on 12th May 2019. The mixed cover crop was sown at 4kg/Ha and the wheat (Sceptre) was sown at 80kg/Ha.

Trial Layout:

Total Area: 156m x 100m

Termination Plots	1	2	3	2	3	1	3	1	2	2	1	3	13x 50m
Demonstration Plots	1	2	3	2	3	1	3	1	2	2	1	3	13x 50m

Rep 1 Rep 2 Rep 3 Rep 4

Treatments:

	Yr 1	Yr 2	Yr 3	Termination
1 – Control/rest of paddock	Wheat	Medic w. late season grass termination	Wheat	Late season green manuring in yr 2
2	Mix - 4-5 species –	Vetch/canola or beans (seasonally dependant)	Wheat	Mid-season (pre-seed set) termination of mix in yr 1
3	Mix 4-5 species	Mix - 4-5 species	Wheat	Mid-season (pre-seed set) termination of mix in yr 1 & 2

Mix species composition: 5 species:

1. Smart Radish
2. Bouncer Brassica Rape
3. Subzero forage rape
4. Balance Chicory
5. Volga vetch

The cover crop species are to be terminated prior to seed set. The second treatment on the trial incorporates and earlier termination, or green manuring to ascertain whether this improves the rate of soil health changes within the paddock.

Results and Discussion

Site Assessments Include***:***

- In-crop imagery and pH mapping – Michael Zwar – (*refer Appendix 1-3)*
- Predicta B sampling for full pathogen analysis– pre and post-trial.
- Biomass cuts taken in each section of the trial
- Soil samples taken from each plot before sowing (or any pre-sowing fertiliser).
  Samples to be taken at - 0-10, 10-20, 20-30, 30-60, 60-100 cm segments
  - 0-30cm full analysis; 30-100cm Sulphur, nitrogen, pH
  - Soil samples from each cropping zone taken pre and post trial.

The site was sampled, as a whole paddock surface soil testing program, for pH (Appendix 1) and Potassium (K) (Appendix 3). In the 0 -10cm sample grid pH results showed the majority of samples (29/36) were pH range between 7.0 – 8.3pH, 4 were pH range 6.5 – 6.9 pH and 3 were 6.0 – 6.4 pH. The 25 – 35cm deep soil pH was all in the range 7.0 – 8.86 pH (Appendix 2).

Soil potassium was also analysed for the paddock (appendix 3) and the majority of the range for potassium was 120 – 199.9 ppm of potassium.

Full soil profile soil sampling has been undertaken across the site however this data has yet to be analysed and will be presented in the 2020 results. A soil pit was dug for the 2019 Members Expo (Image 2) to look at the profile present in the paddock. This showed a distinct amount of variability across the profile transect.

Full PredictaB sampling was undertaken at the site and results can be found in the following report from Dr Marg Evans.

The rainfall for the season at this location was 186.1 mm and Growing Season rainfall was 145.4 mm.

Month	***Monthly Rainfall Total (mm)***
Jan	**7.2**
Feb	**7.6**
Mar	**5.7**
Apr	**7.6**
May	**37.1**
Jun	**48.6**
Jul	**15.3**
Aug	**23**
Sep	**12.8**
Oct	**1**
Nov	**13**
Dec	**7.2**
Total mm	***186.1***

Table 1: Rainfall data – Booleroo Centre(BOM)

The cover crop species mix for 2019 was *(refer image 3)*

- Bouncer Brassica
- Smart radish
- Subzero forage rape
- Balance chicory
- Volga vetch

The seasonal conditions, with an extremely low in-crop rainfall and early finish meant that the cover crop produced limited biomass and was unable to be cut for analysis to determine the biomass yield Tonnes/ Ha. It also had insufficient biomass to implement the early termination treatment. This will occur in year 2 of the trial.

The cover crop was sprayed out prior to seed set (Image 4) with a knockdown herbicide. This was to retain as much organic matter as possible and prevent seed set carrying over into the following year.

There was no grazing on the trial during the growing season. Grazing only occurred Post termination when the trial was lightly grazed to retain soil cover.

For 2020, the Cover crop mixed will changed as chicory performed poorly in this environment and will be:

- Bouncer Brassica
- Smart radish
- Subzero forage rape
- Cobra balansa clover
- Volga vetch

The break crop component to be sown in 2020 is 43Y92 Clearfield canola.

Image 2 - Soil Pit – Members expo August 1st, 2019 with guest speaker Joel Williams

Image 3 - Cover crop 19th August 2019 showing mixed species

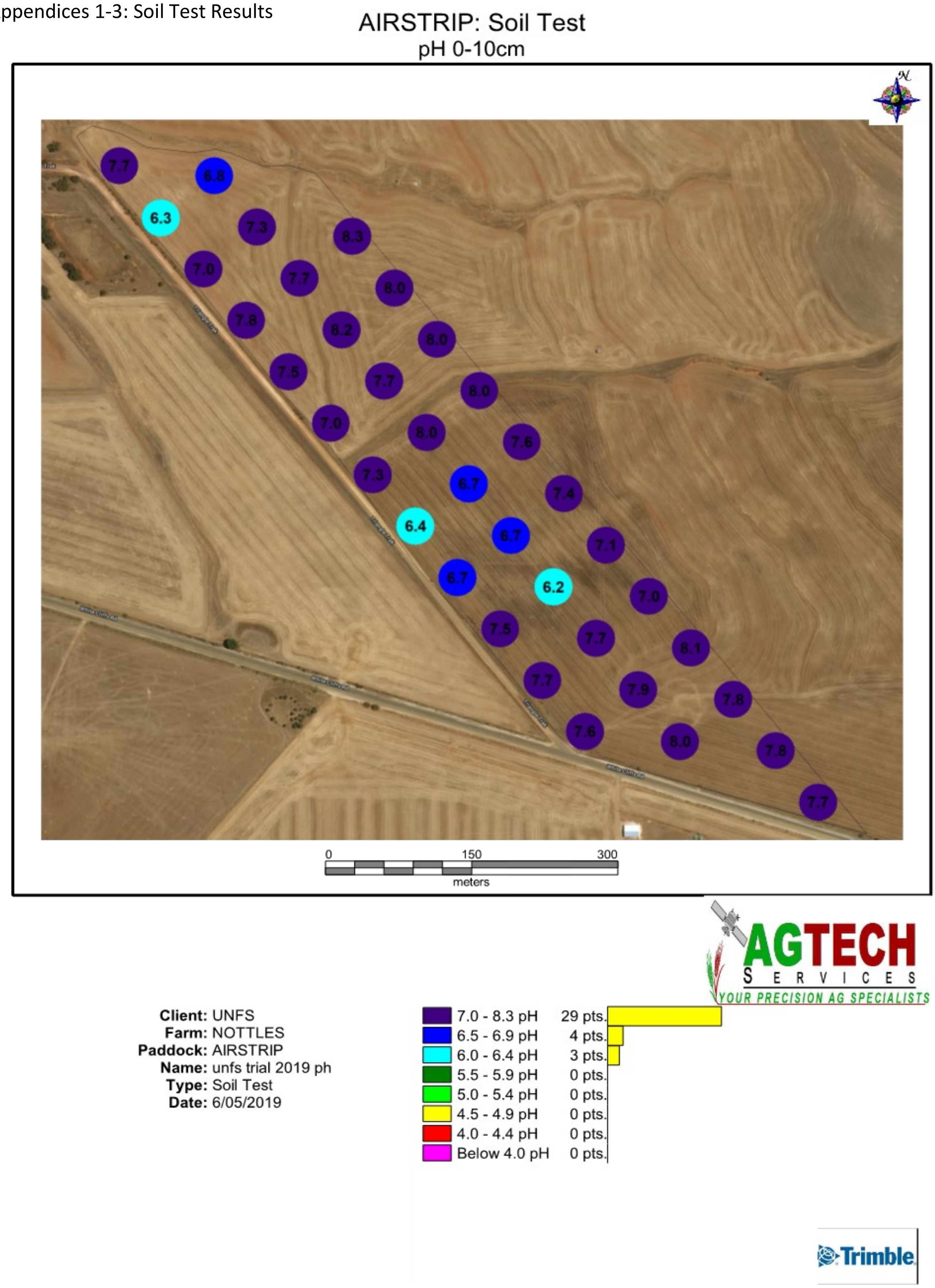
Image 4 - Cover trial 24th October 2019

Acknowledgements :

- Matt Nottle for providing the paddock and managing the trial site.
- Darren Pech – Elders Jamestown – for undertaking the deep soil core soil testing with support from Giles Kearsley. Darren also provided the agronomic support and in-crop data collection under a service agreement with UNFS.
- Ag Excellence Alliance for partnering with UNFS to deliver the trial within the region.
- Agtech Services – Michael Zwar provided sponsorship to the UNFS through his paddock survey work presented in this trial.
- Marg Evans – Soil Disease Technical Expertise and sampling.

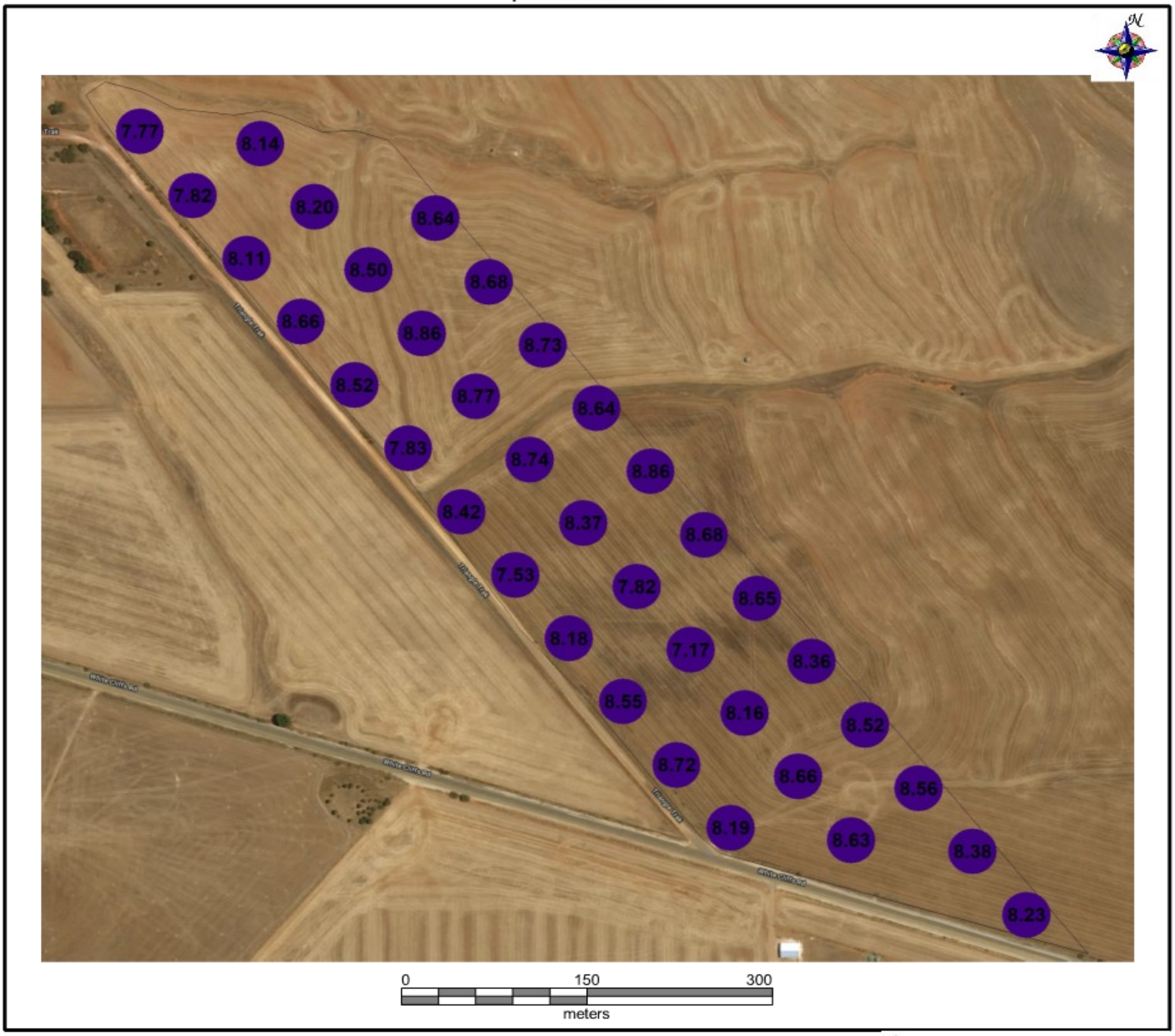
Funding and Delivery Partner Logos

Appendices 1-3: Soil Test Results



Appendix 1 – pH map 0-10cm

AIRSTRIP: Soil Test
pH 25-35cm



Client: UNFS
Farm: NOTTLES
Paddock: AIRSTRIP
Name: unfs trial 2019 ph
Type: Soil Test
Date: 6/05/2019

7.00 - 8.86 pH	36 pts.
6.50 - 6.99 pH	0 pts.
6.00 - 6.49 pH	0 pts.
5.50 - 5.99 pH	0 pts.
5.00 - 5.49 pH	0 pts.
4.50 - 4.99 pH	0 pts.
4.00 - 4.49 pH	0 pts.
Below 4.00 pH	0 pts.

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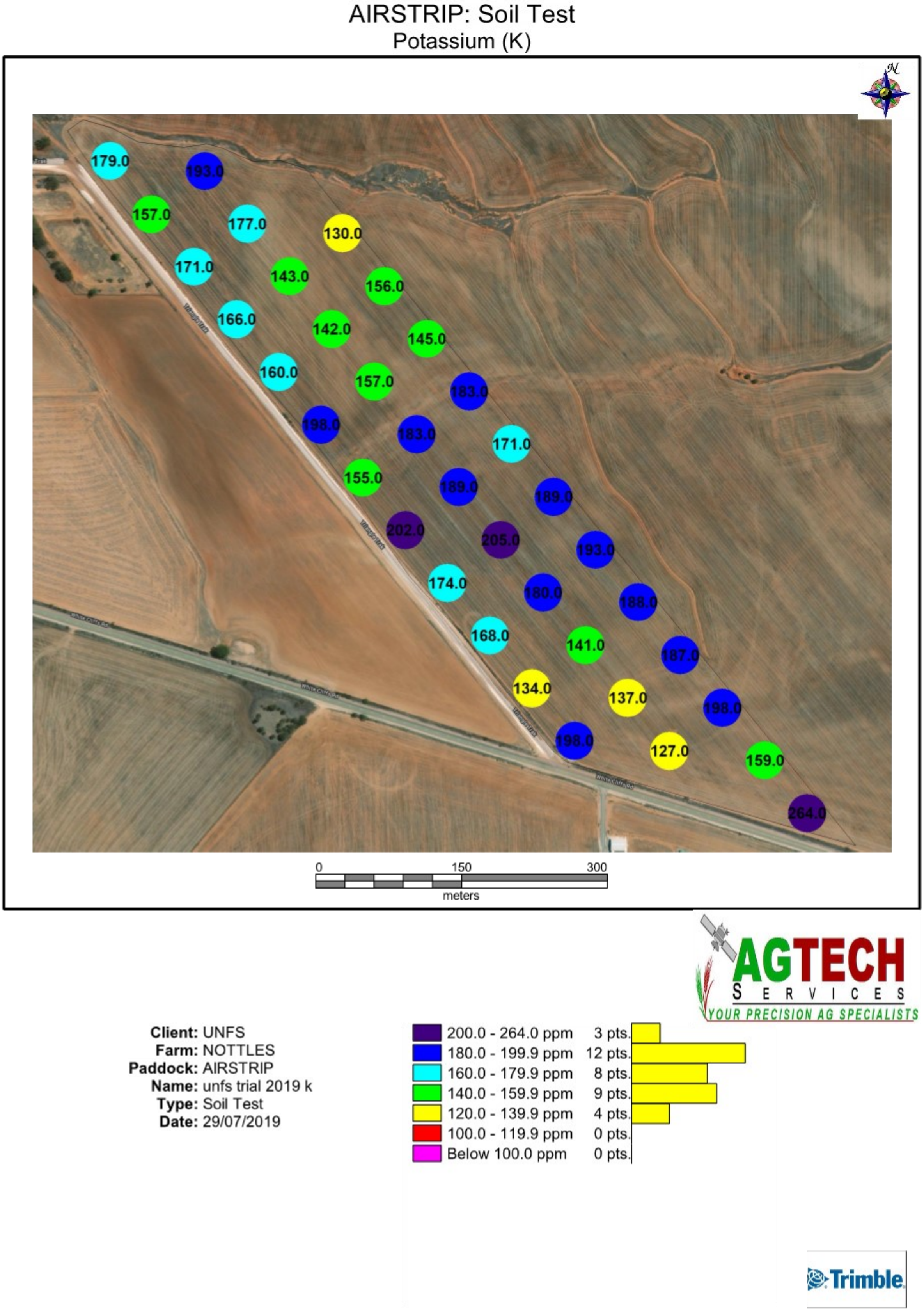
Trimble

Appendix 2 pH map 25 -35cm



Appendix 3: Soil Test Potassium

UNFS Cover Crop Field Trial Evaluations – Implications for Disease

Authors: Margaret Evans (SARDI), Matt Nottle (UNFS), Darren Pech (Elders), Ruth Sommerville (UNFS).
Funded By: National Landcare Program: Smart Farming Partnerships Initiative Rd 1.
Project Number: *UNFS 227*
Project Title: Warm and Cool season mixed cover cropping for sustainable farming systems in south eastern Australia.
Project Duration: 2019-2021
Project Delivery Organisations: SARDI, Elders Jamestown, Upper North Farming Systems

Key messages

- Crown rot, then take-all and rhizoctonia are the most important soil-borne cereal diseases in the cover crop trial and in commercial paddocks at Booleroo Centre.
- Inoculum of these diseases are spatially variable in plots across the cover crop trial as well as on a paddock scale. This variability between plots could affect trial results, making it important to monitor diseases and inoculum levels in the cover crop trial.
- Root lesion nematodes do not present a significant risk to cereal crops or the cover crop field trial at Booleroo Centre. Paddock history (even going back 5 years) does not always explain the crown rot inoculum levels in commercial paddocks.

Why do the work?

Mixed species cover cropping offers a new approach in the Australian context. It is a key component of some farming systems overseas but is yet to be adopted widely in southern Australia. Benefits of cover crops include improving soil organic carbon, structure and health, while decreasing weed and disease levels for following crops.

Many potential cover crops exist and while growers are beginning to investigate these, they lack basic local knowledge to make informed decisions. This has led to the Upper North Farming Systems (UNFS) grower group being involved in the project "Warm and cool season mixed cover cropping for sustainable farming systems in SE Australia".

Where low rainfall, intensive cropping, stubble retention and reduced tillage are combined, stubble and plant root systems take longer to break down. This means that soil/stubble-borne diseases e.g. crown rot (CR), root lesion nematodes (RLN), take-all (TA) and rhizocotonia (Rh) become increasingly difficult to manage. It is assumed that cover crops reduce disease levels, but this effect has not been quantified in Australian farming systems. To understand the role of cover crops in South Australian farming systems it is critical to understand the effects of those cover crops on soil/stubble-borne cereal diseases.

On this basis, the cereal disease work undertaken in 2019 aimed to quantify:
Starting inoculum levels of soil/stubble-borne cereal diseases in the cover crops trial.
Inoculum levels of soil/stubble-borne cereal diseases (particularly CR and RLN) in commercial paddocks and to determine the influence of paddock history and management on those levels.

How was it done?

The standard PREDICTA® B paddock sampling protocol was used and samples were taken with a 10 mm diameter Accucore sampler to a depth of 10 cm. Cores were taken in 5 diagonal legs, preferentially on-row. Three soil cores and 1 stubble piece were taken at each of 3 points along each diagonal and combined to make a single sample (45 cores, 15 stubble pieces) for each trial plot or paddock. Samples were submitted for q-PCR DNA analysis.
Soil samples were taken from 12 paddocks on 1 April 2019 and from the cover crop field trial plots after crop emergence on 14 April 2019. Paddocks were selected from around the edges of Matt Nottle's property, where the cover crop trial is located, East of Booleroo Centre. Paddock history, stubble management, paddock preparation and general comments were recorded for each paddock

Results and discussion

As would be expected, stem nematode, the oat strain of take-all and eyespot were not present in any samples. Cereal cyst nematode also was not present in any samples and that is good, as this nematode can quickly build up from very low levels and cause major yield losses.

<u>Cover crop field trial</u>
The diagram below shows the risk of yield loss from each of 5 pathogens causing cereal diseases. Each square represents a plot within the trial and colours indicate the risk of yield loss – green = low risk; orange = medium risk; red = high risk; white = below detection.

		Crown rot		Take-all		Rhizoctonia		*Pratylenchus neglectus*		*Pratylenchus thornei*	
Rep	Treatment	Demonstration	Temination	Demonstration	Temination	Demonstration	Termination	Demonstration	Termination	Demonstration	Termination
1	Wheat	4.15	3.39	1.36	1.02	1.21	0.97	4	1	4	13
	Wheat	4.13	3.76	1.22	0.97	1.13	1.35	3	2	5	12
	Mix 4-5 species	4.21	3.70	1.32	1.11	<0.5	1.20	1	4	10	8
2	Wheat	3.84	3.99	1.20	1.19	1.28	1.80	2	3	11	10
	Mix 4-5 species	3.81	3.80	0.99	1.01	1.10	0.58	1	2	9	9
	Wheat	4.10	4.15	1.31	1.30	1.47	1.42	4	2	10	12
3	Mix 4-5 species	3.89	3.78	1.06	0.91	1.71	<0.5	2	3	18	15
	Wheat	4.09	3.70	1.20	1.05	<0.5	<0.5	3	2	10	6
	Wheat	3.96	1.42	1.23	0.97	0.88	<0.5	2	20	7	4
4	Wheat	4.19	3.62	1.14	1.15	2.10	1.82	3	8	8	5
	Wheat	3.96	3.43	0.99	1.13	1.37	<0.5	2	8	12	3
	Mix 4-5 species	3.84	3.90	1.17	1.15	1.59	1.50	3	4	7	5

CR is the biggest risk at the site, followed by TA. As is normal for Rh, the risk across the site is very patchy but generally is less than for CR and TA at this site. The root lesion nematodes (RLN) *Pratylenchus neglectus* and *P. thornei* are generally a low risk.

It is clear that the inoculum levels for TA and Rh vary from plot to plot and that there is one plot with much lower CR inoculum than is seen in all the other plots. These differences in inoculum levels can directly influence trial results. By understanding starting levels of disease inoculum in each plot, it becomes possible to use this information to assist in interpreting results and in understanding the best use of cover crops in South Australian farming systems.

<u>Paddock sampling</u>
Findings were consistent with those seen in the cover crop trial area – CR, followed by TA and Rh were the main disease issues. CR was present in 82% of paddocks at levels likely to cause yield losses (high risk - 64%; medium risk - 18%). TA was of less concern, being present in 90% of paddocks but only at medium (45%) and low (45%) risk of causing yield losses. RH was of least concern, being present in 72% of paddocks but only at medium (36%) and low (36%) risk of causing yield losses. This suggests that results from the cover crops trial are likely to apply widely in the Booleroo Region.

Stubble was retained and crops direct sown in all paddocks except for one that was in continuous pasture. Five-year paddock histories did not provide a consistent explanation for the presence or absence of high levels of CR inoculum and this requires more examination of paddock use in relation to seasonal conditions in each of the 5 yrs.

One paddock sampled in two sections		
	East	West
Crown rot	0.71	2.92
Take-all	0.47	0.22
Rhizoctonia	1.89	1.40
P. neglectus	<0.1	<0.1
P. thornei	<0.1	<0.1
Paddock history		
2018	Lentils Jumbo	
2017	Wheat Trojan	
2016	Canola TT	
2015	Barley Hindmarsh	
2014	Wheat Scout	

The diagram on the left shows that distribution of disease inoculum is uneven on a paddock scale. This means that the distribution is uneven on a large (paddock) scale as well as on a small (trial plot) scale.

Acknowledgements

- Project funding – Cover Crop Trial Site - National Landcare Program - Smart Farming Partnerships initiative funding Round 1 via subcontract with Ag Ex Alliance.
- Project funding – Soil Disease Investigation - GRDC projects DAS1807 - Improved disease management in South Australian field crops through surveillance, diagnostics and epidemiology knowledge and DAN00175 - National Crown rot epidemiology and management program
- Matt Nottle, for providing the paddock and implementing the paddock treatments.

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Australian Government | National Landcare Programme

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Mixed cover crops for sustainable farming

Fiona Tomney[1] and Mark Stanley[2]

[1]SARDI, Minnipa Agricultural Centre; [2]Ag Excellence Alliance

Location
Minnipa Agricultural Centre, paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Paddock history
2018: Medic pasture
2017: Scepter wheat
2016: Medic pasture
Soil type
Red sandy loam
Plot size
12 m x 1.5 m x 4 reps

Key messages

- **Crop intensive farming systems are running down soil carbon.**
- **Mixed species cover cropping offers a new approach that may address the issue.**
- **Local guidelines need to be developed so that farmers can make informed decisions about incorporating cover crops into their farming systems.**

Why do the project?

Crop intensive farming systems are running down soil carbon, requiring increased inputs to maintain or increase yield without necessarily improving profitability. Mixed species cover cropping offers a new approach to reverse this trend in the Australian context. It is a key component of some farming systems overseas but is yet to be adopted widely in southern Australia. In the context of this project, mixed species cover crops refers to a diverse mix of plant species grown together but often outside the main growing season to build fertile and resilient soils.

Potential benefits of cover crops include improving soil organic carbon, structure and health, while decreasing weed and disease levels for following crops, but these must be balanced against the cost of growing the cover crop and the water and nutrients it will use. Many potential cover crop options exist and while growers are beginning to investigate these, local guidelines are yet to be developed to inform decisions.

A trial at Minnipa is investigating mixed species cover crops grown over winter. The principle behind growing a mixture of species rather than a monoculture is that it mimics naturally occurring diverse ecosystems. Different root systems host different microorganisms, fungi and soil biota that improve the dynamic properties of soil leading to healthier soil that has higher infiltration rates for water and are better able to retain that moisture. This retained water can potentially be used for the following cereal crops. Different root systems also inhabit different parts of the soil profile and therefore access water and nutrients more completely, so no single section is severely depleted. Organic matter is distributed more evenly throughout the soil profile and more carbon is available to soil organisms. The qualities of two or more different species may also improve the overall productivity. Legumes fix nitrogen that can be used by other plants. Tall plants provide shade for emerging seedlings, reducing their exposure to water and temperature stress. Climbing plants such as peas will often use the taller plants as a trellis. The fibrous root systems of many cereals and grasses bind the soil to protect it from wind erosion, particularly under dry conditions. Brassicas can function as biofumigants, suppressing soil pests, especially root pathogens and plant-parasitic nematodes. Leaving residue on the soil surface lowers the soil temperature, reducing soil water loss through evaporation and providing protection from erosion. A diverse cover crop also offers a more balanced diet to livestock.

How was it done?

Ten species were selected as potential components of a winter cover crop based on their suitability for the local rainfall and soil type, seed availability, ability to be included in mixes and existing district practices. The species were also selected to include a range of legumes, brassicas, cereals and grasses. A mix including all ten species in equal amounts, four other mixes composed of subsets of these species and each species as a monoculture were sown. As a control there was a fallow treatment where the plots were left unsown (Table 1). The trial was sown into moist soil on 31 May 2019 with 60 kg/ha DAP.

Table 1. Winter cover crop species sown at Minnipa on 31 May 2019.

Cover Crop Species	Sowing Rate
PM-250 Strand medic	7.5 kg/ha
Volga vetch	40 kg/ha
Field peas	100 kg/ha
Mulgara oats	60 kg/ha
Safeguard annual ryegrass	5 kg/ha
Cereal rye	40 kg/ha
Triticale	70 kg/ha
Stingray canola	2 kg/ha
Tillage radish	5 kg/ha
Narbon beans	120 kg/ha
Ten Species Mix	10% of the sowing rate of each species as a monoculture
Control (fallow)	NA
Jake's Party Mix (oats, vetch & canola)	40 kg/ha oats, 20 kg/ha vetch, 1.5 kg/ha canola
Mandy's Mix (oats & medic)	40 kg/ha oats, 7.5 kg/ha medic
Fluff's Mix (canola & field peas)	2.5 kg/ha canola, 30 kg/ha field peas
Fi's Mix (tillage radish, ryegrass, cereal rye, oats, field peas & vetch)	18% of the sowing rate of each species as a monoculture

PM-250 strand medic was included to represent the common district practice of regenerating medic pastures being used in rotation with cereal crops. As a legume species it fixes nitrogen.

Volga vetch is a legume so has the benefit of adding nitrogen to the soil. It can be grown in the lower rainfall areas of southern Australia where no other legume crops perform consistently well. It can also be grazed or cut for hay. Its dense, spreading structure provides shade to the soil.

Field peas are legumes so fix nitrogen. They can be grown in most cropping regions of southern Australia.

Mulgara oats are a hay variety that we had available, which can produce a highly competitive crop canopy that can compete well with weeds when sown early. Oats were included as a treatment to represent a common district practice of sowing oats to provide grazing and ground cover, with the option of later cutting for hay or harvesting the grain.

Safeguard annual ryegrass can mature rapidly in drought conditions, producing abundant winter forage in marginal areas. It has no herbicide resistance and is resistant to annual ryegrass toxicity.

Cereal rye is suited to infertile, sandy soils and is drought resistant. It has the ability to produce a soil-binding cover on land where other cereals grow poorly.

Triticale can make good use of land that is marginal for other cereals and is adapted to alkaline soils. It has an aggressive, fibrous root system that binds light soils reducing erosion and builds soil organic matter. It also provides excellent residual ground cover and can be grazed.

Stingray canola is a brassica commonly included in crop rotations in low rainfall southern Australia.

Tillage radish is a brassica bred specifically for its large tuberous taproot, which is claimed to reduce soil issues such as compaction. It is drought hardy with the ability to access subsoil moisture and nutrients. It also produces very palatable feed.

Narbon beans (*Vicia narbonensis*) are a legume suited to low rainfall and alkaline soils, with resistance to aphids. They can be grazed, cut for hay or used for green manure.

Jake's Party Mix was included because this same mix was sown on the MAC Farm by Jake Hull in 2019 to provide grazing for the MAC sheep.

Mandy's Mix was included because oats and medic produced the most dry matter of the mixes included in Amanda Cook's 2018 trial 'Maximising dry matter production for grazing systems on alkaline soils'.

Fluff's Mix was suggested by Ian Richter as canola and field pea had the greatest benefit to subsequent cereal crops in Suzanne Holbery and Roy Latta's 2011-2014 'Crop Sequences' trial.

Fi's Mix was selected to represent a balance of species from cereals/grasses, legumes and brassicas. Retrospectively I would have replaced Safeguard annual ryegrass with canola to provide an extra brassica species.

Table 2. Dry matter measurements at Minnipa 13 September 2019.

Cover crop species	Shoot dry matter (t/ha)
PM-250 Strand medic	0.48 de
Volga vetch	0.89 d
Field peas	1.15 cd
Mulgara oats	2.94 a
Safeguard annual ryegrass	1.24 cd
Cereal rye	2.44 ab
Triticale	2.52 ab
Stingray canola	1.50 cd
Tillage radish	1.41 cd
Narbon beans	1.14 cd
Control (fallow)	NA
Ten Species Mix	2.24 b
Jake's Party Mix (oats, vetch & canola)	2.42 ab
Mandy's Mix (oats & medic)	2.40 ab
Fluff's Mix (canola & field peas)	1.57 c
Fi's Mix (tillage radish, ryegrass, cereal rye, oats, field peas & vetch)	2.60 ab
LSD (P=0.05)	*0.62*

What happened?

Plants began to emerge and establish vigorously two weeks post seeding. The performance of PM-250 Strand medic was compromised by being sown too deep and struggled all season with low plant numbers. Dry matter cuts were taken on 13 September 2019 (Table 2) at early grain fill, as a measure of maximum biomass.

Despite triticale and Jake's Party Mix producing the best early vigour, Mulgara oats produced the most dry matter of all treatments by the end of the season; 2.94 t/ha at early grain fill.

Of the mixes, Fi's Mix produced the most dry matter with 2.60 t/ha. As expected the PM-250 Strand medic produced the lowest amount of dry matter with 0.48 t/ha.

The trial was terminated with glyphosate on 2 October 2019 to prevent seed set and further water use.

What does this mean?

Whilst some species were shown to grow more vigorously and/or produce more biomass, this is only one measure of the effectiveness of cover crops. The most important factor to consider is their benefits to the following crop. Cover crops can improve soil health, nutrient cycling, organic carbon, and soil moisture; decrease weed populations and increase the population of beneficial insects, however these benefits may not be measurable after only one phase.

The trial will be sown to wheat in 2020 to evaluate the impact of each cover crop option on crop performance. The amount of crop residue and ground cover will be assessed prior to seeding, as will soil moisture, organic carbon and chemical fertility.

Acknowledgements

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Thank you to Dot and Reg Brace for donating the triticale seed, and to Gareth and Roanne Scholz for donating the tillage radish and cereal rye seed.

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CSIRO

Government of South Australia

Australian Government

Zinc and Copper Micronutrient Applications on Wheat 2019

Author: Andrew Catford and Matt Foulis
Funded By: South Australian Grain Industry Trust – UNF117
Project Title: Increasing the knowledge and understanding of Micronutrient deficiency in the upper north region. ***Project Duration:*** *2017 - 2020*
Project Delivery Organisations: *UNFS (Project #224), Northern Ag*
Location: *Booleroo Centre*

Key Points:

- Zinc & Copper as oxides and chelates were used
- Copper & Zinc essential for plant growth and pollination
- No significant difference found between any treatments. This may be a result of dry year and limited growth, or other limiting factors impacting plant growth and yield.

Methodology:

At a site located 6km east of Booleroo centre, Sceptre wheat plots were applied with varying rates and formulations of zinc and copper (**Table 1)**. The trial aims to assess yield and/or quality benefits from the application of these foliar products. Site selection was made using historical soil test data, deliberately selecting a location known to test low for both Zinc (Zn) and Copper (Cu). Copper is known for its importance in producing chlorophyll and pollen, so both an early and a late application were applied to the site. Zinc on the other hand is known for its importance in seedling vigour, so an early application only was applied.

The trial was a randomised block design with 8 treatments plus a control across three reps. The trial plan is shown in Table 1 below. The trial was placed over the farmer sown crop and marked out in crop post crop emergence so that an even crop establishment site could be achieved.

Table 1: Treatments applied:

Number	Product	Strength (g/L)	Rate (L/ha)	Timing
1	Wilchem Sentinal Zinc Chelate	60	2.5	GS 14
2	Wilchem Sentinal Zinc Chelate	60	1	GS14
3	Wilchem Sentinal Copper Chelate	60	2.5	GS14
4	Wilchem Sentinal Copper Chelate	60	1	GS14
5	Icon Zinc Oxide	1500	0.1	GS14
6	Icon Zinc Oxide	1500	0.5	GS14
7	Icon Copper Oxide	1070	0.1	GS14
8	Wilchem Sentinal Copper Chelate	60	2.5	GS40
9	Control (Untreated)			

Zinc and copper chelate applied at 1L/ha and zinc and copper oxides applied at 100ml/ha were to be representative of common field rates used in the district. The zinc and copper chelate applied at 2.5L/ha were to more closely match the grams active applied using the icon and copper oxides at the 100ml/ha rate. This was to give a fair comparison on whether formulation type had an impact on plant response. Zinc oxide was also applied at an increased rate of 500ml/ha to try an establish if a more pronounced response would be achievable at a relatively extreme rate. Copper chelate was also applied at both GS14 and GS40. The later application has become more common among growers in recent years, to coincide with late fungicide timings. All other treatments were applied at GS14 as is common district practice.

Table 2: Relevant timings at trial site:

	Assessment/Application	Date
Grower Pre-Emergent	Sakura 118kg/ha applied using growers boomspray	8/5/19
Grower Sowing	Sceptre wheat sown at 78kg/ha with 90kg/ha of 28:13 using growers seeding unit	8/5/19
Grower Post-Emergent	nil	nil
GS14 Treatments	Hand Boom Application	19/6/2019
GS40 Treatments	Hand Boom Application	15/8/2019
Tissue Test	1 Sample Per Rep	20/8/2019

The trial sites were randomised complete block design with three replicates. The micronutrients were applied using a hand boom at a water rate of 100L/ha on the 19th of June and the late copper applied on the 15th of August. Tissue tests were conducted on each treatment taking the 10 youngest expanded blades from each plot (30 per treatment) on the 20th of August. The plots were harvested by SARDI at the season's end. Grain was then sent off for micronutrient analysis. Both the harvest data and grain sample data was then analysed for statistical significance using ANOVA at the 5% significance level.

Table 3: Data collected from the trial:

Test Type	Tissue Test	Grain Sample Test	Harvest Data
Factor Analysed	Aluminium mg/kg	Aluminium mg/kg	Test Weight
	Boron mg/kg	Boron mg/kg	Protein
	Calcium %	Calcium %	Moisture
	Chloride %	Chloride %	Wet Gluten
	Cobalt ug/kg	Cobalt ug/kg	Screenings
	Copper mg/kg	Copper mg/kg	Yield
	Iron mg/kg	Iron mg/kg	
	Magnesium %	Magnesium %	
	Manganese mg/kg	Manganese mg/kg	
	Molybdenum ug/kg	Molybdenum ug/kg	
	Nitrate Nitrogen mg/kg	Nitrate Nitrogen mg/kg	
	Nitrogen Total (Dumas) %	Nitrogen Total (Dumas) %	
	Nitrogen/Phosphorus Ratio	Nitrogen/Phosphorus Ratio	
	Nitrogen/Potassium Ratio	Nitrogen/Potassium Ratio	
	Nitrogen/Sulphur Ratio	Nitrogen/Sulphur Ratio	
	Phosphorus %	Phosphorus %	
	Potassium %	Potassium %	
	Sodium %	Sodium %	
	Sulfur %	Sulfur %	
	Zinc mg/kg	Zinc mg/kg	

Results and Discussion

The trial showed no significant increase in copper or zinc levels in the plant tissue tests. There were no trends in the zinc levels assessed across all treatments. Tissue tests showed a trend of all treatments resulting in some increase in copper levels in the plant compared with the control treatment, with the late application of copper chelates showing the greatest increase. Unfortunately, none of this data was significant when analysed.

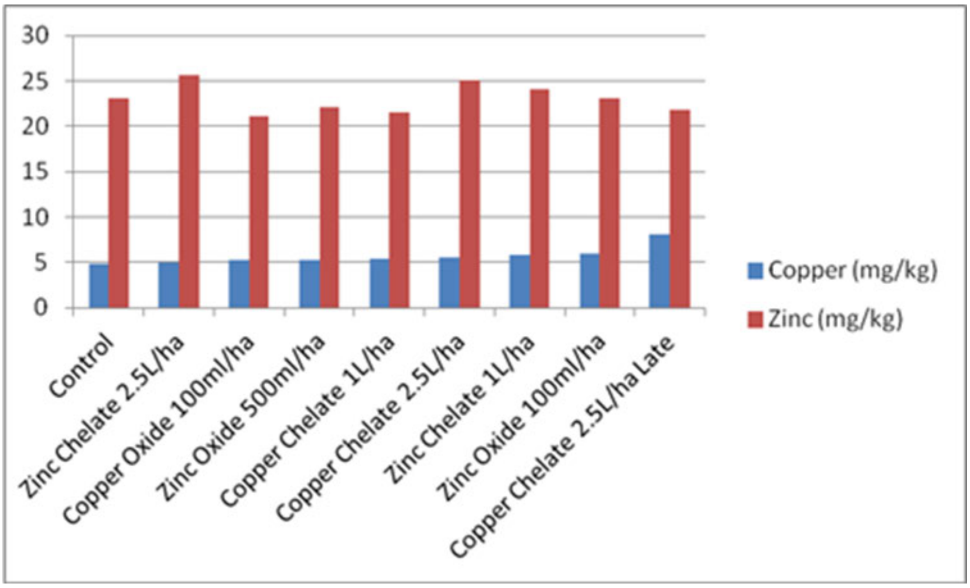


Figure 1: Tissue test results showing zinc and copper levels (mg/kg) for each treatment

All other nutrients tested in the tissue test did not show any relevant trends to the treatments.

The grain sample test data did not show any significant differences for any factor tested between the treatments. There were also no obvious trends to suggest that the treatments would have produced significant difference if replicated out further.

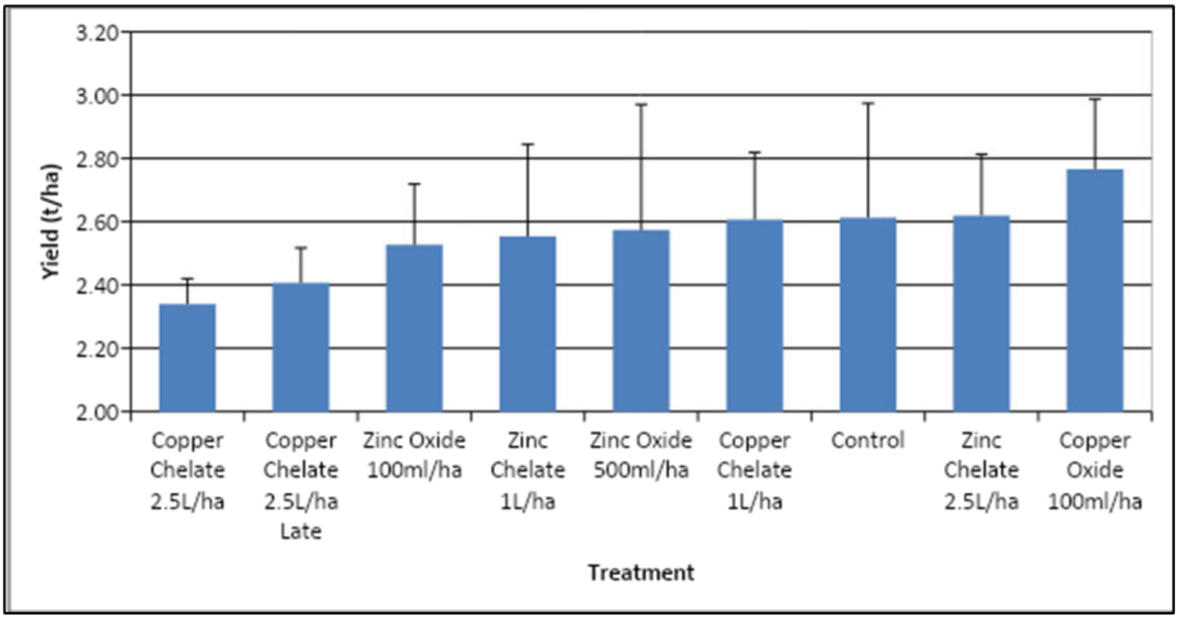


Figure 2. Yield harvest data (t/ha) for each of the treatments. Error bars show standard deviation.

All treatments yielded statistically equal or poorer than the control treatment. This could be due to the plants not displaying clinical deficiency but due to reduced plant biomass sub-clinical micronutrient deficiencies. Zinc and copper are both very important in plant development and growth. With normal growing conditions and an average winter rainfall the results could be expected to be amplified with a greater plant biomass resulting in a larger micronutrient requirement. The grain quality data collected for the trial showed no significant differences between any of the treatments for any factor tested.

Weather Station Data – Booleroo UNFS 863701

2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
AVG (°C)	29.7	26.2	23.3	18.2	11.7	8.1	8.9	8.3	13.5	19	20.2	27.6	17.8
MIN (°C)	7.9	6.5	5.4	1.2	0.5	-3.8	-2.2	-3.5	-2.5	-0.5	0.6	4	-3.8
MAX (°C)	59.3	55.6	52.3	43.3	31.3	25.2	22.5	24.6	33.9	43.8	48.7	59.4	59.4
SUM (mm)	5.8	6.8	3.8	4.8	31.8	44.5	12	20.5	10.5	0.8	9	8.5	158.5
AVG (% RH)	38.2	43.4	49.1	50.1	69.7	72.9	76.4	-	-	-	-	-	56.8
MIN (% RH)	7.7	12.7	13.7	11.3	28.3	33.2	24.9	-	-	-	-	-	7.7
MAX (% RH)	94	90.5	96.9	95.7	98.6	99.2	99.3	-	-	-	-	-	99.3
Weather Station- UNFS Booleroo 863071 - installed by Agbyte													
Data for 2019 Calender year.													

For full soil moisture profile refer to report in this book called Weather Station Report – Booleroo Centre

See appendix for full tissue, grain and harvest data.

Summary

There was no significant response to any applied treatment at this site. This included formulation type, rate of product and timing of the copper chelate application. Unfortunately, it was an extremely dry season with terminal spring conditions significantly reducing crop yields. This is the second trial to have netted similar results in consecutive seasons in this region, both being exposed to terminal spring conditions (2018 and 2019). Further trial work in this space could be worthwhile investigating the same treatments with the addition of a Molybdenum treatment. Molybdenum is important in the plant for nitrogen pathways and could assist with increased nitrogen use efficiency. During an average season, it is expected to show increased results with a greater plant biomass and more rapid plant growth requiring a greater amount of micronutrients.

Acknowledgements:

- Matt Foulis and Andrew Catford – Northern Ag for managing the trial site and data collection
- JP Carey for the paddock for the trial.
- South Australian Grains Industry Trust for funding the trial.
- Thanks to Sonic Essentials and Wilchem for providing the product used in the treatments.

Micronutrients trial – Booleroo Centre Appendix

Table 1. Average harvest data from treatments.

	Average	Test Weight (kg/hl)	Protein (%)	Moisture (%)	Wet Gluten (%)	Screenings (%)	Yield (t/ha)	Grade
1	**Zinc Chelate 2.5L/ha**	81.20	11.97	9.03	30.40	5.43	2.62	AUH2
2	**Zinc Chelate 1L/ha**	81.07	11.97	9.00	30.03	6.00	2.55	AUH2
3	**Copper Chelate 2.5L/ha**	80.13	12.90	9.07	33.10	5.73	2.34	AUH2
4	**Copper Chelate 1L/ha**	81.33	11.50	9.00	28.50	5.57	2.61	AUH2
5	**Zinc Oxide 100ml/ha**	81.07	11.40	9.03	28.37	6.07	2.53	AGP1
6	**Zinc Oxide 500ml/ha**	80.73	12.23	8.83	31.60	5.43	2.57	AUH2
7	**Copper Chelate 2.5L/ha Late**	80.73	11.90	9.07	29.60	5.47	2.41	AUH2
8	**Copper Oxide 100ml/ha**	81.67	10.37	9.07	25.03	6.23	2.77	AGP1
9	**Control**	80.93	10.63	9.07	25.67	6.07	2.61	AGP1
	Average	80.99	11.65	9.02	29.14	5.78	2.56	AUH2

Table 2. Average grain sample data from the treatments.

	Aluminium mg/kg	Boron mg/kg	Calcium %	Chloride %	Cobalt ug/kg
Zinc Chelate 2.5L/ha	9.43	1.20	0.0320	0.0803	60.67
Zinc Chelate 1L/ha	10.06	1.47	0.0310	0.0833	47.00
Copper Chelate 2.5L/ha	11.41	1.45	0.0370	0.0707	25.33
Copper Chelate 1L/ha	8.71	1.24	0.0297	0.0877	31.33
Zinc Oxide 100ml/ha	11.06	1.41	0.0333	0.0997	31.67
Zinc Oxide 500ml/ha	9.52	1.45	0.0317	0.1120	27.67
Copper Chelate 2.5L/ha Late	10.16	1.32	0.0353	0.0850	25.00
Copper Oxide 100ml/ha	8.71	1.24	0.0297	0.0877	31.33
Control	9.85	1.32	0.0313	0.0940	21.33

	Copper mg/kg	Iron mg/kg	Magnesium %	Manganese mg/kg	Molybdenum ug/kg
Zinc Chelate 2.5L/ha	3.3967	40.40	0.1113	41.85	93.67
Zinc Chelate 1L/ha	3.8000	39.63	0.1130	41.73	102.67
Copper Chelate 2.5L/ha	3.6500	45.23	0.1147	38.60	81.33
Copper Chelate 1L/ha	3.3100	34.90	0.1097	39.19	117.33
Zinc Oxide 100ml/ha	3.7833	40.63	0.1133	39.95	134.33
Zinc Oxide 500ml/ha	3.5367	39.40	0.1120	40.49	92.33
Copper Chelate 2.5L/ha Late	3.7133	40.37	0.1127	39.23	82.00
Copper Oxide 100ml/ha	3.3100	34.90	0.1097	39.19	117.33
Control	3.7100	37.83	0.1140	39.98	153.33

	Nitrate Nitrogen mg/kg	Nitrogen Total (Dumas) %	Nitrogen/Phosphorus Ratio	Nitrogen/Potassium Ratio	Nitrogen/Sulphur Ratio
Zinc Chelate 2.5L/ha	2.3333	2.27	9.23	5.87	16.73
Zinc Chelate 1L/ha	4.0000	2.15	8.63	5.57	16.07
Copper Chelate 2.5L/ha	3.6667	2.48	8.47	5.57	17.43
Copper Chelate 1L/ha	5.3333	1.95	9.00	5.43	15.80
Zinc Oxide 100ml/ha	4.6667	2.22	8.93	5.57	16.63
Zinc Oxide 500ml/ha	3.6667	2.32	9.53	5.80	16.80
Copper Chelate 2.5L/ha Late	7.0000	2.23	8.10	5.20	16.87
Copper Oxide 100ml/ha	5.3333	1.95	9.00	5.43	15.80
Control	7.0000	2.02	8.57	5.30	15.80
	Phosphorus %	Potassium %	Sodium %	Sulfur %	Zinc mg/kg
Zinc Chelate 2.5L/ha	0.2457	0.3870	0.0014	0.1353	21.54
Zinc Chelate 1L/ha	0.2490	0.3877	0.0021	0.1333	20.80
Copper Chelate 2.5L/ha	0.2943	0.4457	0.0013	0.1423	25.59
Copper Chelate 1L/ha	0.2177	0.3607	0.0030	0.1237	16.26
Zinc Oxide 100ml/ha	0.2523	0.4010	0.0022	0.1330	21.17
Zinc Oxide 500ml/ha	0.2467	0.4010	0.0020	0.1377	21.86
Copper Chelate 2.5L/ha Late	0.2767	0.4293	0.0014	0.1327	21.99
Copper Oxide 100ml/ha	0.2177	0.3607	0.0030	0.1237	16.26
Control	0.2360	0.3797	0.0030	0.1273	17.49

<u>Table 3</u> Average grain sample data from the treatments.

	Aluminium mg/kg	Boron mg/kg	Calcium %	Chloride %	Cobalt ug/kg
Zinc Chelate 2.5L/ha	6.93	5.89	0.149	0.35	10
Zinc Chelate 1L/ha	5.9	6.73	0.154	0.359	10
Copper Chelate 2.5L/ha	8.51	5.7	0.175	0.39	10
Copper Chelate 1L/ha	8.95	7.32	0.19	0.521	10
Zinc Oxide 100ml/ha	8	7.43	0.17	0.413	10
Zinc Oxide 500ml/ha	8.15	6.84	0.183	0.498	10
Copper Chelate 2.5L/ha Late	12.07	6.51	0.209	0.631	10
Copper Oxide 100ml/ha	8.29	8.04	0.187	0.457	10
Control	8.27	6.66	0.154	0.32	10
	Copper mg/kg	Iron mg/kg	Magnesium %	Manganese mg/kg	Molybdenum ug/kg
Zinc Chelate 2.5L/ha	5.04	47.2	0.115	53.3	10
Zinc Chelate 1L/ha	5.9	45.6	0.123	49.91	130
Copper Chelate 2.5L/ha	5.5	51.2	0.115	43.82	10
Copper Chelate 1L/ha	5.36	54.1	0.122	67.79	10

Zinc Oxide 100ml/ha	5.98	53	0.123	47.25	10
Zinc Oxide 500ml/ha	5.33	52.9	0.116	53.25	10
Copper Chelate 2.5L/ha Late	8.14	59.5	0.113	60.86	100
Copper Oxide 100ml/ha	5.21	53.8	0.128	56.43	10
Control	4.9	48	0.124	46.37	10
	Nitrate Nitrogen mg/kg	Nitrogen Total (Dumas) %	Nitrogen/ Phosphorus Ratio	Nitrogen/ Potassium Ratio	Nitrogen/Sulphur Ratio
Zinc Chelate 2.5L/ha	3	3.096	10.4	1.5	13.7
Zinc Chelate 1L/ha	1	3.118	10.6	1.4	13.7
Copper Chelate 2.5L/ha	3	3.296	10.4	1.4	14.1
Copper Chelate 1L/ha	2	3.364	12.2	1.5	13.8
Zinc Oxide 100ml/ha	2	3.287	11.4	1.5	14.5
Zinc Oxide 500ml/ha	1	3.394	12.5	1.5	14.4
Copper Chelate 2.5L/ha Late	2	3.54	11.9	1.6	14.4
Copper Oxide 100ml/ha	1	3.418	12.6	1.6	14.1
Control	2	2.948	10.1	1.4	13.5
	Phosphorus %	Potassium %	Sodium %	Sulfur %	Zinc mg/kg
Zinc Chelate 2.5L/ha	0.297	2.078	0.0093	0.226	25.65
Zinc Chelate 1L/ha	0.295	2.204	0.0102	0.228	24.06
Copper Chelate 2.5L/ha	0.317	2.3	0.0105	0.234	25.02
Copper Chelate 1L/ha	0.276	2.227	0.0126	0.244	21.57
Zinc Oxide 100ml/ha	0.288	2.174	0.0127	0.226	23.14
Zinc Oxide 500ml/ha	0.272	2.224	0.0123	0.235	22.03
Copper Chelate 2.5L/ha Late	0.298	2.277	0.0129	0.246	21.87
Copper Oxide 100ml/ha	0.271	2.194	0.0134	0.242	21.07
Control	0.291	2.093	0.0109	0.218	23.1

2019 Member's Expo - A full house

Figure 1. Soil test results from the trial site

SoilMate Lab Result Status Report

Date Printed :13-Mar-2020 08:37:25 AM

Trading Name	JPG CAREY
Farm	WHITE CLIFFS
Paddock	BACK
Contact	JP CAREY

Sample Barcode 070182026 **Sample Date** 01-Mar-2020

Adviser Name Andrew Catford **Analysis Date** 12-Mar-2020

Evaluation Table Wheat & Triticale Raingrown, Southern Australia, 2.5 t/ha, PBI (0-70)

Nutrient	Result	Low	Marginal	Sufficient	High	Excess	Sufficiency Range
pH (1:5 H2O)	6.4						6.0 - 8.5
pH (1:5 CaCl2)	5.6						5.2 - 7.7
EC (1:5 H2O) dS/m	0.12						0.00 - 0.80
EC (se) (dS/m)	1.3						0.0 - 6.0
EC (se) (dS/m) (Cladj)	0.9						0.0 - 6.0
Chloride (1:5 H2O) mg/kg	56						0 - 250
Organic carbon (Walkley Black) %	0.66						1.00 - 2.00
Nitrate nitrogen (KCl) mg/kg	16						10 - 50
Ammonium nitrogen (KCl) mg/kg	2						0 - 5
Phosphorus (Colwell) mg/kg	28						25 - 100
Phosphorus DGT ug/L	40						60 - 100
Phosphorus Buffer Index (Colwell) (PBIc)	19						15 - 280
Phosphorus Environmental Risk Index	1.5						0.00 - 0.65
Potassium (Amm-Acet.) cmol+/kg	0.75						0.20 - 10.00
Potassium % of CEC	11.8						1.0 - 10.0
Sodium:Potassium Ratio	0.4						0.0 - 5.0
Sulfate-S (KCl40) mg/kg	9.8						3.0 - 8.0
Calcium (Amm-Acet) cmol+/kg	3.8						1.0 - 100.0
Calcium % of CEC	59.9						55.0 - 90.0
Magnesium (Amm-Acet.) cmol+/kg	1.5						0.5 - 200.0
Magnesium % cations	23.7						0.0 - 25.0
Sodium (Amm-Acet.) cmol+/kg	0.29						0.00 - 3.00
Exch. sodium %	4.6						0.0 - 6.0
Electrochemical Stability Index	0.026						0.050 - 10.000
Dispersion Index (Loveday/Pyle)	4						0 - 6
Aluminium (KCl) cmol+/kg	0.10						0.00 - 0.50
eCEC cmol+/kg	6.3						5.0 - 100.0
Copper (DTPA) mg/kg	0.59						1.00 - 5.00
Zinc (DTPA) mg/kg	0.49						0.80 - 5.00
Manganese (DTPA) mg/kg	18						6.0 - 50.0
Boron (hot CaCl2) (mg/kg)	1						0.5 - 8.0

UNFS Micronutrients Trial
Zinc and Copper
Micronutrient Applications on Wheat
Mambray Creek 2019

Author: Jonathon Mudge
Funded By: South Australian Grains Industry Trust – (UNF117)
Project Title: Increasing the knowledge and understanding of micronutrient deficiency in the Upper North
Project Duration: 2017 - 2020
Project Delivery Organisations: Upper North Farming Systems, YP AG

Summary:

At Mambray Creek in 2019, Scepter wheat was applied with varying rates and formulations of both Zinc and Copper at several different timings. The aim being to understand whether applying additional micronutrients to the crop would provide a benefit to the crop throughout the course of the season.

Two formulations of Zinc, Zinc Chelate and Zinc Oxide, were applied at different rates. The high rate of chelate was applied at the same active loading of the low rate of Oxide to understand whether formulation type would be a factor. The same formulation types of Copper were also assessed to understand whether this played a role in increased or decreased production.

Copper was also applied at two different application timings in order to determine if this timing of application showed any significant differences in growth and yield.

Methodology:
The Trial was a randomised block design with 9 treatments across 3 growth stages. There were 3 replicates with plots of 10m x 2m.

Treatment List:
Table 1: Treatments and the application timing.

Number	Treatment	Rate	Timing
1	Untreated		
2	Wilchem Signature Zinc Chelate	1L/ha = 80gai	GS 14
3	Wilchem Signature Zinc Chelate	3L/ha = 240gai	GS 14
4	Ezyflo Zinc Oxide	370ml/ha = 240gai	GS 14
5	Ezyflo Zinc Oxide	740ml/ha = 480gai	GS 14
6	Wilchem Signature Copper Chelate	500ml/ha = 25gai	GS 23
7	Wilchem Signature Copper Chelate	1L/ha = 50gai	GS 23
8	Wilchem Signature Copper Chelate	1L/ha = 50gai	GS 39
9	Copper Oxide	100ml/ha = 50gai	GS 39

Table 2: Chronology of events:

Application Details	Date
Pre-emergent: 1.5L/ha Trifluralin	2nd May
Scepter wheat sown @ 55kg/ha + 80kg/ha DAP	2nd May
Post-emergent: 200ml/ha Diuron + 330ml/ha MCPA 750 + 50ml/ha Lontrel Advanced	25th May
Z14 Zinc Treatments	25th May
Z23 Copper Treatments	14th June
100L/ha UAN	14th June
Tissue Tests (treatments 1-5)	25th June
Z39 Copper Treatments	2nd August
Harvest	15th November

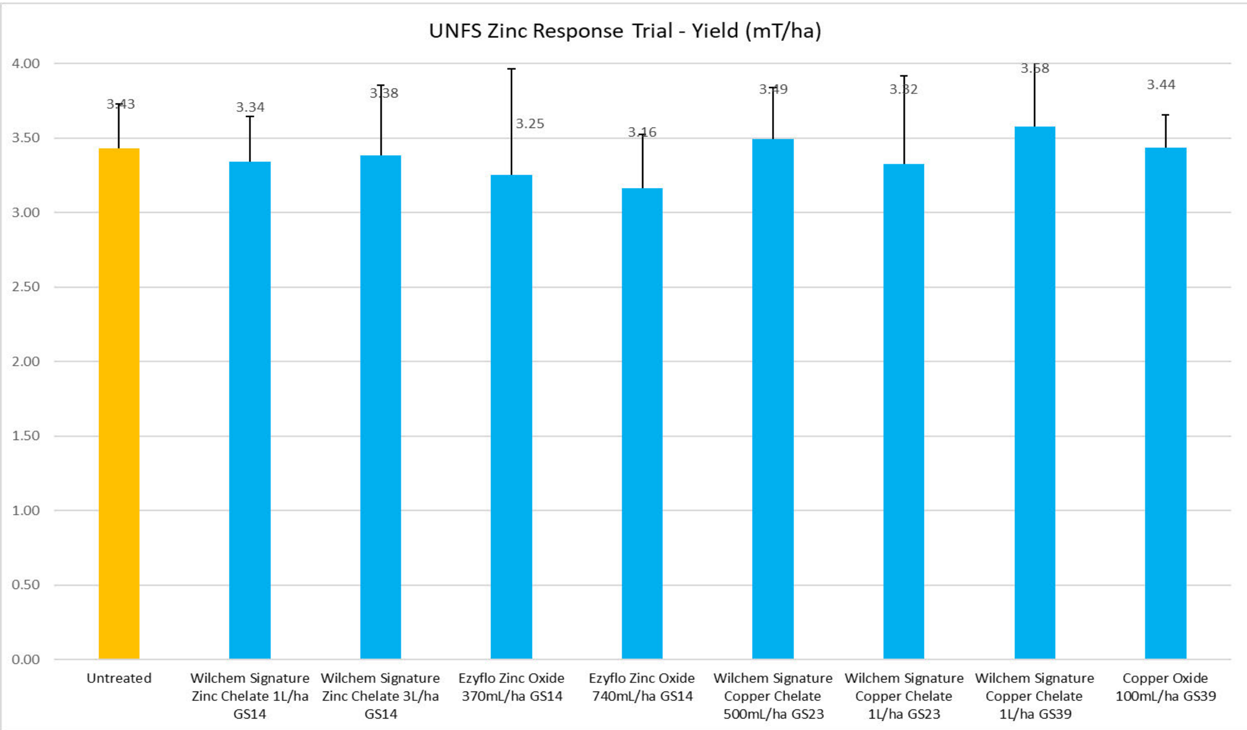


Image 1: Zinc response yield results (mT/ha). No significant difference between treatments.

Table 3: Tissue Test Results - Tissue tests were taken on each plot on 25th June 2019 for the Zinc treatments.

The Copper Treatments did not have tissue tests taken.

Treatment	NO_3	N	P	K	Calcium	Mg	Sodium	Sulfur	
	mg/kg	%	%	%	%	%	%	%	
Untreated	390	5.18	0.44	3.58	0.22	0.15	0.036	0.42	
Zinc Chelate @ 1L/ha	448	5.21	0.43	3.61	0.23	0.15	0.076	0.43	
Zinc Chelate @ 3L/ha	271	5.12	0.4	3.6	0.25	0.14	0.048	0.4	
Zinc Oxide @ 370ml/ha	357	5.23	0.41	3.68	0.23	0.16	0.048	0.42	
Zinc Oxide @ 740ml/ha	254	5.09	0.43	3.6	0.23	0.14	0.043	0.4	
Copper Chelate @ 500ml/ha	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Copper Chelate @ 1L/ha Early	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Copper Chelate @ 1L/ha Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Copper Oxide @ 100ml/ha	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

	Boron	Copper	Zinc	Mn	Iron	Al	Cobalt	Mo	Chloride
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%
Untreated	8.5	7.8	24	66	130	34	<0.16	0.76	1
Zinc Chelate @ 1L/ha	8.4	7.6	23	66	110	20	<0.16	0.89	1
Zinc Chelate @ 3L/ha	7.7	7.4	24	67	98	19	<0.16	1	1.1
Zinc Oxide @ 370ml/ha	8.7	7.6	23	65	95	19	<0.16	1	1
Zinc Oxide @ 740ml/ha	8.1	7.4	23	63	92	16	<0.16	0.88	0.99
Copper Chelate @ 500ml/ha	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper Chelate @ 1L/ha Early	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper Chelate @ 1L/ha Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper Oxide @ 100ml/ha	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Discussion:

Tissue tests taken on the 25th of June from the untreated as well as the early Zinc application treatments showed no clear trends in nutrient levels in the plant with Zinc levels remaining consistent throughout the 5 treatments tested. At the time the tissue tests were taken no visual differences were apparent.

First inspection and first treatments sprayed(25th May)

There was no apparent visual differences throughout the season between the Zinc or the Copper treatments.

Yield was assessed with the trial harvested on the 15th November. As shown in Image 1, there was no significant differences between any of the yields nor were there any apparent trends in the yield data. The copper treatments appeared on average to result in a higher yield than both the Zinc treatments and the untreated however with a high variance across the trial it's hard to draw any meaningful conclusions from this.

The trial site was selected after soil tests taken showed up to be on the low end of the adequate Zinc range (see appendix). However given the lack of response to a Zinc application in this case, it suggests that the level of Zinc in the soil may have to be bridging on very low/deficient before any meaningful response is shown.

Untreated on 18th August

High Rate Zinc Oxide on 18th August

Conclusion:

After no response was found from the application of micronutrients in this trial, it suggests that only select paddocks or scenarios will result in a benefit from such application. Benefits are more likely to be seen when soil test results are at very low or deficient levels or even more so when tissue test levels show up as deficient.

Appendix 1: Soil Test Result:

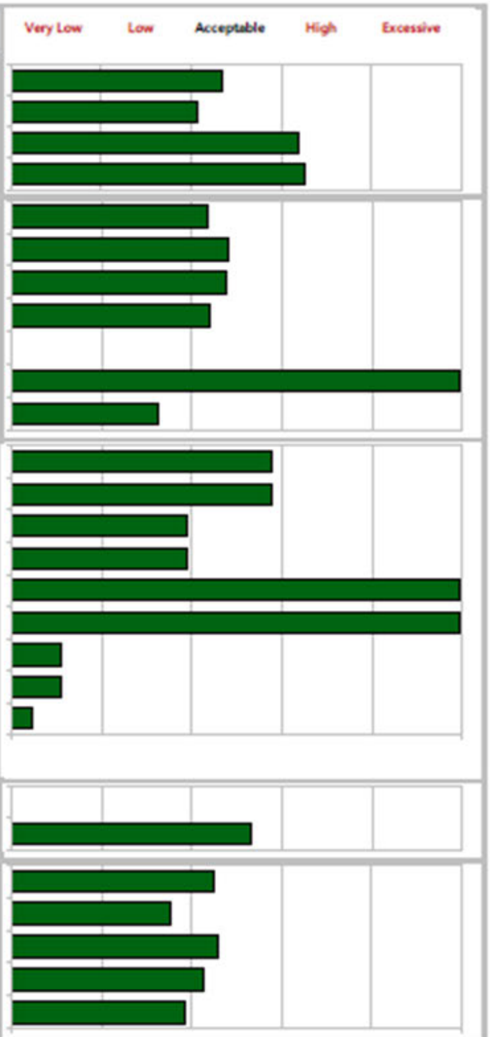
CS1 Complete Soil Analysis

Apal

Submission 23730

Customer: LJ Mudge & Sons
Sample Name: Sandhill 0-10
Barcode: 110043188
Agent: YP AG
Crop: Wheat
Date: 14-Feb-19

		Unit	Desired Level	Level Found
	ECEC	c.mol/kg	5 - 25	10.7
	Organic Carbon (W&B)	%	>0.7	0.68
	pH 1:5 (Water)		6.0 - 7.0	7.64
	pH 1:5 (CaCl2)		5.5 - 6.5	7.27
Exchangeable N-P-K-S	Nitrate - N	ppm	10 - 50	15.0
	Ammonium - N	ppm	1 - 5	3.2
	Colwell Phosphorus	ppm	25 - 35	30
	PBI + ColP		<100	30
	DGT-P	µg/L	-	NR
	Colwell K	ppm	50 - 80	470
	KCl Sulfur (S)	ppm	10 - 20	7.7
Exchangeable cations	Calcium (Ca)	ppm	1000 - 1100	1670
		c.mol/kg		8.33
	Magnesium (Mg)	ppm	175 - 200	142
		c.mol/kg		1.17
	Potassium (K)	ppm	> 120	412
		c.mol/kg		1.05
	Sodium (Na)	ppm	< 120	26
		c.mol/kg		0.11
	Exch. Aluminium (Al)	c.mol/kg	< 0.5	0.02
	Exch. Hydrogen	c.mol/kg	-	<0.02
Salt	Chlorides (Cl)	ppm	<180	NR
	Salinity EC 1:5	dS/m	< 0.15	0.20
Trace Elements	Boron (B)	ppm	0.5 - 2.0	0.88
	DTPA Iron (Fe)	ppm	10 - 70	8
	DTPA Manganese (Mn)	ppm	4 - 50	15.0
	DTPA Copper (Cu)	ppm	0.5 - 5.0	0.62
	DTPA Zinc (Zn)	ppm	1.0 - 5.0	0.91
Exchangeable Cation %	Ca:Mg RATIO		2 - 8	7.13
	Calcium	% Ca	60 - 75	78.0
	Magnesium	% Mg	10 - 20	10.9
	Potassium	% K	3 - 8	9.9
	Sodium	% Na	<5	1.0
	Exch. Aluminium	% Al	<5	0.2
	Exch. Hydrogen	% H	>0	0.0



Notes

Site Notes:

Average Annual Rainfall: 325mm

2019 Rainfall: 273.3mm

2019 GSR Rainfall: 240mm

Acknowledgements:

Thanks to Barry and Kristina Mudge for hosting the trial site. This trial was delivered as a contracted partnership between Upper North Farming Systems and YP Ag made possible by funding from the South Australian Grains Industry Trust.

Molybdenum and Zinc Micronutrient Trial on Lentils 2019 – Booleroo Centre

Author: Andrew Catford and Matt Foulis
Funded By: South Australian Grain Industry Trust – UNF117
Project Title: Increasing the knowledge and understanding of Micronutrient deficiency in the upper north region. ***Project Duration:*** *2017 - 2020*
Project Delivery Organisations*: UNFS (Project #224), Northern Ag*
Location*: Booleroo Centre*

Key Points:

- Increased molybdenum levels in tissue tests
- Visual improvements noticed in plants with molybdenum treatments
- Opportunity for further trial work to occur

Methodology:

During the 2019 season, at a site 14km north-east of Booleroo centre, a crop of hurricane lentils was applied with varying rates of Molybdenum and Zinc. Molybdenum is an important part in the pathway of legume crops to fix nitrogen, and anecdotal responses to applied Molybdenum have been observed in this region. Adequate molybdenum levels have shown to have improved rhizobium populations of the root mass of legume crops. The aim of this site was to investigate if there were any yield and/or nutrient benefits to either of these applied trace elements.

The trial was a randomised block design with 3 reps and 5 treatments including the control. The trial was pegged out in the farmer sown paddock after crop emergence so that an evenly established site could be chosen.

Table 1: The applied treatments of Molybdenum and Zinc. Applications were made on 13/9/2019 just prior to flowering.

Number	Product	Strength (g/L)	Rate (mL/ha)
1	Control Untreated		
2	Zinc Oxide	1500	100
3	Molybdenum Chelate	10	150
4	Molybdenum Chelate	10	300
5	Molybdenum Chelate	10	500
	+ Zinc Oxide	1500	200

Results and Discussion

Across all treatments a positive response to the applications was recorded in the Molybdenum levels recorded in the tissue tests. The lentil plants took up the applied Molybdenum and Zinc resulting in an increased Molybdenum concentration in the plant (Fig 1). Visual improvements were observed in plant health and biomass. Molybdenum is important in rhizobium health and should lead to an increase in fixed nitrogen. Rhizobium bacteria need 10 times more molybdenum than the plant requires for healthy growth. Of interest the zinc oxide only treatment also resulted in an increased Molybdenum level in the plant, suggesting low zinc levels may affect the ability of the plant to access soil available Molybdenum and therefore inhibit nodulation.

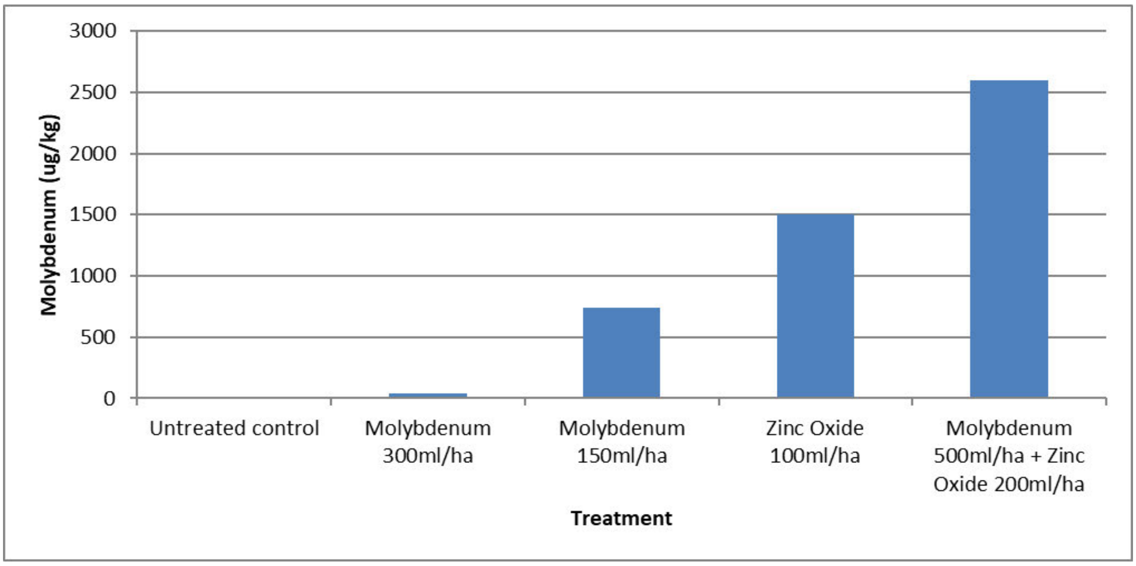


Figure 1: Tissue test results showing Molybdenum (ug/kg) across all treatments

Zinc is important in new cell growth in the plant and assists in allowing stronger root growth. The tissue test zinc levels (Figure 2) have shown that although the zinc only application resulted in greater uptake of Molybdenum by the plant the same is not true in reverse. Higher levels of available Molybdenum did not result in an increase in zinc levels in the plant tissue unless higher levels of zinc were also made available to the plant. The tissue tests also show a continued increase of both Molybdenum and Zinc at the levels applied (rate response) so may still be being applied below the plant required levels.

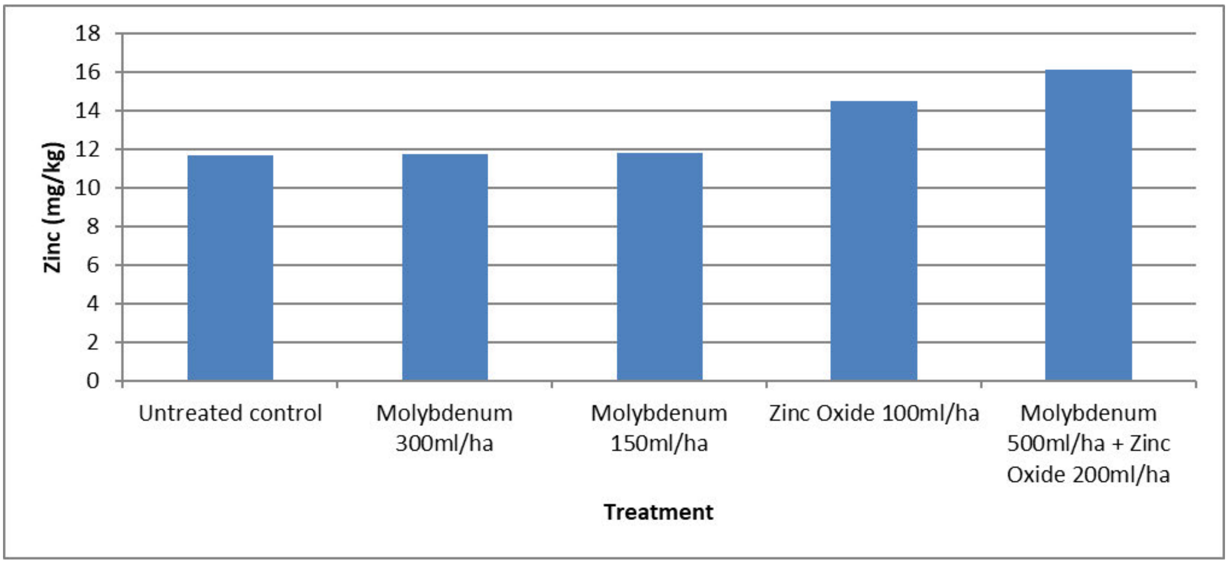


Figure 2: Tissue test results showing zinc (mg/kg) across all treatments

See appendix 1 for full tissue data

The tissue test data was analysed through an annova table and didn't exhibit any statistical differences in the treatments. The trial was due to be harvested to record and analyse grain yield but the trial was droughted and harvest was not achievable.

Summary

Tissue tests of both molybdenum and zinc showed encouraging trends. Unfortunately, the trial site was unable to be harvested due to drought conditions. It would be well worth repeating the trial again in hope of achieving a harvestable site, and analysing yield and quality data in lentils. Further investigation into the carry over nitrogen from rhizobium fixation into a following cereal crop could have benefits and analysed by NDVI, this could provide valuable future trial work.

Acknowledgements:

- Matt Foulis and Andrew Catford – Northern Ag for managing the trial site and data collection
- Joe Koch for the paddock for the lentil trial
- South Australian Grains Industry Trust for funding the trial
- Thanks to Sonic Essentials and Wilchem for providing the product used in the trial

Images: Ladies on the Land Workshops in 2019 - Application of Ag Tech in field.

Appendix 1

	Aluminium mg/kg	Boron mg/kg	Calcium %	Chloride %	Cobalt ug/kg	Copper mg/kg	Iron mg/kg	Magnesium %	Manganese mg/kg	Molybdenum ug/kg
Treatment	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result
Molybdenum 150ml/ha	220.14	17.4	1.233	0.385	10	6.34	209.1	0.279	67.59	740
Molybdenum 300ml/ha	237.25	17.93	1.267	0.412	10	6.28	214.7	0.3	73.82	1500
Zinc Oxide 100ml/ha	242.92	19.4	1.399	0.303	10	6.79	226.4	0.296	78.8	36
Molybdenum 500ml/ha + Zinc 200ml/ha	187.06	17	1.185	0.423	17	6.02	184.9	0.273	66.65	2600
Untreated control	205.34	19.27	1.292	0.275	17	6.25	204	0.284	74.81	10
[redacted]	Nitrate Nitrogen mg/kg	Nitrogen Total (Dumas) %	Nitrogen/ Phosphorus Ratio	Nitrogen/ Potassium Ratio	Nitrogen/Sulphur Ratio	Phosphorus %	Potassium %	Sodium %	Sulfur %	Zinc mg/kg
Treatment	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result
Molybdenum 150ml/ha	2	2.969	11.8	1.8	19.7	0.251	1.656	0.0257	0.151	11.81
Molybdenum 300ml/ha	2	2.798	10.6	1.6	18.8	0.263	1.738	0.0373	0.149	11.72
Zinc Oxide 100ml/ha	0	3.303	11.5	2.2	19.5	0.287	1.528	0.0298	0.169	16.1
Molybdenum 500ml/ha + Zinc 200ml/ha	1	2.879	11.5	1.7	20.3	0.25	1.67	0.0609	0.142	11.69
Untreated control	2	3.171	11.5	2.2	20.5	0.275	1.471	0.0225	0.155	14.48

Calibration of the commercial soil test for P on a red calcareous loam

Sjaan Davey[1], Nigel Wilhelm[2] and Ian Richter[3]
[1]SARDI, Struan Research Centre, Naracoorte; [2]SARDI, Waite Campus; [3]SARDI, Minnipa Agricultural Centre

Location
Minnipa
Minnipa Ag Bureau
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 235 mm
2019 GSR: 205 mm
Yield
Potential: 2.1 t/ha (W), 1.3 t/ha (C)
Actual: 1.7 t/ha (W), 0.25 t/ha (C)
Paddock history
2018: Wheat before canola, canola before wheat trial
2017: Pasture
2016: Pasture
2015: Pasture
Soil type
Red sandy clay loam
Soil test
$pH_{(H20)}$ 8.4, PBI 79, K 523 mg/kg
Plot size
20 m x 2 m x 4 reps x 25.5 cm row spacing
Trial design
Completely randomised design, 2 bays deep x 44 plots long x crop type (wheat or canola)
Yield limiting factors
Low rainfall, frost

Key messages

- **With low rainfall and poor growth at many sites, crops required little P to maximise grain yield.**
- **On a red sandy clay loam at Minnipa, wheat only needed a Colwell P value of 10-15 mg/kg to achieve maximum grain yield without P fertiliser.**
- **Canola appears to have a lower critical P level than wheat.**

Why do the trial?

Soil testing for N, P, K and S is a key strategy for monitoring soil fertility of cropping soils as well as for refining fertiliser application strategies for future crops. For this to be successful, the relationship between the soil test and likely response to applied nutrients needs to be well calibrated. Many of these calibrations were developed from fertiliser trials conducted over 20 years ago and have provided robust guidelines on many soil types, but mostly for cereals. Since these trials were conducted cropping systems have changed significantly and altered the face of soil fertility in the Australian grains industry. A detailed re-examination of those existing guidelines is needed to ensure they are still relevant in current farming systems.

As part of the GRDC funded MPCN2 (More Profit from Crop Nutrition) program, a review of data in the Better Fertilizer Decisions for Cropping (BFDC) database showed gaps exist for key crops, soils and regions. Most of these gaps relate to crops that are (i) new to cropping regions or are a low proportion of cropped area, i.e. break crops, (ii) emerging nutrient constraints that had previously been adequate in specific soil types and (iii) issues associated with changing nutrient profile distribution. This project (UQ00082) is closing gaps in the BFDC database using replicated trials. Trials have been established on sites selected for nutrient responses and run over multiple years to develop soil test-crop response relationships. By using wheat as a benchmark alongside a break crop, we should be able to extend the relevance of the guidelines beyond the conditions at the trial site.

How was it done?

A P deficient site on a red sandy clay loam was selected near Pildappa on upper Eyre Peninsula. Soil P status was very low at < 6 ppm Colwell P in the top 10 cm. On 7 May 2018, P fertiliser treatments were applied at 11 rates from 0 - 200 kg P/ha to create a range of soil P reserves.

Two identical trials were sown at the site in 2018, one with Mace wheat as the benchmarking crop and Stingray canola for comparison.

In 2019, 44T02 canola was seeded over the wheat trial and Mace wheat over the canola. Crops were inter-row seeded on the previous crop rows with no P fertiliser. Both crops received urea banded under the seed row @ 49 kg/ha and wheat received an extra 11 kg/ha of urea with the seed.

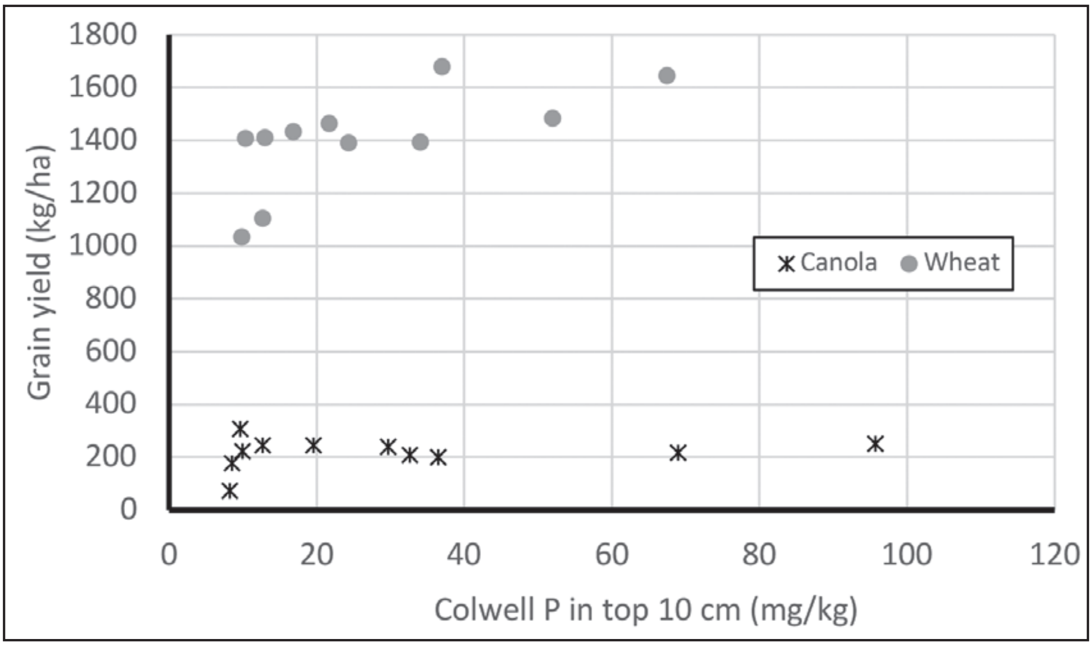


Figure 1. Grain yield of wheat and canola with increasing Colwell P in the topsoil at Pildappa, SA in 2019.

What happened?

Despite periods of very severe water stress during the season, both crops grew substantially better where soil tests were high for P (above 15 mg/kg in the top 10 cm for wheat, and above 10 mg/kg for canola). Canola appeared to be more stressed than wheat during the dry periods and the grain yield of canola was very poor, especially relative to wheat. Maximum grain yields for wheat were 1.6 t/ha compared with 0.3 t/ha for canola. Wheat grain yields were reduced by more than 30% (or nearly 0.5 t/ha) by P deficiency, for canola the reduction was more than 70% (or about 0.15 t/ha) (Figure 1).

Colwell P values in 2019 were approximately half of those recorded in 2018 but most were still much higher than untreated levels. This shows that while P is strongly fixed in this red calcareous sandy loam, applications of P in one year can still have benefits at least into the year after application.

What does this mean?

The minimum Colwell P soil test for wheat in 2018 was about 11 mg/kg. Below this value, wheat would suffer substantial yield penalties if grown without P fertiliser. The same figure estimated from the 2019 wheat crop is about 15 mg/kg. Both of these critical levels are substantially lower than the current standard of 20-25 mg/kg for mallee-type soils. These values are probably low due to the very low production levels experienced in both seasons. Under these conditions, crops require very little P to maximise growth.

The canola was not harvested in 2018 so its sensitivity to low soil P levels could not be compared to wheat in that year, but in 2019 its critical level was lower than wheat (approximately 10 mg/kg compared to 15 mg/kg for wheat). This suggests that canola can grow without the need for P fertiliser at lower soil P reserves than wheat. However, it does not necessarily mean that canola should be grown with lower rates of P than wheat because the optimum rate for P fertiliser is determined by many factors such as value of the commodity and the long term goal for soil P reserves, not just crop sensitivity.

For this project, 2020 will be a critical year because it is the last growing season for the project and so far our data set for calibrating soil tests in current farming systems consists entirely of seasons drier than average and in many cases extremely dry. 2020 is our last chance to estimate soil critical levels for N, P, K and S under wetter conditions and thus have a more balanced data set.

Acknowledgements

Mike Bell (The University of Queensland) who leads the UQ00082 project funded by GRDC. Thank you to Neil King, Katrina Brands, Steve Jeffs and Bradley Hutchings for undertaking the field work and processing samples.

SARDI
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GRAINS RESEARCH & DEVELOPMENT CORPORATION

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Comparative effects of pesticides on South Australian soil microbial functions

Jowenna Xiao Feng Sim[1], Casey Doolette[1], Barbara Drigo[1], Erica Donner[1], Allan Mayfield[2] and Enzo Lombi[1]

[1]Future Industry Institute, University of South Australia; [2]South Australian Grain Industry Trust

Key messages

- **This study will deliver South Australian farmers with information to aid decision making on the use of pesticides by investigating the effect of 20 pesticides, including insecticides, herbicides and fungicides on soil microbial function in three South Australian (SA) soils.**
- **The information on cumulative effects and persistence of negative effects on selected soil-pesticide combinations could be instrumental in safeguarding the long-term productivity and profitability of SA grain growers.**
- **Understanding the correlation between a pesticide's mode of action and its effects on soil function may aid in the development of new active ingredients and/or the reformulation of current pesticides.**
- **The insights into lab-field transferability will provide greater understanding of how the complexities of environmental factors affect pesticide impacts on soil functions.**

Why do the trial?

This project will deliver essential information to South Australian farmers for identifying the best soil-pesticide combinations for maintaining healthy, well-functioning soil microbial communities in their soils.

Crop protection products, such as pesticides, have contributed to the profitability of the agriculture sector, contributing $20.6 billion to the annual harvested crop in Australia. However, pesticides can affect soil microbial community structure and function and hence vital, microbially-driven ecosystem services such as nutrient cycling, soil structural stability and plant pathogen control.

There are several factors that influence the effect that a pesticide will have on soil microorganisms and soil fertility. Such factors include the chemical structure, concentration and toxicity of the pesticide and soil properties. Different pesticides will therefore affect soil microbial communities differently depending on soil type, but these interactions are not well understood. Most past studies have only investigated the effect of a single pesticide on a single nutrient cycle (mostly the nitrogen cycle), using a limited number of soil types. For example, 15 previous studies have investigated the effect of pesticides on nitrate production in soil, and most of these studies only tested one pesticide in one soil. More importantly, of these 15 studies, only one used an Australian soil; a Queensland sugarcane cropping soil. Therefore, there is a scarcity of information regarding the potential effects of pesticides on the soil microbial communities of southern Australian agricultural soils.

One of the aims of this study is to investigate the comparative effect of 20 commercial agricultural pesticides on soil functions driven by microbial and enzymatic activities in three different SA soil types. The cumulative effects and persistence of negative impacts of selected soil-pesticide combinations will also be further studied to ensure ongoing pesticide performance and benefit. Overall, this project will aid farmers in the selection of future pesticide strategies that maximise farm outputs while retaining, or even improving, SA soil fertility.

How was it done?

During the first 12 months of this three-year project, we have carried out laboratory experiments testing 20 commercialised pesticides, with different modes of action (Table 1), on three SA soil types. The pesticides include four insecticides, eight herbicides, and four fungicides, all supplied by six agrochemical companies; Bayer, BASF, Syngenta, FMC, Nufarm and ADAMA. The three SA soil types are 1) a grey calcareous sandy soil from Piednippie, Eyre Peninsula 2) a clay-loam soil from the Hart Field site in the Clare Valley where a field trial will also be conducted in 2020, and 3) a sodic soil from Pine Hill, South East SA.

Table 1. Pesticides selected for targeted investigation.

Pesticide	Class	Mode of action	Product name	Supplier	Concentration of active ingredient
Chlorpyrifos	Insecticide	AChE inhibitor	Chlorpyrifos 500EC	Nufarm	500g/L
Fipronil	Insecticide	Chloride channel blocker	Legion	Nufarm	500 g/L
Alphacypermethrin	Insecticide	Sodium channel blocker	Astound Duo	Nufarm	100 g/L
Imidacloprid	Insecticide	nAChR modulator	Gaucho®	Bayer	600 g/L
Chlorsulfuron	Herbicide	ALS inhibitor	TACKLE®	ADAMA	750 g/kg
Imazamox	Herbicide	ALS inhibitor	Raptor	BASF	700 g/kg
Atrazine	Herbicide	PS II inhibitor	Atragranz	Nufarm	900 g/kg
Trifluralin	Herbicide	Microtubule inhibitor	Triflur X	Nufarm	480 g/L
Propyzamide	Herbicide	Microtubule inhibitor	Rustler® 900WG	FMC	900 g/L
Prosulfocarb	Herbicide	Lipid synthesis inhibitor	Countdown®	Adama	800 g/L
Metolachlor	Herbicide	VLCFA inhibitor	Bouncer® 960S	Nurfam	960 g/L
Pyroxasulfone	Herbicide	VLCFA inhibitor	Sakura 850WG	Bayer	850 g/kg
Isoxaflutole	Herbicide	HPPD inhibitor	Balance® 750WG	Bayer	750 g/kg
Clopyralid	Herbicide	Synthetic auxin	Archer 750	Nufarm	750 g/L
Paraquat	Herbicide	PS I inhibitor	Shirquat 250	Nufarm	250 g/L
Glyphosate	Herbicide	EPSP inhibitor	Weedmaster® DST	Nufarm	470 g/L
Flutriafol	Fungicide	Sterol biosynthesis inhibitor	Intake® HiLoad Gold	Nufarm	500 g/L
Metalaxyl-M	Fungicide	RNA polymerase I	ApronXL	Syngenta	350 g/L
Penflufen	Fungicide	SDH inhibitor	EverGol Prime	Bayer	240 g/L
Azoxystrobin	Fungicide	Ubiquinol oxidase inhibitor	Supernova 250 SC	Nufarm	250 g/L

The 20 pesticides were tested on the three soil types at two different doses (equivalent to one and five times the recommended dose) and incubated for four weeks under controlled conditions (i.e. constant temperature, and humidity) to give 120 treatments prepared in triplicate. At the end of each incubation period, a suite of high-throughput molecular tools was used to monitor the structure, diversity and function of soil microbial communities involved in three nutrient cycles: carbon cycle, nitrogen cycle and phosphorus cycle. We further investigated effects on the nitrogen cycle by measuring potential nitrification (a test that indicates the potential for ammonium to be converted to nitrite; one of the most important steps in the nitrogen cycle), and, the expression of functional genes involved in this process (i.e. *amoA* genes).

All statistical analyses are being carried out using GraphPad Prism 8.2.0. In the middle of the second year, this study will assess lab-field transferability of the experimental data by establishing a field trial that will be conducted over two years at the Hart Field Site. The field trial will test three to five selected soil-pesticide combinations of special interest to growers. The cumulative effects and persistence of the selected pesticides will also be investigated in laboratory experiments that will run in parallel to the field trial. Repeat applications will be applied every six months and samples will be collected two weeks after pesticide application, just before the next application. The fate of the pesticides will also be tested in parallel throughout the experiment using ^{14}C-labelled compounds. For the correlation of a pesticides' mode of action to any negative impacts on non-target organisms, multiple pesticides of interest with similar modes of action will be further investigated to determine the presence of any possible relationship.

What happened?

Data have been collected from the laboratory experiments in the first year of the project (2019) and are currently being analysed. More laboratory work will be continued in the second year of the project and more results will be collected from the Hart field trial, which will start in May 2020.

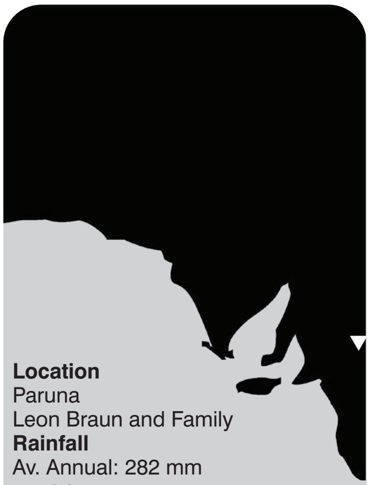
Acknowledgements

This work is funded under the South Australian Grain Industry Trust (SAGIT) project USA118. We thank all the suppliers (Bayer, BASF, Syngenta, FMC, Nufarm and ADAMA) for providing the pesticides and thank to Amanda Cook and Ian Richter (SARDI, Minnipa Agricultural Centre), Melissa Fraser (PIRSA) and Sarah Noack (Hart Field Site) for collecting and sending the field soils.

Improving vetch growth and nodulation on Mallee sands

Brian Dzoma[1], Nigel Wilhelm[2], Hugh Drum[2] and Kym Zeppel[1]

[1]SARDI, Loxton Research Centre; [2]SARDI, Waite Research Precinct



Location
Paruna
Leon Braun and Family
Rainfall
Av. Annual: 282 mm
Av. GSR: 190 mm
2019 Total: 136 mm
2019 GSR: 105 mm
Paddock history
2019: Vetch
2018: Wheat
Soil type
Sand
Soil test
pH (Water): 7.45
Plot size
15 m x 2 m x 3 reps
Trial design
Factorial RCBC with 3 replicates
Yield limiting factors
Moisture, compaction

Key messages

- **Placing P with the seed or banded to a depth of 8 cm below the seed does not affect vetch nodulation, leaf tissue P concentration and late flowering shoot dry matter.**
- **Leaf tissue P concentration and late flowering shoot dry matter increase with increasing rates of P.**

Why do the trial?

Phosphorous (P) is an essential macronutrient which influences plant shoot and root growth. It is generally the least available nutrient, particularly in sandy soils due to chemical bonding with Fe, Al, Ca and Mn in most production regions of Australia. Inadequate P restricts root and shoot growth and other functions which reduce N fixation by legumes. Vetch (*Vicia sativa*), a versatile pasture legume that can be used for grain, pasture, hay/silage or green manure, is being grown on naturally infertile Mallee soils which are often quite deficient in P. Vetch struggles to achieve optimum productivity on low P soils resulting in less fixed nitrogen returned to the system. This article reports on the responses of vetch to different rates of P placed at different depths below the seed at seeding. By achieving the optimum rate and right depth to place the P at sowing, productivity gains in the form of improved dry matter production, grain yield, nodulation and N fixation can result in multiple benefits, particularly in low rainfall mixed farming systems.

How was it done?

A replicated field trial was established in 2019 at Paruna (northern SA Mallee) on a red loamy sand (Colwell P, 16 mg/kg). The trial was sown to Volga vetch @ 35 kg/ha on 23 May. Five rates of P were applied as triple superphosphate (TSP) (0:46:0), at 3 different depths below the seed (Table 1). Plot length was 15 m and all treatments were replicated three times.

Emerged plants were counted on 19 June 2019 to determine plant population, and on 15 August, Clethodim @ 500 ml/ha + 1 L/ha wetter was applied to control grassy weeds. Samples for nodulation and leaf tissue P were taken on 8 August. Late flowering/early podding biomass was sampled on 5 September.

What happened?

With total growing season rainfall of only 105 mm, crop growth and productivity was severely limited. However, visual responses to the different rates of P applied at different depths were evident during the early part of the growing season, before flowering.

Response to P rates

Mean plant population for the site was 70 plants/m^2 and was not consistently affected by increasing rates of P (Figure 1a), regardless of its position. This shows there are situations where P applied at sowing up to 32 kg P/ha will not have a negative impact on crop establishment (but this will not always be the case). Overall nodulation for the site was good, as the mean total number of nodules per root was 48. For vetch on light soils, 20 nodules per plant at 8 weeks post sowing is considered satisfactory (GRDC, 2014). The mean nodules per root were not consistently affected by the different rates of P (Figure 1c).

Plant tissue analysis is an important tool because it shows the nutrient status of plants at the time of sampling. This, in turn, is a guide as to whether soil nutrient supplies are adequate. Plant tissue analysis can also detect unseen deficiencies and may confirm visual symptoms of deficiencies. The most sensitive tissue for detecting P deficiency is the youngest mature leaf. The critical level for vetch during vegetative growth is 0.3% (GRDC, 2018). Leaf tissue P at the site ranged from 0.15–0.24%, which is lower than the critical level. Leaf tissue P in vetch increased with increasing P applied at sowing (Figure 1b).

Table 1. Treatment details, Paruna 2019.

Crop	Volga vetch
Main plot factor (P placement)	With seed
	Shallow (4 cm below seed)
	Deep banded (8 cm below seed)
Sub-plot factor (kg P/ha)	0, 4, 8, 16, 32
Experimental design	Factorial RCBD x 3 replicates

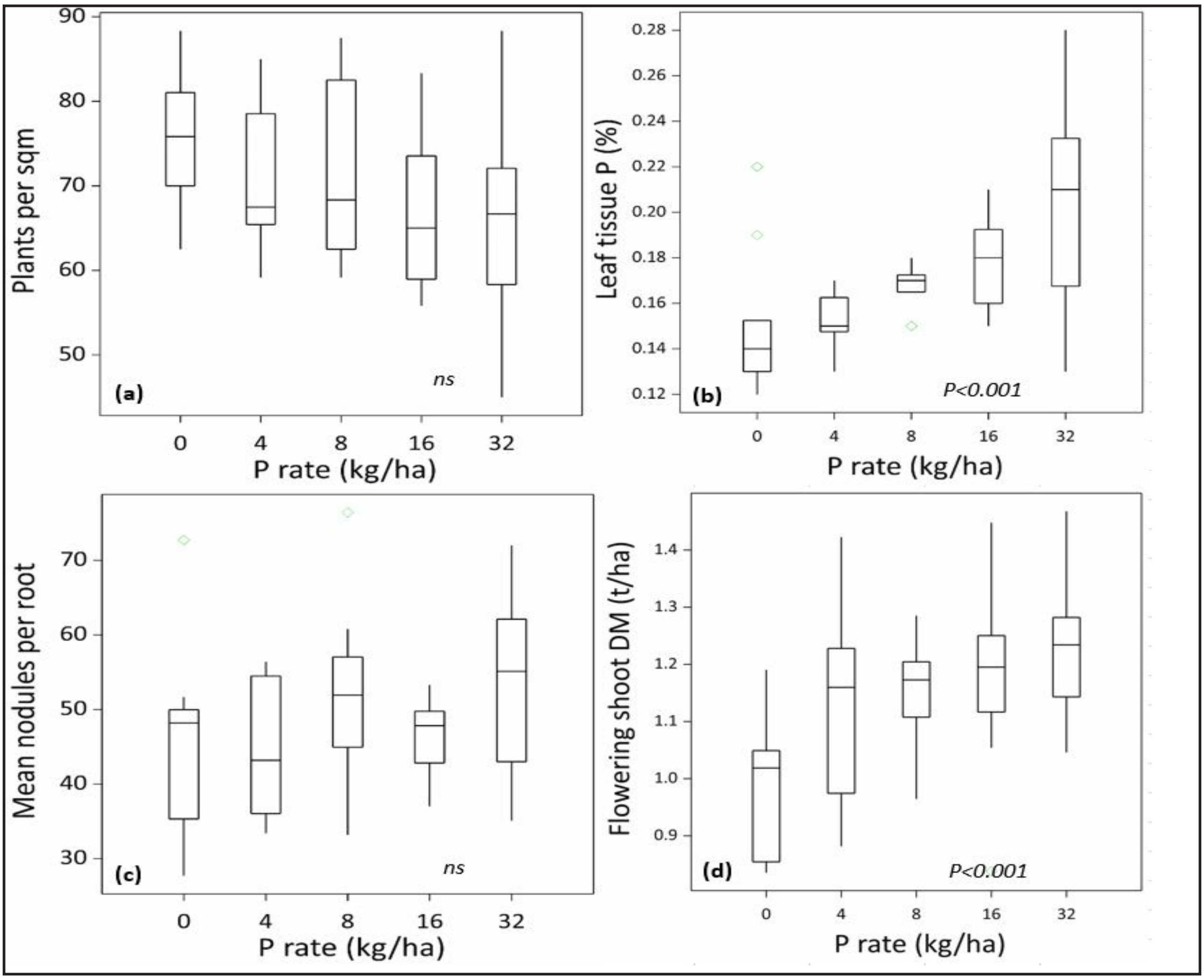


Figure 1. (a) Effect of different P rates on crop establishment leaf tissue, (b) P concentration, (c) nodules per root and (d) late flowering shoot dry matter.
Box and whisker plots show the shape of the distribution, the central value, and the variability. The lines extending from the boxes indicating variability outside the upper and lower quartiles, and the median is shown as a line in the centre of the box

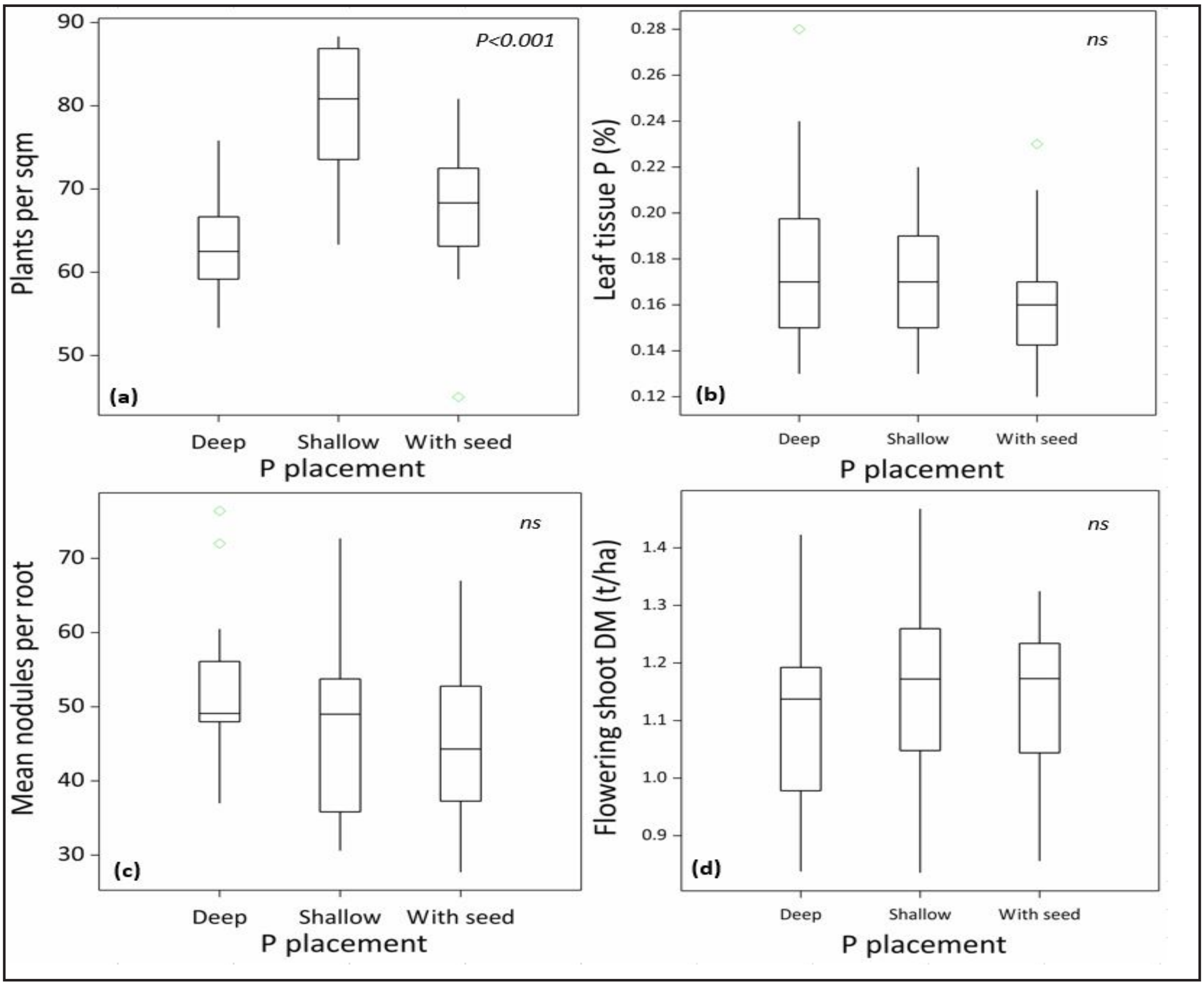


Figure 2. (a) Effect of P placement on crop establishment, (b) leaf tissue P concentration, (c) nodules per root and (d) late flowering shoot dry matter.

Crop biomass production was low because of a hot dry finish to the season. Flowering shoot DM for the site ranged from 0.95–1.30 t/ha, and the vetch crop responded positively to higher rates of P (Figure 1d). Matic *et al*., (2006) reported that average DM yield for Rasina vetch grown in 2006 at a trial site in Kingsford was 4.8 t/ha and 2.5 t/ha in Lameroo and Nagel *et al*., (2011) have reported that average grain yield for 2009, 2010 and 2011 was 2.2 t/ha from 4 sites in SA. Our trial site mean of 1.3 t DM/ha for late flowering DM reflects the impact of a below average season for the SA northern Mallee.

Responses to P placement

Establishment was significantly affected by the depth of placement of P at sowing. Plants/m^2 ranged from 63 (deep), 67 (with seed) and 79 (shallow). The shallow banding of P at sowing had significantly more plants/m^2 than deep banding or placing the P in the seed zone at sowing (see Figure 2a). Establishment with P in the seed row was possibly depressed by fertiliser toxicity, by P deficiency with deep P and better with shallow P because it avoided fertiliser toxicity and also supplied P to the crop (i.e. avoided P deficiency). Several authors (Singh *et al*., 2005; Bell *et al*., 2018 and McBeath *et al*., 2007) have reported that applying P at depth (15 to 30 cm deep on 50 cm bands) can improve yields over a number of cropping seasons (if other nutrients are not limiting). With our deepest treatment (8 cm below the seed), P was placed in the top 10 cm soil layer which is often dry. This explains the lack of response because of the immobile nature of P, limited rainfall and crop root architecture. There was no response in leaf tissue P, number of nodules per root and flowering shoot DM, to P placement as shown in Figures 2b-d.

What does this mean?

Vetch is now a significant legume rotation in cereal cropping systems in Australia's low and medium rainfall zones. There is limited recognition of the impact of phosphorus on vetch productivity in low rainfall Mallee environments. Estimates of the impact of soil P levels on nodulation and N fixation in alkaline coarse textured soils are also poorly understood.

We imposed four different rates of P as TSP at three different placement depths to investigate productivity responses that can be achieved by vetch on soils with low P reserves. Our results have shown that P fertiliser placed up to 8 cm below the seed will not result in more nodules on roots and will not improve DM production above P placed closer to the surface which is consistent with the results from a similar trial at Peebinga, 2018 (Dzoma *et al*., 2018).

However, it should be noted that if targeting higher plant densities, shallow banding P fertiliser can improve plant numbers and crop establishment. To improve vetch productivity on soils with low P reserves, the results show that dry matter production can be significantly improved by increasing the rate of P fertiliser at sowing. Matic *et al*., 2008 have also noted the importance of adding P when sowing Woolly pod vetch, as it generally provides a good start and growth. P applications, however, need to be matched against expected productivity gains for different soil types and rainfall regions to make sure fertiliser applications are economically justifiable.

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The research undertaken as part of this project is made possible by the significant contributions of the Braun family (Paruna) through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support. SAGI for statistical analysis and support. SARDI/GRDC Mallee Bilateral project - Improving sustainable productivity and profitability of Mallee farming systems with a focus on soil improvements (DAS00169-BA).

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC Sandy soils IMPACT trials – Warnertown

Author: Sam Trengove
Funded By: GRDC - CSP00203
Project Title: 'Increasing production on sandy soils in low and medium rainfall areas of the Southern Region'
Project Duration: 2019
Project Delivery Organisations: Trengove Consulting

Location – Warnertown, -33.2832, 138.0872

Constraints - Low organic carbon, low Cation Exchange Capacity, Mild water repellence, compaction (assumed, not yet measured)

Key findings -

- Grain yield increased 0.68 t/ha (18%) in response to deep ripping to a depth of 50cm.
- Crop establishment was reduced by 50% in the Plozza treatment, as a result of buried straw causing issues with seed row burial and deep seed placement.

Treatments –

1. District practice (Control)
2. Shallow ripping to 30cm (Rip30)
3. Deep ripping to 50cm (Rip50)
4. Deep ripping to 50cm with inclusion plates (Rip50 + IP)
5. Deep rip to 50cm + Plozza plough to 30cm (Rip + Plozza)
6. Deep rip to 50cm + Spading to 30cm (Rip + Spade)

Key dates –

Operation	Date
Amelioration	11th April 2019
Seeding	14th May 2019
Intervix application	9th July 2019
Harvest	5th November 2019
Crop lower limit sampling	8th November 2019

How was it done?

Variety: Spartacus CL.

The Spartacus CL seed was contaminated with Compass seed at approximately 30%. The Intervix application 9th July killed Compass plants in the population. Plant counts were conducted prior to Intervix application.

Fertiliser: 32:10 @ 100kg/ha IBS. Chicken litter was applied to the whole site at 5 t/ha prior to treatment implementation.

The trial was a randomised complete block design with 6 treatments and 3 replicates. The trial was located on a sand hill near Warnertown. The ripping treatments were implemented using a Yeomans plough ripper with three tines per plot on 450mm spacing. The Plozza plough was a converted John Shearer one-way plough and was built by the trial co-operator Brendon Johns and cut approximately 3.8m. Two passes of the Plozza were made for each Plozza treatment and the actual plot was located in the second pass. The spader was a Farmax 1.8m machine. Due to dry conditions in April, prior to implementing the Plozza and spading treatments these plots were ripped with the Yeomans plough to 50cm to enable the treatments to reach their targeted working depth. Both the spade and plough treatments were implemented at 5 km/h. The trial was arranged so that the treatments ran up and over the sand hill parallel to the grower's operations. Plot dimensions were 50m * 1.5m sown on 2.1m centres and was 1 bay deep and 31 rows long with buffers left for the grower's controlled traffic lines and allowing 3 additional buffers around each Plozza treatment to allow for the first cut of the one way plough. Harvested area was reduced to 25m.

Measurements during the growing season included crop emergence and early vigour, Green Seeker NDVI 6th August and 23rd September, Grain yield and grain quality. Crop lower limt soil samples were taken to a depth of 120 cm. these were broken into segments of 10 – 20, 20 – 40, 40 – 60, 60 – 90 and 90 – 120cm.

Results

Plant density was greatly reduced by the Plozza treatment (Table 1). Accurate seeding depth was difficult to maintain, the greatest impact came from straw that had been buried by the Plozza and to some extent the Spader treatments, becoming wrapped around the seeding tine under the soil surface. This had the effect of making the seeding boots much wider than normal and causing a large amount of soil disturbance. This action on the rear tines on the seeder, wrapped in straw, passing through the soil pushed soil over the front rows of the seeder. This meant that many of the seeds sown by the front rows of the seeder were germinating at a depth greater than 100mm. As Spartacus is a short coleoptile variety many of these plants did not emerge at the surface. As a result, plant density in the Rip+Plozza treatment was reduced by half compared to the other treatments.

The Emergence score conducted 28th May indicated that the Rip+IP treatment had better 28% better emergence compared to the other treatments. This score was a visual assessment of the entire plot area and may be a better representation of plot emergence than the actual plant count. This measurement supports the finding that the Plozza treatment had lower emergence compared to other treatments.

Green Seeker NDVI data shows the reduced plant numbers in the Rip+Plozza treatment had much lower NDVI (0.366) compared to the remaining treatments (Table 1). The Rip+IP treatment produced the highest NDVI at this time with 0.593, 28% higher than the control and significantly higher than all other treatments. No other treatments, straight rip or Rip+Spade, differed significantly from the control. A second NDVI measurement was taken in late September with an average value of 0.361. The reduction in NDVI indicates senescence had begun at this time and no significant differences were identified.

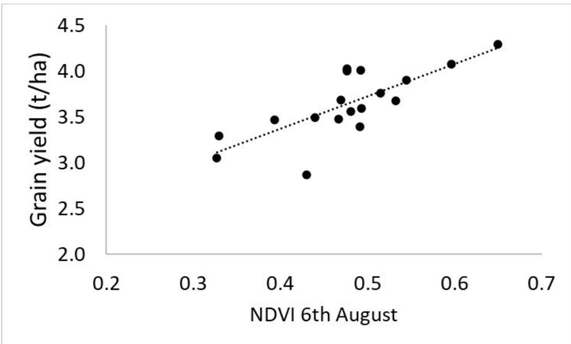

Figure 1. The relationship between Green Seeker NDVI recorded 6th August and grain yield (t/ha), y = 3.5543x + 1.9465, R2 = 0.5892.

Grain yield had a good relationship with crop NDVI recorded 6th August (Figure 1). This indicates that grain yield was partly driven by early season biomass and that the Rip+Plozza treatment was likely to be lower yielding due to low plant numbers and biomass. Despite the low plant numbers in this treatment it was able to maintain the same grain yield as the control treatment (3.31 t/ha). Treatments that were higher yielding than the control were the Rip50, Rip50+IP and Rip+Spade. All of these treatments were ripped to a depth of 50cm and produced an average grain yield of 3.89 t/ha, 18% higher yielding than the control treatment.

Of the grain quality measurements, the Rip+Plozza treatment was significantly different to all other treatments across all measured characteristics. It had high Protein (15%) and small grain size (higher screenings and lower retention). The Rip+Spade treatment was also higher in protein (12.2%), where the total N offtake for these two treatments average 77 kg N/ha (data not shown), and tended to be higher than the remaining treatments (control = 59 kg N/ha). This suggests that the inversion and mixing treatments have generated more available N that the crop has exported in the grain. The inversion and mixing treatments allow for more burial of topsoil organic matter and applied chicken litter. It is presumed that the additional N has been generated through increased mineralisation of the buried organic matter and chicken litter.

Crop lower limit soil samples to a depth of 120cm were taken from the control and the Rip50 treatment, however no measurable difference in soil moisture was identified. The average total remaining water in the soil after harvest at this site was 54 mm (assumed bulk density 1.5 kg/L).

Treatments producing higher yields naturally generate more gross income, however the treatments that generate the highest partial gross margin are those that have high gross income but low treatment cost basis (Table 2). Therefore, ripping treatments are favoured in this instance. It has been demonstrated in several other trials that yield improvements are likely to continue beyond the first season, which is essential to justify the high costs for some treatments. This trial will be continued for another two seasons to monitor the longer-term treatment effects on productivity and profitability.

Table 1. Emergence Score (0 = no emergence, 10 = 100% of plot emerged), Green Seeker NDVI 6th August and 23rd September, grain yield (t/ha), protein (%), Screenings (%) and Retention (%) for the Warnertown GRDC Sandy soil IMPACTS trial 2019.

Treatment	Emergence Score 28th May	Plants density (plants/m2)	NDVI 6th Aug	NDVI 23rd Sept	Grain yield (t/ha)	Protein (%)	Screenings (%)	Retention (%)
Control	6.8	126	0.464	0.300	3.31	11.1	1.9	87.8
Rip30	6.7	129	0.492	0.333	3.61	11.3	1.3	86.5
Rip50	7.5	128	0.501	0.367	3.82	11.2	2.3	81.5
Rip50+IP	8.7	127	0.593	0.400	4.02	11.1	1.7	87.4
Rip+Plozza	6.7	63	0.366	0.400	3.28	15.0	4.3	69.8
Rip+Spade	8.2	120	0.454	0.367	3.84	12.2	1.7	87.9
LSD (0.05)	*1.6*	*11*	*0.072*	*ns*	*0.38*	*0.1*	*1.1*	*6.9*

Table 2. Partial Gross Margin analysis for the first year of the Kybunga GRDC Sandy soil IMPACTS trial. Price assumptions, Treatment costs as per table and barley $270/t

Treatment	Cost ($/ha)	Grain yield (t/ha)	Income ($/ha)	Partial Gross Margin ($/ha)
Control		3.31	895	895
Rip30	50	3.61	975	925
Rip50	70	3.82	1031	961
Rip50+IP	100	4.02	1085	985
Rip+Plozza	150	3.28	886	736
Rip+Spade	250	3.84	1036	786

Acknowledgements

Funding for this trial is gratefully acknowledged from GRDC project CSP00203 ‘Increasing production on sandy soils in low and medium rainfall areas of the Southern Region. Brendon and Denise Johns are thanked for hosting the trial on their property and assistance with applications of pesticides and fertiliser throughout the season.

GRDC
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UNFS SOUTHERN PULSE EXTENSION PROJECT
2019 REPORT

Author: Rachel Trengove, Southern Pulse Extension Project Officer, UNFS
Funded By: GRDC BWD 9175825.
Project Title: GRDC Southern Pulse Extension Project: "Building capacity, skills and knowledge for the pulse industry in the southern region: Supporting expansion of high value pulses into new areas and ensuring sustainable profitability of all key pulse crops".
Project Duration: 2017-March 2021
Project Delivery Organisations: BCG, UNFS

Background

Grain growers are being supported to diversify into pulse crops in non-traditional production areas of Victoria and South Australia through Grains Research and Development Corporation (GRDC) initiative.

The Southern Pulse Extension project is a GRDC investment that aims to provide growers and their advisers with the information and resources they need to make informed decisions and maximise possible production and income potential from pulses.

At the core of the project is the establishment of twelve "Pulse Check" discussion groups across Victoria and South Australia.

The Pulse Check groups meet at least four times a year over two years to discuss issues relating to pulse crop production, management and marketing. They are focused on a "back to basics" approach to pulse production through practical in-field learning and group discussion.

Each group consists of growers and advisers with varying experience in production of lentils or chickpeas. Those with no or limited experience are particularly encouraged to take advantage of a unique opportunity to learn from more experienced growers in their region and experts in the industry.

Pulse trial sites have been incorporated into Pulse Check group activities.

Since the commencement of the project, UNFS has hosted several pulse check group workshops. Given the diversity of the Upper North region, the meetings are being alternated between the western and eastern sides of the Flinders Ranges.

Pulse Check Group Extension Activities for 2019

Pulse Check meetings for 2019 are listed below including topics covered and attendance:

February 2019 – pre-seeding Pulse Check meeting

9am-12pm, Napperby Tennis Club
Penny Roberts and Sarah Day (SARDI) presented a summary of results and findings of Southern Pulse Agronomy Project trials in our upper north region. Following this, Daniel Hillebrand, Matt Foulis and Barry Mudge facilitated a discussion on pulse pre-seeding planning including fertiliser and weed control.
32 people attended the meeting.

July 1st 2019 - post-seeding Pulse Check meeting

Monday 1st July – 9am-12pm was a crop walk held at the Willowie Trial site. Agronomists Daniel Hillebrand and Matt Foulis led the crop walk through the SARDI trials facilitating a general discussion with group members. 28 people attended.

August 22nd 2019 – Bus Tour – Reducing Limitations to Pulse Production

Our Pulse check group was notified of a pulse related bus tour organised by Hart and GRDC in our region. It was included as one of our meetings for our group and was attended by 11 UNFS members, all travelling independently of the bus. The tour started at the Willowie trial site where Penny Roberts and Sarah Day presented and gave an overview of a low rainfall break crop project including variety selection for low rainfall environments, as well as lentil herbicide management, pulse nutrition trials and a vetch end-use trial. Jenny Davidson (SARDI Pulse Pathologist) discussed disease and fungicide management and there was a field plot machinery demonstration as well. We then travelled to Wirrabara where Liz Farquharson and Ross Ballard presented on nitrogen fixation and acid tolerant rhizobia in acidic soils during a crop walk through trials. The bus tour continued to Bute where Navneet Aggarwal presented recent findings from his Weed Ecology project which looks at weed management in high break crop intensity farming systems.

September 13th 2019 – Pre-canopy closure Pulse Check meeting

Friday 13th September 9am-11:30am was a crop walk held at the Warnertown Trial site. Penny Roberts and Stuart Sheriff presented on SARDI trials facilitating a general discussion with group members. 29 people attended the meeting. It was followed by the Nelshaby Ag Bureau Sticky Beak Day.

SUMMARY

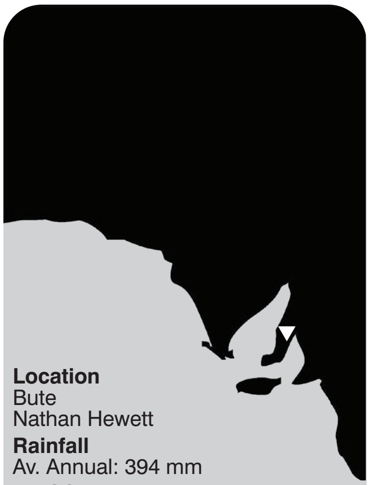
The pulse check groups are proving successful in helping local farmers gain the confidence and skills necessary to adopt new pulse varieties, or to improve on their current practices. Due to a project extension there are three more Pulse Check meetings planned between now and March 2021 when the project finishes. The project will aim to further build growers and advisor's knowledge and understanding of the key aspects of pulse production.

Acknowledgements:

Southern Pulse Extension Project Managers, Pru Cook & Claire Browne, BCG.
Grains Research Development Corporation for project funding.

Herbicide tolerance and weed control in lentil on sandy soils

Sam Trengove, Stuart Sherriff and Jordan Bruce
Trengove Consulting



Location
Bute
Nathan Hewett
Rainfall
Av. Annual: 394 mm
Av. GSR: 295 mm
2019 Total: 216 mm
2019 GSR: 213 mm
Yield
Actual: 1.3t in control treatments, highest yielding treatmants were up to 1.4t/ha
Paddock history
2018: Wheat
2017: Lentil
Soil type
Neutral to alkaline sand hill, with deep sand (>1m) in a dune swale environment
Soil test
0-10 cm: PBI 41, DGT P 84, N 42, SOC 0.69%, $pH_{(H20)}$ 7.7
10-30 cm: PBI 58, DGT P >5, N 22, SOC 0.24%, $pH_{(H20)}$ 8.6
Plot size
1.5 m x 10 m on 2 m centres x 3 reps
Trial design
Randomised complete block design
Yield limiting factors
Low rainfall and terminal drought, moderate effects, low levels of pod drop prior to harvest

Key messages

- **Sandy soils can have narrow safety margins for commonly used broadleaf herbicides used in lentils. Herbicide damage from some Group C and B herbicides reduced lentil growth and grain yield on a sandy soil at Bute.**
- **Herbicide efficacy on four weed species was variable between products. Herbicide combinations were required to provide high levels of control of all four weed species.**
- **Optimising the herbicide strategy in lentils on sandy soils requires a balance between minimising crop effect, but achieving acceptable weed control. This requires knowledge of the target weeds and their resistance status to determine which herbicides to use and in what combination. The benefit of high level weed control then needs to be weighed against the risk of herbicide damage to the crop.**

Why do the trial?

Herbicide damage in lentils can occur readily on sandy soils from both pre and post emergent applications. Low clay content, low organic carbon and low cation exchange capacity of sand hills predispose these areas to increased risk from herbicide damage. It is possible that even without visible plant injury symptoms, there is an underlying level of herbicide damage restricting biomass production and yield of lentils on these soil types. Previous work conducted on a similar soil type in 2015, 2017 and 2018 showed that in some cases when more than one herbicide is applied the level of damage can be greater than the sum of the damage of the single herbicides on their own. The results from trials such as these can be influenced greatly by soil type and weather events and therefore need to be repeated to explore the range of responses that can occur.

In previous trials, the weeds that are present in the plots have been removed so that the effect of the herbicide is the only factor that is influencing crop performance. It is possible that higher weed density as a result of either no or low efficacy herbicide treatments being applied, will lead to reduced grain yield compared to more damaging, higher efficacy treatments.

This trial aimed to test the safety level of several commonly used herbicide options and combinations on PBA Hurricane XT lentils in both plots with natural weed populations present and plots with weeds removed by hand to limit competition with the crop.

How was it done?

The trial was a randomised complete block design with 17 herbicide treatments and two weed population treatments. In the plots with weeds removed, all weeds were removed by hand during the counting process and this was done at a time to limit the competition with the crop. The trial had three replicates.

The plots were 10 m x 1.5 m and were sown with PBA Hurricane XT using knife points and press wheels on 250 mm spacing with 60 kg MAP on 17 May 2019.

Pre-emergent herbicides were applied on 16 May 2019 prior to sowing using a hand boom, post emergent treatments with diflufenican and Intercept were applied using a shielded sprayer to prevent herbicide movement between plots on 27 June and 9 July respectively. Herbicide treatments are displayed in Table 1.

Measurements throughout the season included vigour and herbicide damage scores, GreenSeeker NDVI, weed density, weed biomass scores, pod drop prior to harvest and grain yield. Crop lower limit soil samples were taken post-harvest to a depth of 120 cm, these were segmented to 10-20, 20-40, 40-60, 60-90, and 90-120. Results were analysed with the statistical package R.

What happened and what does this mean?

Crop performance

Weed competition

The hand weeding treatment, plus and minus weeds, only affected NDVI recorded on the 19 August and 24 September. As a result of removing the weeds from the plots by hand, the total plot biomass was reduced and therefore the NDVI readings were reduced by 4% and 5% respectively. Unexpectedly, hand weeding the plots to remove the weeds did not increase the grain yield of lentils, indicating that the weed competition did not cause significant yield loss even in the nil herbicide treatments.

Group C herbicides (simazine, diuron, metribuzin, Terbyne, simazine/diuron mixture)

The Group C herbicides simazine, diuron and Terbyne reduced GreenSeeker NDVI by an average of 23% on 22 July (Table 2). This level of damage from these three herbicides continued until 19 August (24% reduction). By 24 September the damage from the simazine and diuron treatments was no longer significant whereas the Terbyne treatment NDVI was still 16% lower than the control. The metribuzin treatments caused less damage than the other Group C herbicides with an 11% and 9% reduction in NDVI for the 22 July and 19 August respectively. Grain yield was not significantly reduced by metribuzin, diuron or the simazine/diuron combination applied alone. The other Group C herbicide treatments of simazine and Terbyne reduced grain yield by 17 and 26%, respectively.

Group F herbicide (diflufenican)

Diflufenican applied alone had no significant negative impact on any crop performance attribute measured. However, there is a trend for the NDVI to be lower where simazine/diuron was applied in combination with diflufenican compared to simazine/diuron applied alone.

Group B herbicides (chlorsulfuron and Intercept)

Chlorsulfuron applied alone (IBS) reduced crop NDVI 22 July by 14% compared to the control. However, at later timings NDVI was unaffected when chlorsulfuron was applied alone. Despite little effect on crop NDVI at later timings, grain yield (0.93 t/ha) was still reduced by 27% with no other herbicides present. This suggests there was significant effect on the crop below the soil surface that was not obvious in above ground canopy growth.

Table 1. Herbicide treatments for the lentil herbicide tolerance weed control trial at Bute 2019.

Herbicide treatment	Treatment code	Group C	Group C Rate (g/ha)	Diflufenican (mL/ha)	Chlorsulfuron (g/ha)	Intercept (mL/ha)
1	Nil	0	0	0	0	0
2	Sim	Simazine900	400	0	0	0
3	Diu	Diuron900	800	0	0	0
4	Ter	Terbyne750	750	0	0	0
5	Met	Metribuzin750	180	0	0	0
6	Si/Di	Sim/Diu	200/400	0	0	0
7	Chl	0	0	0	5	0
8	Int	0	0	0	0	500
9	Si/Di+Chl	Sim/Diu	200/400	0	5	0
10	Si/Di+Int	Sim/Diu	200/400	0	0	500
11	Chl+Int	0	0	0	5	500
12	Si/Di+Ch+Int	Sim/Diu	200/400	0	5	500
13	Dff	0	0	150	0	0
14	Si/Di+Dff	Sim/Diu	200/400	150	0	0
15	Si/Di+Ch+Dff	Sim/Diu	200/400	150	5	0
16	Si/Di+Dff+Int	Sim/Diu	200/400	150	0	500
17	Complete	Sim/Diu	200/400	150	5	500

Note: Not all rates and herbicides used in this trial are registered for use in lentil and the results and findings reported in this article do not constitute a recommendation of their use by the authors.

Table 2. Crop performance, including vigour score 22 July (0=poor vigour 9=high vigour), GreenSeeker NDVI for 22 July, 19 August and 24 September and grain yield (t/ha) for the lentil herbicide tolerance trial at Bute 2019. NDVI values are predicted from a REML spatial analysis conducted using the statistical package R, letters denote statistical differences.

Treatment code	Group C	Group C Rate (g/ha)	Diflufe-nican (mL/ha)	Chlorsul-furon (g/ha)	Intercept (mL/ha)	Pred. Vigour score 22 July		Pred. NDVI 22 July		Pred. NDVI 19 Aug		Pred. NDVI 24 Sept		Grain yield (t/ha)	
Nil	0	0	0	0	0	7.1	d	0.304	h	0.563	f	0.670	ef	1.27	ab
Sim	Simazine	400	0	0	0	5.2	abcd	0.230	abcdf	0.410	abc	0.592	cde	1.06	cdef
Diu	Diuron	800	0	0	0	4.4	abc	0.228	abcd	0.433	bcd	0.609	cdef	1.15	bcd
Ter	Terbyne	750	0	0	0	5.2	abcd	0.240	bcde	0.415	bc	0.565	c	0.95	def
Met	Metribuzin	180	0	0	0	5.3	abcd	0.264	efg	0.514	def	0.674	ef	1.26	ab
Si/Di	Sim/Diu	200/400	0	0	0	5.5	bcd	0.241	abcdeg	0.451	cde	0.619	cdef	1.13	bcde
Chl	0	0	0	5	0	6.0	cd	0.262	eg	0.506	def	0.597	cde	0.93	ef
Int	0	0	0	0	500	7.1	d	0.299	h	0.534	f	0.662	def	1.44	a
Si/Di+Chl	Sim/Diu	200/400	0	5	0	5.0	abc	0.235	abcde	0.443	bcde	0.567	c	1.00	cdef
Si/Di+Int	Sim/Diu	200/400	0	0	500	5.1	abc	0.247	cdeg	0.427	bc	0.583	cd	1.28	ab
Chl+Int	0	0	0	5	500	5.5	bcd	0.258	deg	0.438	bcde	0.554	bc	0.65	g
Si/Di+Ch+Int	Sim/Diu	200/400	0	5	500	4.5	abc	0.225	abc	0.363	ab	0.475	ab	0.55	g
Dff	0	0	150	0	0	6.2	cd	0.275	gh	0.524	ef	0.688	f	1.39	a
Si/Di+Dff	Sim/Diu	200/400	150	0	0	4.0	ab	0.217	abc	0.399	abc	0.576	cd	1.16	bc
Si/Di+Ch+Dff	Sim/Diu	200/400	150	5	0	3.6	ab	0.211	ab	0.383	abc	0.562	c	0.92	f
Si/Di+Dff+Int	Sim/Diu	200/400	150	0	500	3.2	a	0.217	abc	0.368	ab	0.543	bc	1.14	bcd
Complete	Sim/Diu	200/400	150	5	500	3.7	ab	0.209	a	0.337	a	0.454	a	0.61	g
LSD (P=0.05)						*REML*		*REML*		*REML*		*REML*		*0.2*	
CV														*16.9*	
Fpr						*<0.001*		*<0.001*		*<0.001*		*<0.001*		*<0.001*	

Intercept applied alone on 9 July did not have any impact on NDVI or grain yield. However, when applied in combination with chlorsulfuron, which did not affect NDVI at these timings either, NDVI was reduced by 23% and 19% on 19 August and 24 September, respectively. Although Intercept applied alone (1.44 t/ha) did not reduce grain yield and chlorsulfuron reduced grain yield by 27%, when these two Group B products were applied in combination, grain yield (0.65 t/ha) was reduced by 49% compared to the control. When the Group B herbicides and simazine/diuron were applied in combination, the grain yield (0.55 t/ha) was not significantly lower than the two Group B products applied together. This is in contrast to previous trials, where damage from Group B and C herbicides combined has increased the crop effect.

NDVI and grain yield relationship

Data from previous trials has shown that there is a strong relationship between crop biomass, measured as NDVI, and grain yield on these sandy soil types. The data from this trial supports this, in that the herbicide treatments that caused significant reductions in NDVI also reduced grain yield. Where this trial differs to previous trials is that the slope of the curve is much steeper than has been observed in most previous trials. This means that the reduction in crop biomass has had a more severe impact on grain yield than in previous trials.

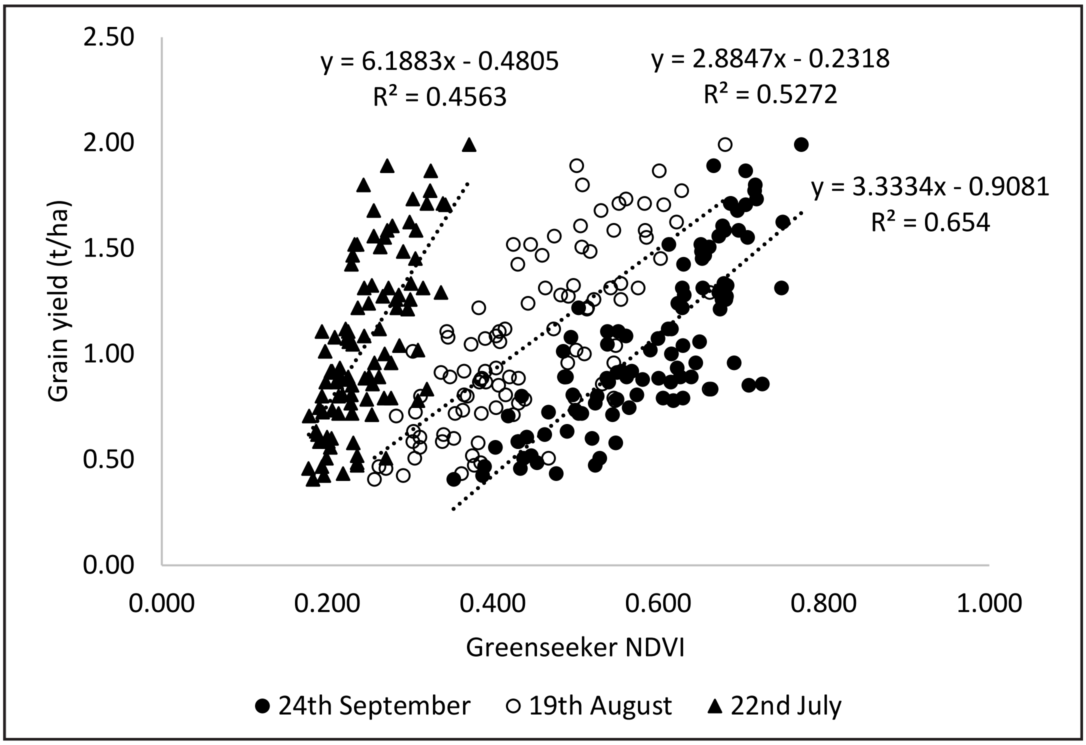


Figure 1. The relationship between plot GreenSeeker NDVI and lentil grain yield (t/ha) for the lentil herbicide tolerance and weed control trial at Bute 2019.

Table 3. Weed efficacy statistics for the lentil herbicide tolerance trial at Bute 2019 including medic populations (5 August), medic score (5 August) (0=no medic remaining, 100=no impact on medic biomass), sow thistle/m² (5 August), sow thistle/plot (30 September), mustard/m2 (5 August), mustard/plot (30 September) and wild turnip/plot (30 September).

Treatment code	Medic /m²	log (1+ Medic /m²)	Medic Score	Log (1+ Medic Score)	Thistle /m²	Thistles /plot	Log (1 + Thistles /plot)	Mustard /m²	Mustard / plot	Log (1 + Mustard /plot)	Turnip /plot	Log (1 + Turnip /plot)
Nil	232.1	5.0	100.0	4.6	4.1	18.0	2.9	2.1	23.0	2.9	1.3	0.7
Sim	86.0	4.1	60.0	4.0	0.4	5.3	1.7	0.5	5.7	1.9	0.3	0.2
Diu	68.9	3.9	41.7	3.6	1.1	6.3	1.8	1.1	5.7	1.7	2.3	1.2
Ter	42.1	2.9	45.0	3.8	1.2	7.0	2.0	0.7	4.0	1.4	0.3	0.2
Met	56.1	3.3	66.7	4.2	1.9	20.3	3.0	0.7	7.3	2.0	2.3	1.0
Si/Di	89.5	4.0	34.0	3.3	1.3	5.0	1.7	0.5	3.7	1.4	0.7	0.4
Chl	44.9	3.3	2.5	1.1	4.7	30.7	3.4	9.9	31.7	3.5	1.0	0.5
Int	82.7	4.2	13.3	2.6	1.5	4.7	1.7	3.5	38.3	3.2	0.3	0.2
Si/Di+Chl	21.5	2.8	2.7	1.0	0.4	6.3	1.9	0.5	6.3	1.7	0.0	0.0
Si/Di+Int	35.2	3.0	2.3	1.0	0.3	3.0	1.1	0.9	8.7	2.3	0.0	0.0
Chl+Int	27.2	3.1	1.2	0.7	2.0	8.0	2.2	4.8	27.7	3.4	0.0	0.0
Si/Di+Ch+Int	30.3	2.5	0.8	0.6	0.3	2.0	1.0	0.5	6.0	1.8	0.0	0.0
Dff	51.2	3.4	65.0	4.1	0.5	0.7	0.5	0.7	0.0	0.0	0.0	0.0
Si/Di+Dff	23.3	2.8	10.5	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Si/Di+Ch+Dff	15.9	2.1	1.3	0.6	0.7	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Si/Di+Dff+Int	18.3	2.3	1.7	1.0	0.5	0.0	0.0	0.1	0.3	0.2	0.0	0.0
Complete	19.7	2.8	1.0	0.6	1.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0
LSD (0.05)		*1.1*	*15.9*	*0.6*	*1.8*	*7.1*	*0.7*	*2.5*	*20.1*	*1.0*	*1.5*	*0.7*
CV		*28.6*	*52.3*	*24.04*	*118.8*	*61.90*	*27.18*	*136.9*	*121.80*	*37.70*	*170.40*	*161.20*
Fpr		*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*0.003*	*<0.001*	*0.014*	*0.017*

Weed efficacy

Medic *(Medicago spp.)*

Medic control was evaluated through plant population and a score of biomass. In some treatments medic population did not truly represent the efficacy of the herbicide, as although there may have been high plant numbers, the biomass of the medic had been reduced by over 90%, so the second score was conducted.

Of the Group C herbicides, Terbyne and metribuzin reduced the medic population by 82% and 76% respectively (Table 3) where simazine and diuron, or the mixture, did not significantly reduce the population at this time. Chlorsulfuron applied alone reduced the medic population by 81% and, despite being applied post emergent, the diflufenican was able to produce 78% control. Combining the three herbicide treatments, Si/Di, Dff and Chl produced the greatest level of control at this time.

The medic score better represents the efficacy of the herbicides on medic populations at this site. The Group C herbicide metribuzin and simazine were not effective at reducing medic biomass significantly, but diuron, Terbyne and the simazine and diuron mix reduced the biomass score by 55%, 58% and 66%, respectively. A general observation was that any medic surviving Group C application did not suffer ongoing suppression, where the surviving plants were more or less unaffected by Group C herbicide application in the spring. This is in contrast to the Group B herbicide effects on medic which were long lasting. When the simazine/diuron mixture was applied with diflufenican a 90% reduction in biomass score was achieved where diflufenican alone did not have any significant effect. The Group B herbicide, chlorsulfuron, had the biggest impact on the medic biomass with a 96% reduction. Intercept, applied post emergent did not perform as well as chlorsulfuron when applied individually, but produced a similar level of control to chlorsulfuron when applied in combination with other herbicides such as the simazine and diuron mix.

Common sow thistle *(Sonchus oleraceus)*

Early population counts of sow thistle (5 August) show a population in the untreated plots of 4.3 plants/m^2. All Group C herbicide treatments were able to provide significant early suppression with an average 75% reduction in numbers. Diflufenican produced a greater level of control with 94% control. Of the Group B herbicides, chlorsulfuron did not have any impact on sow thistle population but the application of Intercept on 9 July reduced the population by 61%.

Once the sow thistles commenced stem elongation and were above the crop canopy, a second count (30 September) was conducted where all sow thistles in the plot were counted. From this data, the efficacy of the Group C herbicides simazine, diuron and Terbyne was maintained, with control of the sow thistle population averaging a 65% reduction in population. However, by this time metribuzin was no longer providing any control. The Group F herbicide diflufenican maintained control of sow thistle with a 96% reduction in population, and in combination with simazine and diuron provided 100% control. As in the early assessment, chlorsulfuron applied alone did not provide any control. There was actually a significant increase in sow thistle density in response to chlorsulfuron application; this may have been due to the reduction in lentil biomass and crop competition increasing weed seedling recruitment and making it easier for the sow thistle to grow beyond the lentil canopy. Intercept maintained control with a 74% reduction in thistle sow population.

Indian hedge mustard *(Sisymbrium orientale)*

At the time of the first assessment of mustard (5 August) there was only a low population with the untreated control plots having only 2 plants/m^2 and no significant reduction in population was identified. At the timing of the second assessment (30 September) the Group C herbicides simazine, diuron and Terbyne provided an average of 78% control reducing the population to only 0.3 plants/m^2. Metribuzin appeared to have an impact on the population, but likely due to the low population and variation across the site, this was not found to be significant. Neither of the Group B herbicides provided any control, indicating that the Indian Hedge Mustard population at this site is likely resistant to these Group B herbicides. In contrast, the diflufenican treatments provided 100% control.

Wild Turnip (*Brassica tournefortii*)

Wild turnip had the lowest population of all species. The untreated control only had an average of 1.3 plants/plot. Despite the low population, some treatment differences were still evident. Diflufenican provided virtually 100% control, with only a single wild turnip plant being found in all 15 plots treated with it. Also, any combination of two herbicides was able to provide virtually complete control.

Acknowledgements

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SAGIT

Trengove Consulting

Managing frost and heat in lentil and faba bean

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Location
Minnipa Agricultural Centre, Paddock N9
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2018 Total: 239 mm
2018 GSR: 176 mm
Yield
Potential: Pulses - 2 t/ha
Actual: 1 to 1.2 t/ha
Paddock history
2017: Wheat
2016: Pasture
2015: Wheat
Soil type
Clay Loam
Soil test
Nitrate 16, ammonium 2, sulphur 9.3 (mg/kg)
Plot size
1 m x 1 m x 3 reps
Trial design
The trial was a factorial split plot design with sowing date allocated to main plots and variety to subplots
Yield limiting factors
Limited rainfall throughout the growing season

Location
Roseworthy
Rainfall
Av. Annual: 400 mm
Av. GSR: 315 mm
2018 Total: 275 mm
2018 GSR: 201 mm
Yield
Potential: Pulses - 5 t/ha
Actual: 1.5 to 2 t/ha
Paddock history
2017: Barley
2016: Canola
2015: Faba bean
Soil type
Sandy clay loam
Soil test
Ammonium 15, nitrate 10 (mg/kg)
Plot size
1 m x 1 m x 3 reps

Key messages

- **Pulses are more vulnerable to yield loss from heat and frost stress in a critical period centred around early podding.**
- **Sowing time and variety choice are crucial to reduce risk of stress at this stage.**
- **We define the safer window for the critical period as less than 10% chance of frost (0°C in the Stevenson screen) and less than 30% chance of heat (>34°C in the Stevenson screen).**
- **In environments of upper Eyre Peninsula, such as Minnipa, there is limited frost risk, hence early sowing will minimise heat risk and maximise potential yield.**
- **However, at sites such as Laura (Mid North), there is a safer window after frost and before heat.**
- **Results should be considered in conjunction with grower specific conditions and the trade-off between early sowing, weed and disease management and rainfall.**

Why do the trial?

Pulses are growing in popularity as a result of good prices and rotational benefits such as decreased N input and enhanced grass weed control options. However frost and combinations of water and heat stress at critical growth stages can compromise crop yield. Previous work in pulses has established that the most important time to maintain growth and limit stress is the period around pod set. Sowing date and variety choice are the two main tools to manipulate time of flowering and pod-set, and thus manage the risk of extreme temperatures, water stress and the trade-off between frost and heat risk.

This research aims to identify the safer temperature windows for the critical period for yield for faba bean and lentil in cropping regions of southern Australia. This work follows on from EPFS Summary 2016 p62, EPFS Summary 2017, p146 and EPFS Summary 2018, p62.

How was it done?

Field trials have been conducted at Minnipa Agricultural Centre (2016-18), Hart (2016), Roseworthy (2017-18), Bool Lagoon (2016-17) and Conmurra (2018) to test the effect of sowing date on phenology and yield of lentil and faba bean varieties. We combined six sowing dates ranging from 20 April to 11 July with ten varieties of each crop chosen in consultation with breeders and industry experts. Faba bean varieties included Icarus, AF03001-1, PBA Rana, PBA Samira, Farah, PBA Zahra, Aquadulce, 91-69, Fiord, and Nura. Lentil varieties were PBA Blitz, Northfield, CIPAL901, CIPAL1301, PBA HurricaneXT, PBA Hallmark XT, PBA Giant, PBA Jumbo2, Nugget, and Matilda.

For each species at each location, three replications were sown for each variety and sowing date. Crops were sown by hand in a split-plot design with sowing dates allocated to the main plot and

Trial design
As above
Yield limiting factors
Limited rainfall throughout the growing season

Location
Conmurra
Rainfall
Av. Annual: 650 mm
Av. GSR: 490 mm
2018 Total: 709 mm
2018 GSR: 570 mm
Yield
Potential: Pulses - 5 t/ha
Actual: 3 t/ha
Paddock history
2017: Faba bean
2016: Cereal
2015: Cereal
Soil type
Black clay loam
Soil test
Ammonium 5, nitrate 35, sulphur 9 (mg/kg)
Plot size
1 m x 1 m x 3 reps
Trial design
As above
Yield limiting factors
Some accidental herbicide damage limited yield

varieties randomized within each subplot. Plot size was 1 m^2 and consisted of 3 rows, 0.27 m apart. Density was 60 plants/m^2 (faba bean) and 120 plants/m^2 (lentil). Prior to sowing, P was supplied by applying 80 kg/ha of MAP (10:22:0:0). During the growing season, we measured phenology twice weekly within the central rows of the plots. We recorded emergence and the date when 50% of plants within the central row show the first appearance of: flowers, pods, end of flowering and maturity.

Phenology data was then used to calibrate and validate APSIM (Figure 1). The model was used with historical weather data to simulate flowering date for early, mid and later flowering varieties across 61 years and nine sowing dates ranging from 1 April to 1 August. We use 200°Cd (degree days) after flowering as the critical period.

What happened?

Lentil data is still being analysed so only the faba bean data is presented. The observed data was matched to the simulated data explaining more than 87% of the variability (Figure 1) providing a reliable tool to predict flowering across varieties, sowing dates, years and environments. In agreement with observations, modelling showed that delayed sowing reduced the length of phenological phases and reduced the spread of the critical period (Figure 2 bottom panels).

The safer window for the critical period ranged from before 9 October in Minnipa, and between 1 September and 27 October in Laura (Figure 2).

Due to the low frost risk at Minnipa, sowing any variety before 15 July hits the safer window. However, at sites such as Laura where spring frosts are a risk, but the onset of heat occurs later in spring, sowing needs to be later than 1 May (or with PBA Samira on 1 May) and can be as late as 30 July.

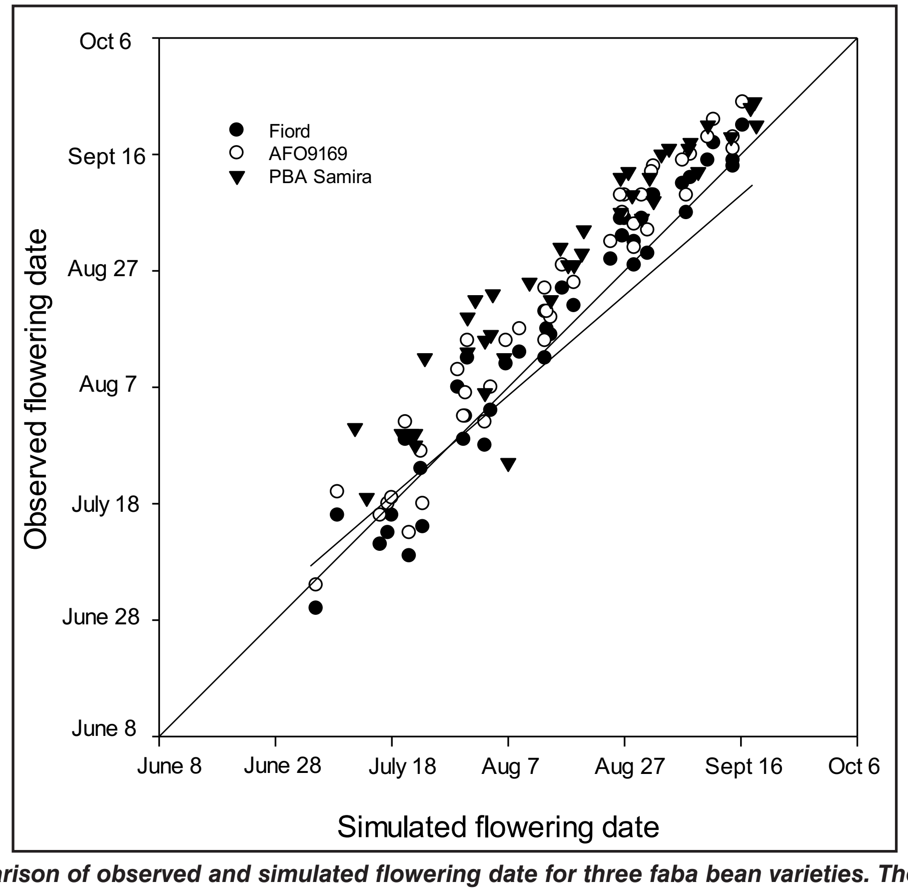

Figure 1. Comparison of observed and simulated flowering date for three faba bean varieties. The solid line is the 1:1 line representing perfect agreement, while the shorter line is a reduced major axis (RMA) regression done with IRENE. R^2 for the individual regressions are: Fiord 0.91, PBA Samira 0.87 and AFO9169 0.95.

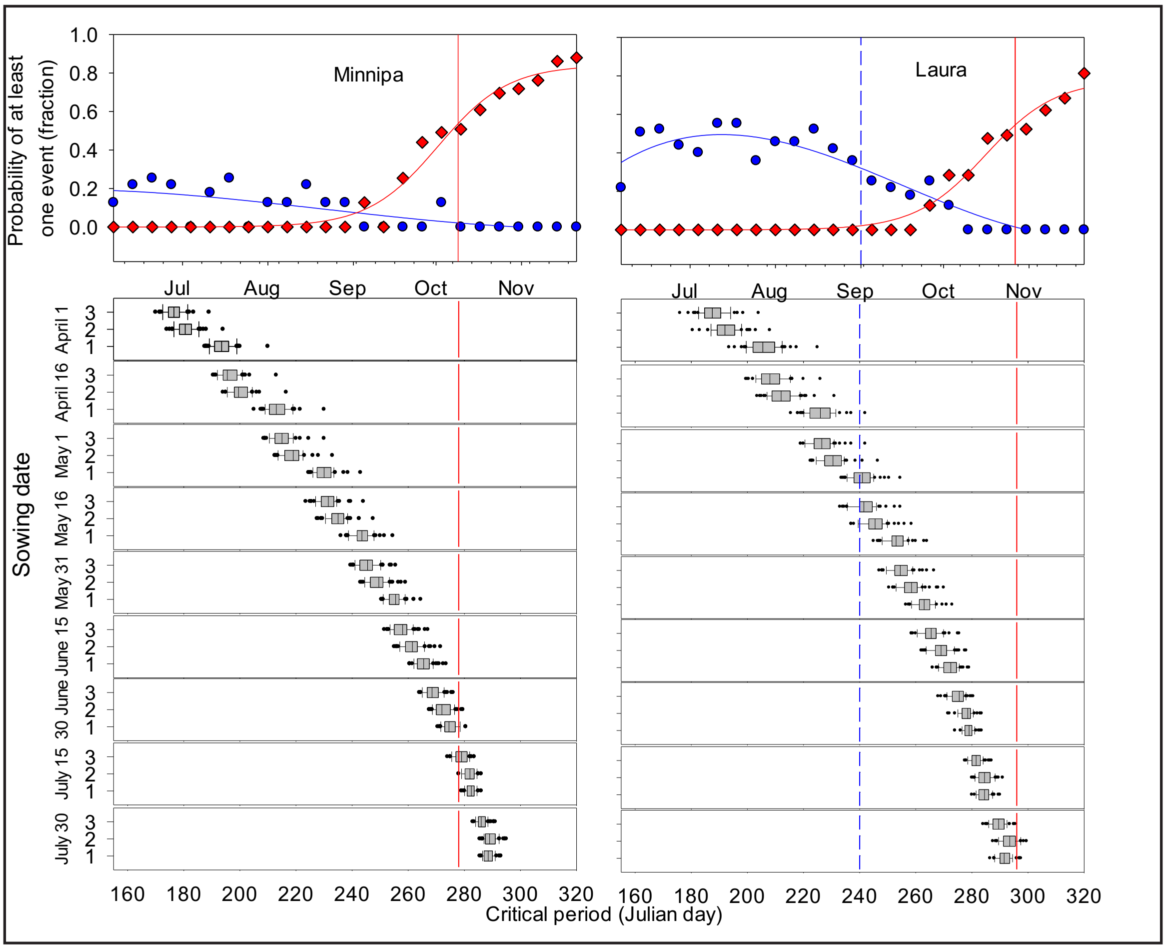

Figure 2. Weekly probability of experiencing at least one frost (circles) or heat event (diamonds) (top panels), and the critical period for three faba bean varieties (bottom panels) with sowing dates ranging from 1 April to 30 July. Varieties are Fiord, PBA Samira and AFO9169. Probabilities have been square root transformed (e.g. take the square root of the probability) in order for the models to best describe the data. For Minnipa the safer window is before the 30% heat risk (solid line), while for Laura the safer window is between the dashed line (10% frost risk) and the solid line (30% heat risk). Note Minnipa does not reach 10% frost risk, hence no dashed line.

What does this mean?

The genetic variability in phenology of both lentil and faba bean coupled with sowing date, can be strategically used by growers to target a specific safer window that reduces likelihood of both frost and heat stress. In the absence of severe frost, sowing before the middle of May will be more likely to provide the maximum yield for drier locations of upper Eyre Peninsula such as Minnipa, whilst allowing some flexibility in the system for other factors such as soil moisture, weed and disease control. In cooler environments delayed sowing is necessary to avoid damage from frost in the critical period. Results for lentil and a wider range of environments for faba bean will be made available later in 2020.

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Vetch Variety Performance on Challenging Soils and Response to Grazing

Author: Stefan Schmidt, Ag Consulting Co.
Funded By: Nelshaby Agricultural Bureau and Upper North Farming Systems Inc.
Project Title: Vetch Variety Performance on Challenging Soils and Response to Grazing.
Project Duration: 2019
Project Delivery Organisation: Ag Consulting Co.

Why do the trial?

Vetch is an important break crop in the Lower Broughton region due to its hardiness and versatility in mixed farming systems. Vetch is known to perform well relative to other legumes on challenging soils. In the lower Broughton region vetch is often the legume of choice on paddocks affected by transient salinity. At present there is little available data exploring the performance of different vetch cultivars on saline soils. This trial aimed to explore the performance of four vetch cultivars on a challenging soil type typical to this region.

Key Message?

Grazing of vetch plots resulted in a significantly lower final biomass at flowering compared to un grazed plots as expected. RM4 vetch had significantly higher biomass levels at flowering post grazing compared to cultivars Timok, Studenicia and Volga which did not significantly differ from one another.

RM4 vetch has a potential fit in the lower Broughton to provide late feed or for increased hay production.

In this year there was no significant difference between the peak biomass at flowering between the four cultivar assessed in this trial.

How was it done?

The trial was a randomised complete block design consisting of 4 vetch cultivars by two treatments grazed (mechanically defoliated on the 27th July) verse ungrazed by four replications. Plots were 10m x 1.5m and were sown with a plot seeder with a knifepoints and press wheels on 250mm row spacings. Herbicide treatments were applied using a 2m hand boom at 100L/ha.

Sowing Date -6th of May

Fertiliser - 60kg/ha Koch MesZ

Sowing Rate - 35kg/ha

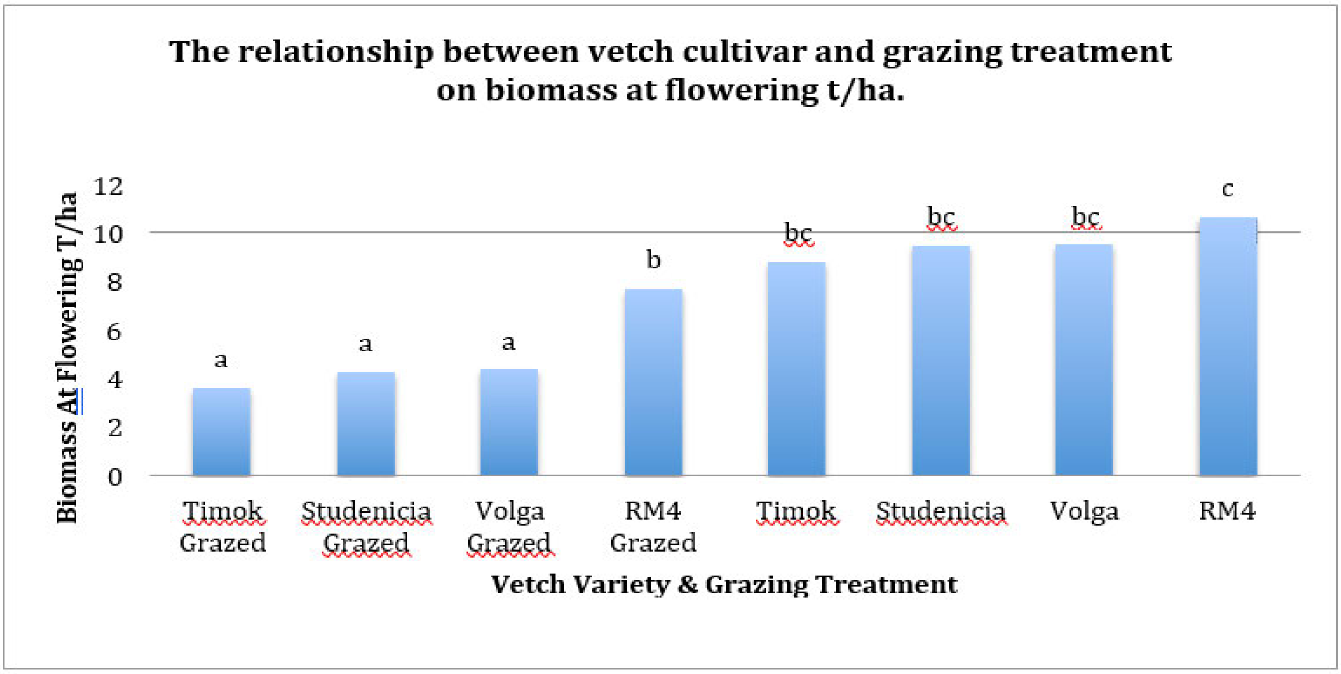
Vetch cultivars Volga, Timok, Studenicia, RM4

Table 1. Characteristics of selected vetch varieties sourced from 2020 SA Crop Sowing Guide.

Vetch Variety	Maturity	Grain Yield	Dry Matter Production	Flower Colour	Pod Shatter % of	Hard Seeds %of	Rust Rating	Ascochyta Rating	Botrytis Rating
Volga	Early	V High	High	Purple	0-2	0-2	R	Ms	S
Timok	Mid	High	V High	Purple	0-2	2-5	R	Ms	S
Studenicia									
RM4 – Wooly Pod	Mid	Moderate	V High	Purple	2-5	2-5	R	MR	V S

Results

Figure 1: Vetch varietal response to grazing. An analysis of variance (ANOVA) was conducted on the data using Genstat statistical software at the 95% level of confidence. Treatments with letters in common are not significantly different. Note biomass at flowering is comprised of approximately 70% water.



Results

Grazing Interaction

Grazing of vetch plots resulted in a significantly lower final biomass at flowering compared to ungrazed plots as expected. RM4 vetch had significantly higher biomass levels at flowering post grazing compared to cultivars Timok, Studenicia and Volga which did not significantly differ from one another.

Total Biomass Production

In this year there was no significant difference between the peak flowering biomass of the ungrazed cultivars

Conclusions

In this trial we were unable to demonstrate a significant difference in peak biomass at flowering between the four cultivars assessed in this trial. With respect to grazing treatments RM4 woolly pod vetch recovered from simulated grazing better than common vetch varieties. This can be most likely attributed to the fact that woolly pod vetches are known to produce biomass later in the season. When grazing treatments were applied on the 27th of July RM4 had produced less biomass than common vetch varieties in this trial. As a result it had used up less resources allowing it to recover and produce more biomass later in the season.

Surprisingly in this trial RM4 vetch has performed as well as common vetch on this challenging soil type. Observations from WA are that RM4 performs well on saline soils. Whilst it has not out performed common vetch in this season it has shown merit as an option to fill feed gaps at the end of the season in this region. In higher rainfall years woolly pod vetch is known to produce significantly higher biomass yields than common vetch. Uptake of woolly pod vetch has been limited in the past because of the hard seeded nature of older cultivars. This barrier to adoption has been overcome in RM4, which is a soft seeded variety. Further research into the fit of RM4 in the district would be of value.

Acknowledgements:

Trial conducted by Stefan Schmitt: Ag Consulting Co on behalf of the Nelshaby Agricultural Bureau and the Upper North Farming Systems Inc. Thankyou for your support!

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Image 1 & 2: UNFS Farming Well in 2019 Event @ the Blacksmith's Chatter in Orroroo, SA.

Alternative Herbicide Options In Vetch

2019 Trial Lower Broughton

Author: Stefan Schmidt, Ag Consulting Co.
Funded By: Nelshaby Agricultural Bureau and Upper North Farming Systems Inc.
Project Title: Alternative Herbicide Options In Vetch Lower Broughton
Project Duration: 2019
Project Delivery Organisation: Ag Consulting Co

Why do the trial?

Vetch is an important break crop in the Lower Broughton region due to its hardiness and versatility in mixed farming systems. Achieving adequate broadleaf weed control can be challenging in vetch due to 1) limited in crop selective herbicides that are safe 2) The shift to earlier/dry sowing which decreases the chance of achieving a knockdown on weeds prior to sowing & 3) Earlier/dry sowing resulting in residual chemicals loosing activity earlier in the season.

Over the past few seasons it have been identified that this shift in sowing practice has increased the levels of hard to control weeds such as statice, iceplant and mallow in vetch. The aim of this trial was to explore a range of pre and post emergent chemical options. That may provide improved weed control in vetch.

Key Messages

Diurex & Diurex + Terrain applied in front of the seeder was safe to use on vetch cv. Volga. Diurex & Diurex + Terrain resulted in improved control of statice & iceplant.

Brodal Options (not registered) alone or with Diurex and Diurex+ Terrain applied in front of the seeder produced some crop phytotoxicity and some minor biomass reduction, however, plots generally recovered adequately.

Igran applied PSPE was safe to use on vetch cv. Volga. Igran applied EPE produced some crop phytotoxicity and some crop biomass reduction that might be considered commercially unacceptable. A lower rate of Igran applied EPE may need to be tested for improved crop tolerance. At the rates used in this trial Igran PSPE only provided marginal improvement in the control of statice and iceplant.

Thistrol Gold + Wetter and Thistrol Gold + Ecopar + Wetter produced some phytotoxicity and some crop biomass reduction that might be considered commercially unacceptable. Thistrol Gold & in combination with Ecopar provided improved control of mallow, and suppression of iceplant and statice.

Several of the herbicides applied in this trial are unregistered for use in vetch and a permit should be sought before considering the use of these on vetch crops.

PSPE – Post Sowing Pre
Emergent EPE – Early Post
Emergent
IBS – Incorporated By Sowing

How was it done?

The trial was a randomised complete block design consisting of 11 treatments with four replications. Plots were 10m x 1.5m and were sown with a plot seeder with a knifepoints and press wheels on 250mm row spacings. Herbicide treatments were applied using a 2m hand boom at 100L/ha.

Sowing Date -6th of May
Fertiliser - 60kg/ha Koch MesZ
Sowing Rate - 35kg/ha
Vetch cultivar- Volga

Table 1. Treatment Details

Trt. No.	Treatment Name	Product Rate/ha	Application Code
1	Untreated control	-	-
2	Diurex	600g	A
3	Diurex Terrain	600g 180g	A A
4	Brodal Options	200mL	A
5	Diurex Brodal Options	600g 200mL	A A
6	Diurex Terrain Brodal Options	600g 180g 200mL	A A A
7	Igran	2L	B
8	Igran	0.7	C
9	Thistrol Gold Activator	2 0.125	C C
10	Thistrol Gold Ecopar Activator	1 400 0.125	C C C
11	Ecopar Activator	800 0.125	C C

Table 2. Application Details

Appl. Code	A	B	C
Appl. Timing	IBS	PSPE	EPE
Date	6th May 2019	6th May 2019	17th June 2019
Time of day	1000 – 1100 hours	1400 – 1415 hours	1100 – 1130 hours
Temperature	14°C	20°C	13°C
Relative Humidity	75%	40%	70%
Wind speed and direction	4 km/hr N	15 km/hr N	15 km/hr NW
Cloud cover	0%	0%	50%
Moisture 1 week after appl.	16.6mm	16.6mm	
Water volume	100 L/ha		
Nozzle type	Albuz AVI 110-01		
Operating pressure	3.5 bar		

Table 3. Crop phytotoxicity assessments conducted on a 0-100 scale where 0 = untreated control and 100 = complete plant death. Crop biomass was assessed using a percent scale relative to untreated plots where untreated = 100%.
Data analysis – An analysis of variance was conducted using ARM 2018, treatment means were separated using Duncan's New Multiple Range Test at the 95% level of probability. Treatments with letters in common are not significantly different.

Trial ID: Port Pirie Vetch Trial				**Vetch *cv.* Volga**					
Location: Port East SA				**Crop Phytotoxicity**		**Crop Biomass**		**Crop Biomass**	
				16 DAA-C		**16 DAA-C**		**43 DAA-C**	
Trt. No.	**Treatment Name**	**Product Rate/ ha**	**Application Code**	**0-100**	**AS**	**%**	**EC**	**%**	**ER1**
1	Untreated control	-	-	0	c	100		100	a
2	Diurex	600g	A	0	c	100	a	100	a
3	Diurex Terrain	600g 180g	A A	1	c	100	a	97	ab
4	Brodal Options	200mL	A	1	c	95	abc	93	bc
5	Diurex Brodal Options	600g 200mL	A A	1	c	98	ab	95	ab
6	Diurex Terrain Brodal Options	600g 180g 200mL	A A A	0	c	95	abc	97	ab
7	Igran	2L	B	0	c	100	a	100	a
8	Igran	0.7	C	7	b	91	cd	83	de
9	Thistrol Gold Activator	2 0.125	C C	15	a	85	e	80	e
10	Thistrol Gold Ecopar Activator	1 400 0.125	C C C	14	a	86	de	88	cd
11	Ecopar Activator	800 0.125	C C	10	ab	93	bc	97	ab
LSD (P=.05)				2.26 - 5.34		5.37		5.2	
Standard Deviation				0.52t		3.7		3.05	
CV				28.92t		3.93		3.26	
Treatment Prob(F)				0.0001		0.0001		0.0001	

IBS/PSPE Crop Safety *DAA – Days After Application

Diurex and Diurex + Terrain were generally quite safe to vetch *cv*. Volga, with no crop phytotoxicity present in these treatments during the trial. Very minor biomass reduction was present in the Diurex

+ Terrain treatment at 43 DAA-C, however, it was not significantly different from the Untreated Control.

Brodal Options, Diurex + Brodal Options and Diurex + Terrain + Brodal Options all produced significant crop phytotoxicity at 28 DAA-A, which suggests that diflufenican applied IBS can cause some bleaching in vetch *cv*. Volga. The crop phytotoxicity had diminished by 16 DAA-C. Brodal Options, Diurex + Brodal Options and Diurex + Terrain + Brodal Options also produced minor biomass reduction at 16 DAA-C and 43 DAA-C.

Igran applied PSPE produced no crop phytotoxicity or reduction in crop biomass.

All herbicide treatments applied IBS or PSPE produced similar crop emergence to the Untreated Control.

EPE CROP SAFETY

All herbicide treatments applied EPE produced significant crop phytotoxicity at 16 DAA-C, although was not considered to be commercially unacceptable.

All herbicide treatments applied EPE produced crop biomass reduction at 16 DAA-C and 43 DAA-C. Igran, Thistrol Gold + Activator and Thistrol Gold + Ecopar + Activator all had significantly less biomass than the Untreated Control at 43 DAA-C. Ecopar + Activator showed good recovery and produced very minor biomass reduction at 43 DAA-C, which was not significantly different to the Untreated Control.

CONCLUSIONS

Diurex and Diurex + Terrain applied IBS were safe to use on vetch *cv*. Volga.

Brodal Options alone or with Diurex and Diurex + Terrain applied IBS produced some crop phytotoxicity and some minor crop biomass reduction, however, the crop generally produced adequate recovery. Lower rates of Brodal Options applied IBS may need to be tested for improved crop tolerance.

Igran applied PSPE was safe to use on vetch *cv*. Volga. Igran applied EPE produced some crop phytotoxicity and some crop biomass reduction that might be considered commercially unnaceptable. A lower rate of Igran applied EPE may need to be tested for improved crop tolerance.

Thistrol Gold + Activator and Thistrol Gold + Ecopar + Activator produced some crop phytotoxicity and some crop biomass reduction that might be considered commercially unacceptable.

Several of the herbicides applied in the trial are unregistered for use on vetch and a permit should be sought before considering the use of these on vetch crops.

Thankyou!

I would like to thank the Nelshaby Agricultural Bureau and the Upper North Farming Systems group for providing funding to carry out this trial. I would also like to thank David Keetch, Field Development Officer from Nufarm for assistance with trial assessments, planning and reporting.

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Nufarm

Dryland Legume Pasture Systems: Small plot species adaptation trial

Fiona Tomney[1], Ross Ballard[2], David Peck[2], Jeff Hill[2], Ian Richter[1] and Naomi Scholz[1]
[1]SARDI, Minnipa Agricultural Centre; [2]SARDI, Waite

Location
Minnipa Agricultural Cenre, paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Paddock history
2018: Medic pasture
2017: Scepter wheat
2016: Medic pasture
Soil type
Red sandy loam
Soil test
pH$_{(H2)}$ (0-10 cm) 8.4
Plot size
5 m 1.5 m x 3 reps x 25.5 cm row spacing

Key messages

- **This is a component of a five year Rural Research and Development for Profit funded project supported by GRDC, MLA and AWI; and involving Murdoch University, CSIRO, SARDI, Department of Primary Industries and Regional Development; Charles Sturt University and grower groups.**
- **This trial aims to assess a diverse range of annual pasture legumes in order to determine whether there are more productive and persistent options for the drier areas (<400 mm) of the mixed farming zone of southern Australia.**
- **The annual medics were the most productive pasture legume producing > 2 t/ha DM and setting > 500 kg/ha of seed. A new Tetraploid Barrel medic was the most productive.**
- **Astragalus was the most promising alternative legume and warrants further evaluation.**

Why do the trial?

Legume pastures have been pivotal to sustainable agricultural development in southern Australia. They provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens, improve fertility through nitrogen (N) fixation and mixed farming reduces economic risk. Despite these benefits, pasture renovation rates remain low and there is opportunity to improve the quality of the pasture base on many low to medium rainfall mixed farms across southern Australia. A diverse range of pasture legume cultivars are currently available to growers and new material is being developed. Some of these legumes, such as the annual medics, are well adapted to alkaline soils and have high levels of hard seed, which allow them to self-regenerate from soil seed reserves after cropping (ley farming system). Other legume cultivars and species are available and being developed that offer improved seed harvestability, are claimed to be better suited to establishment when dry sown and/or provide better nutrition for livestock. Regional evaluation is being undertaken to determine if they are productive and able to persist in drier areas (<400 mm annual rainfall) and on Mallee soil types common to the mixed farming zone of southern Australia.

How was it done?

The trial at Minnipa in paddock S8 was arranged in a fully randomised block design with three replications.

Nine legume entries were sown comprising two new tetraploid (double chromosome number) barrel medics; the new French serradella cultivar Frano, developed by Murdoch University; Ioman astragalus along with a new rhizobia strain; diffuse clover and Cefalu arrowleaf clover. Strand medic line PM-250 and barrel medic cultivar Sultan-SU were included as the controls for comparison.

The trial was sown on 16 May 2019 into moist soil. Plant emergence counts were completed on 18 June. Plots were scored for vigour on 6 August. Ioman astragalus and Frano French Serradella were sampled to determine if nodulation was satisfactory on 2 September. Early dry matter (DM) cuts were completed on 13 September. These samples will be used to determine nutritive value, however the results are not yet available. Plots were sampled to estimate seed production on 4 November 2019.

What happened?

The season opened in May with 44 mm of rainfall, enabling the trial to be sown into moist soil and over a month earlier than in 2018. Although Minnipa received less overall rainfall in 2019, the majority of the rain fell in the growing season, with an early September rainfall providing a valuable boost. This may have allowed some of the later maturing legumes to perform better than they might have in a more typical season.

All legume lines emerged 3 weeks post-sowing, however it was apparent that some lines had uneven or poor emergence, especially the two clover species. This was likely due to their smaller seed size resulting in them being sown too deeply. At this time the best emerged plots were Frano serradella and Ioman astragalus.

All lines continued to grow with the annual medics consistently the most productive species, producing > 2 t/ha DM. The new Tetraploid Barrel medic 1-2 was the most productive line, producing 2.24 t/ha DM.

Ioman astragalus performed well throughout the trial with vigorous early growth and good DM production, over three times that of the accession grown in 2018, with 1.74 t/ha this season compared to only 0.50 t/ha in 2018. Ioman astragalus also appeared to be fixing nitrogen as active nodules were found on its roots.

Frano French serradella consistently displayed more vigorous growth and more biomass than Margurita French serradella (Table 1). Frano produced 0.36 t/ha DM, which was over twice that of Margurita's 0.12 t/ha, however towards the end of their growing season in mid-October, the two cultivars were difficult to tell apart, Margurita having caught up; however in general the performance of the serradellas was poor. From early July the two serradella cultivars began to display a yellowish leaf colour, possibly the result of poor nodulation (2 nodules per plant) which is a known problem for this legume on alkaline soils and observed previously at Minnipa. The discolouration persisted until late September when 46 mm rain freshened up the trial and the serradellas appeared to fully recover.

Cefalu Arrowleaf clover and diffuse clover also had strong responses to the September rainfall, with vigorous growth into early November when the other lines, especially the medics, had already senesced. This extra growth was unfortunately not quantified as the decision was made not to take extra DM cuts, in order to maximise seed set for regeneration. Visually the late biomass of diffuse clover appeared similar to Frano French serradella, despite its very low DM cut of 0.09 t/ha on 13 September.

All legume lines flowered and set seed (Table 2). Ioman astragalus had the highest seed production with 35,761 seeds/m^2 (1698 kg seed/ha). This is considerably more than the 12,643 seeds/m^2 generated by the astragalus accession grown in 2018, but is a reflection of a threefold increase in biomass for 2019. PM-250 Strand medic also produced considerably more seed in this trial with 17,888 seeds/m^2 (601 kg seed/ha) compared to the 2018 trial (6,181 seeds/m^2) as a result of increased biomass.

Table 1. Average plant density (plants/m^2), plot vigour score and dry matter (t/ha) at Minnipa, 2019.

Pasture legume species	Plant density (plants/m^2) 18 June	Average plot vigour score 6 Aug	Dry matter (t/ha) 13 Sept
Ioman Astragalus	152	7.7	1.74 a
Frano French Serradella	116	6.7	0.36 b
Margurita French Serradella	64	5.3	0.12 b
Cefalu Arrowleaf Clover	107	6.5	0.43 b
Diffuse Clover	47	4.8	0.09 b
Tetraploid Barrel medic 1-2	89	7.3	2.24 a
Tetraploid Barrel medic 2-1	112	7.5	2.11 a
Sultan-SU Barrel Medic	120	7.5	2.16 a
PM-250 Strand Medic	75	7.8	2.14 a
LSD (P=0.05)			*0.70*

Table 2. Seed assessment measurements at Minnipa, 4 November 2019.

Pasture legume species	Average No. of seed pods/m^2	Average No. of seeds/pod	Average No. of seeds/m^2	Average seed yield (kg/ha)
Ioman Astragalus	1698	21	35761	1698
Frano French Serradella	500	3	1465	29
Margurita French Serradella	423	3	1145	20
Cefalu Arrowleaf Clover	383	79	30542	318
Diffuse Clover	372	82	30545	338
Tetraploid Barrel Medic 1-2	2172	6	13781	530
Tetraploid Barrel Medic 2-1	2220	7	14575	575
Sultan-SU Barrel Medic	1857	7	13030	563
PM-250 Strand Medic	3005	6	17888	601

The seed production of the serradellas was the least and may be insufficient for adequate regeneration. Margurita's seed set was only 1,145 seeds/m^2 (20 kg seed/ha). This was probably due to its flowering period through mid-September and October, which coincided with some extremely hot temperatures. Cefalu Arrowleaf clover and diffuse clover had even later flowering periods, from mid-October into November. Although both lines still set very large amounts of seed with >30,000 seeds/m^2, this may not have occurred in the absence of the September rainfall.

What does this mean?

Despite another challenging season with less annual rainfall than in 2018, all of the pasture legume lines established, flowered and set seed, although the amount set by the serradellas may be insufficient for regeneration. The annual medics were the most productive pasture legume in terms of both dry matter and seed set. They continue to be the best pasture option for neutral to alkaline soils on the upper EP.

In the 2018 and 2019 Dryland Legume Pasture Systems Legume Adaptation trials, astragalus was the best adapted alternative legume species. This 2019 trial included the cultivar Ioman that grew vigorously, set large amounts of seed and appeared to be actively fixing nitrogen; it can also have seed harvested by a grain harvester. Astragalus merits further investigation in the Minnipa environment, however seed is not commercially available.

The clovers and serradellas showed the ability to respond to spring rain when the medics had already set seed and begun to senesce, however their overall production was poor and the seed set of the serradellas was penalised by its late flowering time. Whilst the clovers still managed to set a considerable amount of seed despite an even later flowering window, which fell through some extremely hot temperatures, their productivity and ability to set seed has not yet been assessed in the Minnipa environment in a season with average spring rainfall.

In 2020 the trial will be sown to wheat, with pasture legume regeneration following the cropping phase measured in 2021. Their regeneration after the cereal phase, which is the recommended practice for some pasture legumes following their establishment year, will be a function of the amount of seed set and suitability of their hard seed level to the Minnipa environment.

Acknowledgements

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Commercial annual legume cultivars are produced by a range of companies and we appreciate them making their cultivars available for this work.

Dryland Pasture Legumes Options - Morchard

Author: Andrew Catford – Northern Ag, Jamie Wilson UNFS
Funded By: Rural R&D for Profit and Mallee Sustainable Farming
Project Title: Boosting profit and reducing risk on mixed farms in low and medium rainfall areas with newly discovered legume pastures enabled by innovative management methods – southern region
Project Number – GRDC Project Number 9175959
Project Duration: 2019 - 2021

Key Points:

- Year 1 of the project looking at different pasture legumes suitability for the low rainfall heavy clays of the Upper North. Site located at Morchard.
- Volga Vetch (Biomass 4.27t/Ha wet weight/1.35t/Ha dry weight), Volga/Sultan Mix (Biomass 3.04t/Ha wet weight/1.04t/Ha dry weight) and PM250 (Biomass 1.8t/Ha wet weight/0.68t/Ha dry weight) provided the highest establishment and biomass
- Nodulation was the highest on Volga Vetch.
- Biomass was the highest in these 3 for wet weight – Volga Vetch -4.27t/Ha wet weight (1.35t/Ha dry weight); Volga/Sultan Mix – 3.04t/Ha wet weight (1.04t/Ha dry weight) and PM250 – 1.8t/Ha wet weight (0.68t/Ha dry weight)
  2020 will look at pasture re-generation in a cropping phase at this site and establishment at a second site near Jamestown.

Background

The Dryland Legume Pasture Species project has been driven by significant changes in farming practices. Over the past three decades there has been a shift from integrated crop-livestock production to intensive cropping in drier areas, which has significantly reduced farm enterprise resilience. Intensive cropping is prone to herbicide resistant weeds, large nitrogen fertiliser requirements, and major financial shocks due to frost, drought or low grain prices.

The overall outcome of this pasture legume demonstration is to gain greater understanding of which pasture legume options are best suited to the environment of the Upper North Region. This demo will be run over 3 seasons (2019, 2020 and 2021) and will look at a number of different factors which influence how a pasture legume is able to fit into the modern rotation of farming in the Low Rainfall Zone (LRZ) regions of South Australia.

Methodology

The Morchard Tennis Club paddock (Northern Side of the Tennis Courts) was the site of this trial and has a uniform clay loam soil profile. As this was a demonstration site the plots were not replicated, the plots were sown with the UNFS Plot seeder. Each Plot was 2.0m X 20m long.

The site was soil tested on the 24th of May 2019. The trial was then sown on 27th May 2019 with 60Kg/Ha 0f 19:13 fertiliser (11.4kg nitrogen/Ha; 7.8kg phosphorus/Ha; 5.4kg sulphur/Ha)

The seeding rate of each variety varied and can be referred to in Figure 1 – Variety and seeding rate below. A range of seeding rates were undertaken to look at establishment, biomass and nodule production.

The site had significantly below average rainfall for 2019 with a Total Rainfall of 135 mm and 90 mm Growing Season Rainfall (Average Annual Rainfall – 325.6mm; Average Growing Season Rainfall (April – October) – 200.5mm per Bureau of Meteorology).

On the 10th of September 2019, Dry Matter Cuts (wet weight and dry weight) and Nodule counts – for N fixing capability were undertaken. Initially the aim was to take 3 biomass cuts at 3 different times but due to the seasonal conditions this was not possible.

This is a self-regenerating 3 year project for effective legume establishment in the Low Rainfall Zone of South Australia. Site 1 at Morchard was sown in 2019. Site 2 at Jamestown was sown in 2019, however this trial site was compromised and a new site will instead be sown in 2020 as year 1.

Year 1;

- Establishment counts ***(Figure 2).***
- Biomass cuts ***(Figure 3)***. Originally planned at three growth stages but due to the poor season we only managed a peak biomass as other cuts would not have shown and results.
- Nodule Counts ***(Figure 4)***, N-Fixation and nutrition tests have been sent off for testing, and we're awaiting results.

	West					
	Row	**Cultivar**	**Species**	**Rate kg/ha**		
Fence	1	Sultan- SU	Barrel Medic	10		
	2	Sultan- SU	Barrel Medic	2.5		
	3	Toreador	Disc Medic	7.5		
	4	Scimitar	Burr Medic	7.5		
	5	PM250	Strand Medic	7.5		
	6	Margurita	Serradella	7.5		
	7	Volga	Vetch	40		
	8	Volga	Vetch	10		
		Sultan- SU	Barrel Medic	10		
	9	Biserrula	Biserrula	5		
	10	Sardi Rose	Rose	3.75		
		Bartolo	Bladder	3.75		
	11	Control				
	12	Sultan- SU	Barrel Medic	10		
	13	Sultan- SU	Barrel Medic	2.5		
	14	Toreador	Disc Medic	7.5		
	15	Scimitar	Burr Medic	7.5		
	16	PM250	Strand Medic	7.5		
	17	Margurita	Serradella	7.5		
	18	Volga	Vetch	40		
	19	Volga	Vetch	10		
		Sultan- SU	Barrel Medic	10		
	20	Biserrula	Biserrula	5		
	21	Sardi Rose	Rose	3.75		
		Bartolo	Bladder	3.75		

***Figure 1** – Seeding rate and variety*

Year 2 (2020, cereal phase) Assessments will focus primarily on the cereal phase with the following measurements to be taken - NDVI, mid-season weed assessment, cereal yield and protein. Pasture generation

Year 3 (2021) Pasture counts of species regeneration after cropping phase, to establish similar criteria as year one.

Results and Discussion

The trial had a wide range of pasture legumes with medics (strand, burr, barrel, and disc), clover (rose and bladder), vetch, biserrula and serradella, refer to Table 1 on the species mix sown at the trial.

Table 1 – Annual pasture legumes sown in the trial

Variety	**Notes**
Sultan – SU – Barrel medic	Tolerant of SU residues, boron tolerant, good aphid resistance
Toreador – Disc medic	Developed for sandy soils
Scimitar – Burr medic	Old cultivar, spineless
PM250 – Strand medic	Powdery mildew resistant, tolerant of SU herbicides, specifically developed for SA dryland mallee systems
Margurita Serradella	WA cultivar suited to acid soils
Volga – vetch	Old cultivar common vetch
Casbah – Biserrula	WA cultivar, limited testing in SA
SARDI Rose Clover	Hard seeded rose clover developed by SARDI in upper mid north
Bartolo Bladder clover	WA cultivar, aerial seeded, acid to alkaline sands and sandy loams

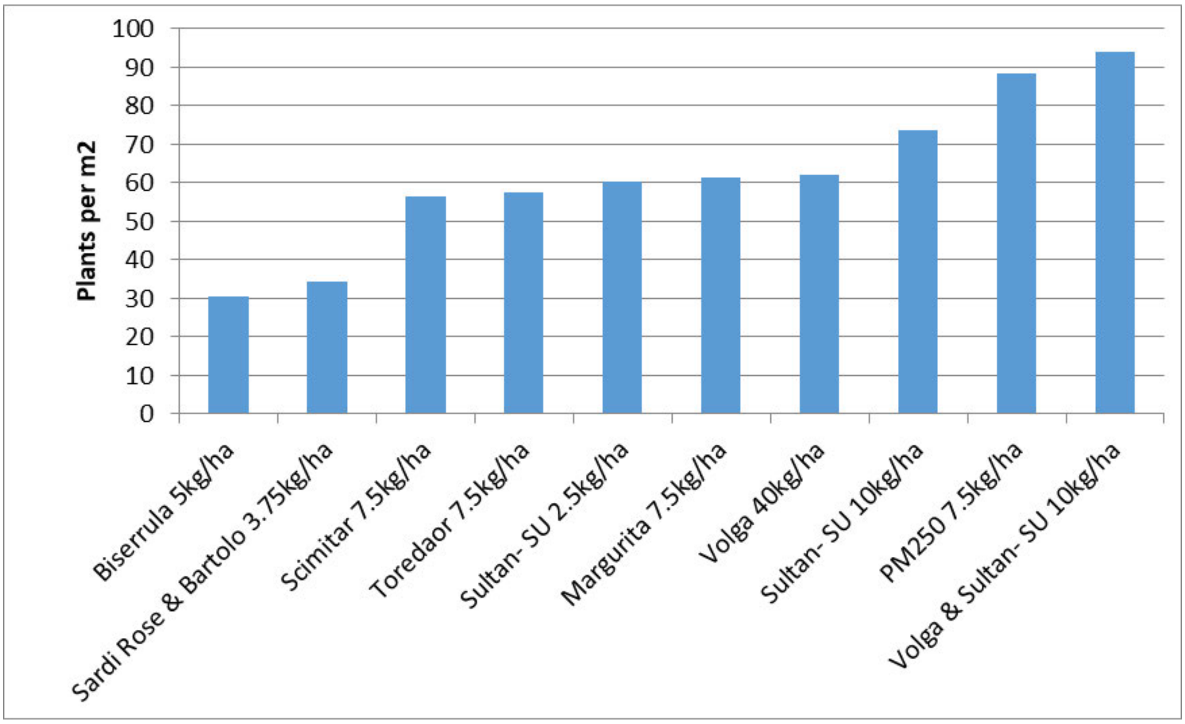

Figure. 2- *Plant establishment counts m^2*

This wide range is to find suitable species to suit the LRZ and for grazing purposes biomass is very important. Biomass also relates to nitrogen fixation if the plants have a good healthy rhizobium establishment on the roots. Legume production can add up to 20kg fixed Nitrogen/ tonne of shoot dry matter per hectare. Healthy rhizobium leads to increased nitrogen fixation and provides residual nitrogen for the following cropping phase. The greater the nodulation on the plant the greater the potential nitrogen fixation.

The three highest biomass plots were Volga Vetch 4.27t/Ha, Volga Vetch/Sultan Medic mix 3.04t/ha and PM250 Medic 1.8t/Ha.

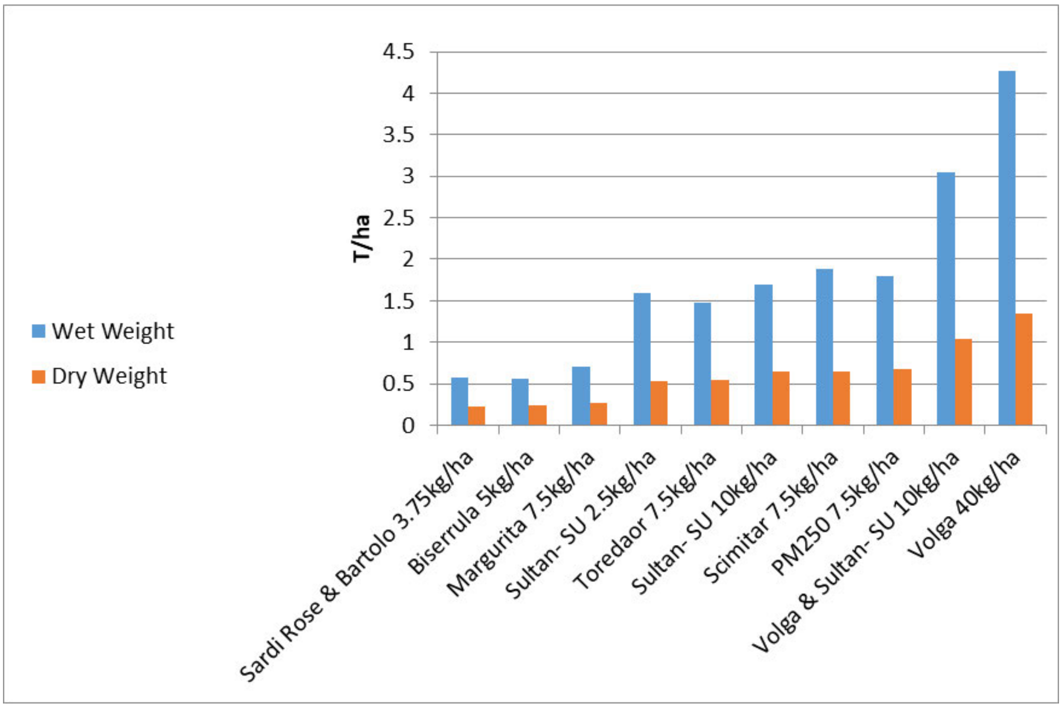

Figure. 3 *Biomass Cuts x species/variety – wet weight and dry weight*

Greater plant numbers at establishment not only provide a potential for greater biomass but have the added benefit of increased competition for weeds. Many of the weeds in the LRZ are poor competitors.

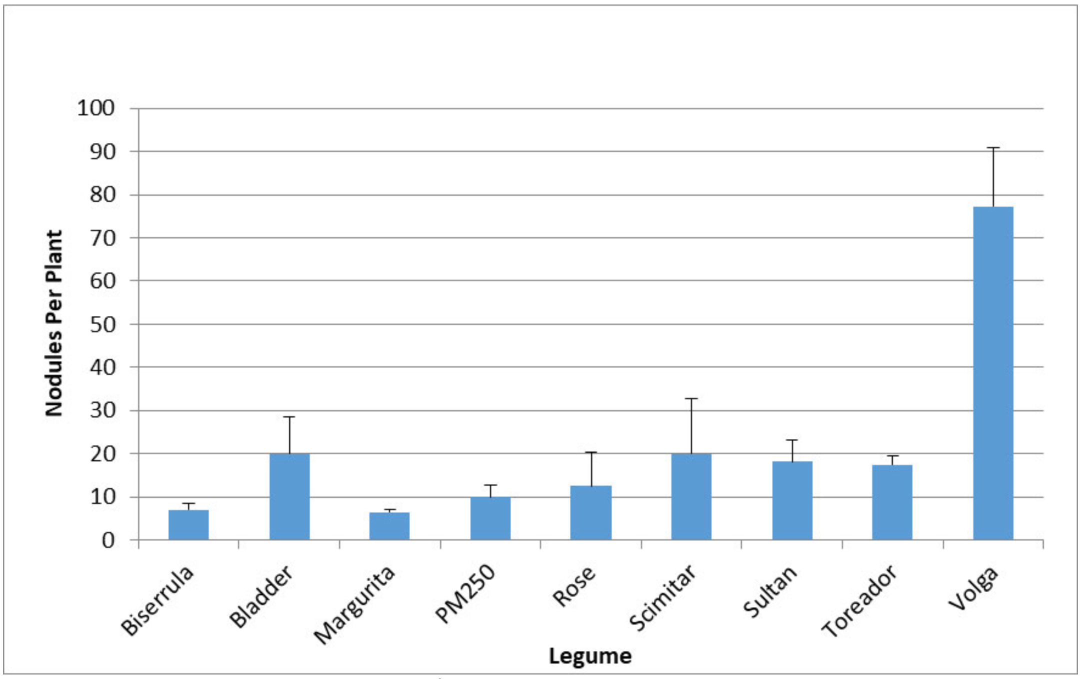

Figure 4 *Effective nodulation X species/variety*

Hard-seededness will be followed for persistence in years 2 & 3 of the trial for self-regeneration of each variety/species.

Photo – 24th October 2019 – trial site biomass post seed set

Acknowledgements:

- Andrew Catford – Northern Ag for managing the trial site and data collection
- Morchard Tennis Club for the use of the paddock
- Rural R&D for Profit and Mallee Sustainable Farming for funding the project and partnering with UNFS for its delivery in the region.

Funding and Delivery Partners

Australian Government
Department of Agriculture, Water and the Environment

Mallee Sustainable Farming

NRI NORTHERN AG NRI

Appendix A: Soil Test Analysis – Morchard Dryland Legume Site 2019

SoilMate Lab Result Status Report

Date Printed :14-Aug-2019 09:17:12 AM

Trading Name	UPPER NORTH FARMING SYSTEM:
Farm	Morchard Tennis Club
Paddock	Pasture Legume Trial
Contact	Andrew Catford

Sample Barcode 070182081 **Sample Date** 04-Jun-2019
Adviser Name Andrew Catford **Analysis Date** 17-Jun-2019
Evaluation Table Wheat & Triticale Raingrown, Southern Australia, 2 t/ha, PBI (0-70)

Nutrient	Result	Low	Marginal	Sufficient	High	Excess	Sufficiency Range
pH (1:5 H2O)	8.3						6.0 - 8.5
pH (1:5 CaCl2)	7.7						5.2 - 7.7
EC (1:5 H2O) dS/m	0.23						0.00 - 0.80
EC (se) (dS/m)	1.4						0.0 - 6.0
EC (se) (dS/m) (Cladj)	1.1						0.0 - 6.0
Chloride (1:5 H2O) mg/kg	100						0 - 250
Organic carbon (Walkley Black) %	0.83						1.00 - 2.00
Nitrate nitrogen (KCl) mg/kg	20						10 - 50
Ammonium nitrogen (KCl) mg/kg	1						0 - 5
Phosphorus (Colwell) mg/kg	35						25 - 100
Phosphorus DGT ug/L	53						60 - 100
Phosphorus Buffer Index (Colwell) (PBIc)	91						15 - 280
Phosphorus Environmental Risk Index	0.4						0.00 - 0.65
Potassium (Amm-Acet.) cmol+/kg	1.4						0.20 - 10.00
Potassium % of CEC	7.1						1.0 - 10.0
Sodium:Potassium Ratio	0.3						0.0 - 5.0
Sulfate-S (KCl40) mg/kg	8.5						3.0 - 8.0
Calcium (Amm-Acet) cmol+/kg	15						1.0 - 100.0
Calcium % of CEC	76.0						55.0 - 90.0
Magnesium (Amm-Acet.) cmol+/kg	2.9						0.5 - 200.0
Magnesium % cations	14.7						0.0 - 25.0
Sodium (Amm-Acet.) cmol+/kg	0.44						0.00 - 3.00
Exch. sodium %	2.2						0.0 - 6.0
Electrochemical Stability Index	0.103						0.050 - 10.000
Dispersion Index (Loveday/Pyle)	1						0 - 6
Aluminium (KCl) cmol+/kg	0.10						0.00 - 0.50
eCEC cmol+/kg	19.7						5.0 - 100.0
Copper (DTPA) mg/kg	1						1.00 - 5.00
Zinc (DTPA) mg/kg	1.8						0.80 - 5.00
Manganese (DTPA) mg/kg	7.4						6.0 - 50.0
Boron (hot CaCl2) (mg/kg)	0.8						0.5 - 8.0

Soil Test Analysis 0-10cm

SoilMate Lab Result Status Report

Date Printed :16-Mar-2020 02:19:14 PM

Trading Name	UPPER NORTH FARMING SYSTEM:
Farm	Morchard Tennis Club
Paddock	Pasture Legume Trial
Contact	Andrew Catford

Sample Barcode 070182078 **Sample Date** 04-Jun-2019
Adviser Name Andrew Catford **Analysis Date** 17-Jun-2019
Evaluation Table Wheat & Triticale Raingrown, Southern Australia, 2 t/ha, PBI (0-70)

Nutrient	Result	Low	Marginal	Sufficient	High	Excess	Sufficiency Range
Chloride (1:5 H2O) mg/kg	129						0 - 250
Nitrate nitrogen (KCl) mg/kg	14						10 - 50
Ammonium nitrogen (KCl) mg/kg	1						0 - 5
Sulfur(KCl-40)-S mg/kg	4.3						3.0 - 8.0

Soil Test analysis 0 -30cm

SoilMate Lab Result Status Report

Date Printed :16-Mar-2020 02:19:39 PM

Trading Name	UPPER NORTH FARMING SYSTEMS
Farm	Morchard Tennis Club
Paddock	Pasture Legume Trial
Contact	Andrew Catford

Sample Barcode 070182079 **Sample Date** 04-Jun-2019
Adviser Name Andrew Catford **Analysis Date** 17-Jun-2019
Evaluation Table Wheat & Triticale Raingrown, Southern Australia, 2 t/ha, PBI (0-70)

Nutrient	Result	Low	Marginal	Sufficient	High	Excess	Sufficiency Range
Chloride (1:5 H2O) mg/kg	82						0 - 250
Nitrate nitrogen (KCl) mg/kg	4						10 - 50
Ammonium nitrogen (KCl) mg/kg	1						0 - 5
Sulfur(KCl-40)-S mg/kg	9.5						3.0 - 8.0

Soil Test Analysis 30-60cm

SoilMate Lab Result Status Report

Date Printed :16-Mar-2020 02:20:25 PM

Trading Name	UPPER NORTH FARMING SYSTEMS
Farm	Morchard Tennis Club
Paddock	Pasture Legume Trial
Contact	Andrew Catford

Sample Barcode 070182080 **Sample Date** 04-Jun-2019
Adviser Name Andrew Catford **Analysis Date** 17-Jun-2019
Evaluation Table Wheat & Triticale Raingrown, Southern Australia, 2 t/ha, PBI (0-70)

Nutrient	Result	Low	Marginal	Sufficient	High	Excess	Sufficiency Range
Chloride (1:5 H2O) mg/kg	304						0 - 250
Nitrate nitrogen (KCl) mg/kg	3						10 - 50
Ammonium nitrogen (KCl) mg/kg	1						0 - 5
Sulfur(KCl-40)-S mg/kg	31.5						3.0 - 8.0

Soil Test Analysis 60-70cm

UNFS Farming Well in 2019 Event @ Orroroo

Dryland Legume Pasture Systems: Legume adaptation trial 2019 regeneration

Fiona Tomney[1], Ross Ballard[2], David Peck[2], Jeff Hill[2], Ian Richter[1] and Naomi Scholz[1]

[1]SARDI, Minnipa Agricultural Centre; [2]SARDI, Waite

Location
Minnipa Agricultural Centre, paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Paddock history
2018: Legume adaptation trial sown and established
2017: Scepter wheat
2016: Medic pasture
Soil type
Red sandy loam
Soil test
$pH_{(H20)}$ (0-10 cm) 8.4
Plot size
5 m x 1.5 m x 4 reps

Key messages

- **This is a component of a new five year Rural Research and Development for Profit funded project supported by GRDC, MLA and AWI; and involving Murdoch University, CSIRO, SARDI, Department of Primary Industries and Regional Development; Charles Sturt University and grower groups.**
- **This trial aims to assess a diverse range of annual pasture legumes in order to determine whether there are more productive and persistent options for the drier areas (<400 mm) of the mixed farming zone of southern Australia.**
- **Annual medics continue to be the best pasture option for neutral/alkaline soils on the upper Eyre Peninsula. Common vetch is an alternative option where a sown legume ley of one year duration is preferred.**
- **Building up a seed bank is critical to the longer term performance of the pasture. The aim in the pasture establishment year should be to maximise seed set.**
- **Levels of hard seed affect regeneration. Legumes with high hard seed levels should be cropped in the year following establishment.**

Why do the trial?

Legume pastures have been pivotal to sustainable agricultural development in southern Australia. They provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens, and improve fertility through nitrogen (N) fixation. Despite these benefits pasture renovation rates remain low and there is opportunity to improve the quality of the pasture base on many low to medium rainfall mixed farms across southern Australia. A diverse range of pasture legume cultivars are currently available to growers and new material is being developed. Some of these legumes, such as the annual medics, are well adapted to alkaline soils and have high levels of hard seed, which allow them to self-regenerate from soil seed reserves after cropping (ley farming system). Other legume cultivars and species are available and being developed that offer improved seed harvestability, are claimed to be better suited to establishment when dry sown and/or provide better nutrition for livestock. Regional evaluation is needed to determine if they are productive and able to persist in drier areas (<400 mm annual rainfall) and on Mallee soil types common to the mixed farming zone of southern Australia.

The Dryland Legume Pasture Systems project will both develop and evaluate a range of pasture legumes together with innovative establishment techniques, measure their downstream benefits to animal and crop production and promote their adoption on mixed farms.

This trial was established in 2018 to assess a diverse range of annual pasture legumes in order to determine whether there are more productive and persistent options for the drier areas (< 400 mm) of the mixed farming zone of southern Australia. In 2019 the trial was allowed to regenerate to determine which legumes regenerated and how their performance differed from the establishment year.

How was it done?

The trial sown in 2018 at Minnipa in paddock S8 was arranged in a fully randomised block design, with four replications. Similar trials were established at Loxton (SA), Piangil (Vic), Kikoira (NSW) and Condobolin (NSW). Data was analysed using Analysis of Variance in GENSTAT version 19. The least significant differences were based on F probability=0.05.

Table 1. Annual pasture legume species sown in the legume adaptation trial at Minnipa in 2018.

Pasture species	Notes
Harbinger Strand medic	Old cultivar; West Coast ecotype
Herald Strand medic	Old cultivar; aphid resistant
Jaguar Strand medic	Pod and leaf holding medic from Pristine Forage Technologies
PM-250 Strand medic	Powdery mildew resistant; tolerant of sulfonylurea (SU) herbicide residues; specifically developed for SA dryland Mallee farming systems
Pildappa Strand medic	West Coast ecotype, previously considered for release
Caliph Barrel medic	Old cultivar
Cheetah Barrel medic	Pod-holding medic from Pristine Forage technologies
Sultan-SU Barrel medic	Tolerant of SU residues; Boron tolerant; good aphid resistance
Boron Burr medic	Boron tolerant; spineless
Scimitar Burr medic	Old cultivar; spineless
Toreador Disc medic	Developed for sandy soils
Minima medic	Widely naturalised in dry areas; spineless
SARDI Rose Clover	Developed in upper mid-north; not widely sown in Mallee but reports of good performance
Rose Clover Early 35623	Experimental; early flowering and aerial seeded
Bartolo Bladder Clover	WA cultivar; aerial seeded, limited testing in the southern region
Prima Gland Clover	WA cultivar
Zulu Arrowleaf Clover	WA cultivar; earliest flowering line
Tammin Subterranean Clover	New cultivar; high level of hard-seed and tolerant of Red-legged Earth Mite
Balansa Clover X nigrescens clover	Experimental; an aerial seeded hybrid
Volga Common Vetch	Old cultivar
Studenica Common Vetch	New vetch specifically developed for drier areas
Capello Woolly Pod Vetch	Old cultivar
Casbah Biserrula	WA cultivar; with limited testing in the southern region
Margurita French Serradella	WA cultivar suited to acid soils
Santorini Yellow Serradella	WA cultivar; hard-seeded suited to acid soils with limited testing in the southern region
Trigonella balansae 5045	New species, aerial seeded.
Trigonella balansae Early 37928	New species, early line; aerial seeded
Astragalus	Experimental Australian Pasture Genebank selection; new rhizobia
Lotus arenarius	Experimental Australian Pasture Genebank selection
Lotus ornithopodiodies	Experimental Australian Pasture Genebank selection

Thirty different pasture legume species (Table 1) were sown to provide a broad range of legume species and attributes. The chosen species are a mixture of old varieties, new varieties, pre-releases, legumes with new traits, and pasture gene-bank selections based on their likely adaptation to rainfall and soil type. Some legume cultivars developed in Western Australia have also been included. These have performed well in WA and more recently in NSW, on their acid-dominant soils, but have had limited evaluation in South Australia where neutral to alkaline soils prevail.

The trial was sown on 27 June 2018 under relatively dry conditions, having received 22 mm of rain in the three weeks prior to seeding. All seed was inoculated with the best available strain of rhizobia and lime pelleted before sowing.

In 2019 the trial was allowed to regenerate. The growth of pasture lines that successfully regenerated were monitored to determine how their performance differed from the establishment year.

The seed of all species was reassessed in the field on 26 March 2019, with seed still present in all plots. On 29 April all plots were raked, to improve seed to soil contact and knock taller lines such as the Zulu Arrowleaf clover, to the ground. Plant emergence counts were completed on 20 May 2019. On 29 July all plots were given a visual score for plot vigour in terms of regeneration and biomass. A Green Seeker was then run over all plots.

Early dry matter (DM) cuts were completed on 31 July 2019 on selected lines. Plots were then mowed to simulate a grazing in late August. No further measurements were taken on the trial during the 2019 season.

What happened?

All lines showed some regeneration apart from the vetches, which have been selected to have <5% hard seed to prevent them becoming a weed in the following cereal crop. The regeneration of the biserrula and serradellas was poor, averaging 5 or less plants/m2, despite the biserrula producing reasonable seed levels in 2018. This is due to their high hard seed level (> 90%) and is consistent with the recommendation that biserrula be cropped the year following its establishment, to enable some breakdown of hard seed. The regeneration of Astragalus, the best adapted alternative legume species in the 2018 trial, was also poor with an average plot score of only 3.0. This was also probably due to high hard seed levels.

Once emerged, the regenerated pasture species continued to grow well thanks to favourable seasonal conditions. Toreador Disc medic consistently appeared to be the pasture legume with the best regeneration in terms of visual biomass, followed by Scimitar Burr medic.

The annual medics developed for alkaline soils, had the highest DM production. After a slower start, PM-250 Strand medic produced the most early (winter) DM (1.27 t/ha), although one of the Toreador plots still appeared to be the best plot in the trial from a visual perspective. Caliph Barrel medic, which produced the most biomass last year (along with Studenica Common vetch) with 1.3 t/ha, was slower to regenerate than the other medic lines, probably due to having harder seeds (>90%), however it still produced above average growth with 1.14 t/ha. The WA bred legumes (bladder clover, serradella and biserrula) developed for acidic sands, produced less DM; the result of poor regeneration and sub-optimal adaptation to soil type (Table 2).

Table 2. Average plot score, early DM and 2018 late DM for selected pasture legume species.

Legume species	Average plot score	Average early DM 31/7/19 (t/ha)	Average late DM 26/9/18 (t/ha)
PM-250 Strand Medic	8.8	1.27	0.72
Toreador Disc Medic	8.8	1.22	0.88
Bartolo Bladder Clover	2.0	0.001	0.18
Trigonella 5045	8.5	0.72	0.31
Casbah Biserrula	2.0	0.002	0.12
Margurita French Serradella	1.4	0.003	0.08
Scimitar Burr Medic	8.0	1.13	0.68
EP Harbinger Strand Medic	8.8	1.10	0.93
SARDI Rose Clover	2.5	0.04	0.23
Caliph Barrel Medic	8.1	1.14	1.30
Jaguar Strand Medic	8.1	0.92	0.65

What does this mean?

Pasture legume production, regeneration and persistence is determined by multiple factors including adaptation to soil type (texture and pH) capacity to set seed (early flowering is desirable in low rainfall areas) and hard seed levels that allow regeneration and persistence through the cropping sequence.

On the alkaline sandy loam and low rainfall conditions at the Minnipa Agricultural Centre, annual medics continue to provide the best option where a self-regenerating legume is preferred. If seed set is maximised in the establishment year the resultant seed bank may be 25 times what is initially sown, and will support pasture regeneration for many years. Common vetch may be a better option where a sown legume ley of one year is preferred, because of its ability to provide early production and options for late weed control. The new vetch cultivar Studenica, which equalled the DM of the most productive annual medic (Caliph barrel) in 2018, is scheduled for commercial release in 2021.

In 2020 the trial will be sown to wheat, with pasture legume regeneration following the cropping phase measured in 2021.

Acknowledgements

This project is supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit program; the Grains Research and Development Corporation, Meat and Livestock Australia; and Australian Wool Innovation. The research partners include the South Australian Research and Development Institute, Murdoch University, the Commonwealth Scientific and Industrial Research Organisation, the WA Department of Primary Industries and Regional Development, and Charles Sturt University, as well as 10 grower groups. Project code: RnD4Profit-16-03-010.

Commercial annual legume cultivars are produced by a range of companies and we appreciate them making their cultivars available for this work.

Dryland Legume Pasture Systems: Medic nodulation and nitrogen fixation

Ross Ballard[1], Fiona Tomney[2], David Peck[1], Jeff Hill[1], Ian Richter[2] and Naomi Scholz[2]
[1]SARDI, Waite; [2]SARDI, Minnipa Agricultural Centre

Location
Minnipa Agricultural Centre, paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Paddock history
2018: Strand medic or trigonella
2017: Scepter wheat
Soil type
Red sandy loam
Soil test
$pH_{(H20)}$ (0-10 cm) 8.3
Plot size
5 m x 1.5 m x 4 reps x 25.5 cm row spacing

Key messages

- **The nodulation of strand medic was below potential, but was not increased by inoculation.**
- **Trigonella formed more nodules than medic, but in the end PM-250 strand medic was more productive and fixed the most N.**
- **Legume inoculation (2018) increased wheat grain protein (2019). The increase could not be attributed to any measure of legume performance.**

Why do the trial?

There are reports of low grain protein levels in wheat following medic pastures and many observations of poor medic nodulation. Previous work has shown that rhizobial inoculation can improve the nodulation of medics in the SA and Victorian Mallee, and that more generally about 50% of the populations of medic rhizobia in soils are sub-optimal in their nitrogen (N) fixation capacity.

This trial aimed to:

- Determine if inoculation can improve medic nodulation at Minnipa,
- Quantify the amount of N fixed by different legumes,
- Assess impacts on the following wheat crop.

How was it done?

The trial commenced in 2018 at Minnipa in paddock S8. It was a factorial experiment (inoculation × legume) arranged in a fully randomized block design, with four replications.

There were three inoculation treatments (no rhizobia applied, or standard and high rates of inoculation) and four legumes. The legumes were Herald strand medic, representing an ‘old’ medic, PM-250 strand medic, representing a ‘new’ medic, Z-2447 medic, a medic with potential improvements in N-fixation capacity, and trigonella, a new aerial seeded legume that is also nodulated by medic rhizobia. The high rate of inoculation was applied as a double rate of recommended label rates of peat inoculant on seed and supplemented with inoculated glass micro-beads also inoculated at double rate and sown at 10 kg/ha with the seed. Standard and high rates of inoculation delivered on average 10,000 and >30,000 rhizobia per seed, respectively. Nodulation, root and shoot dry-matter (DM) production and N-fixation were measured.

In 2019, the plots were over-sown with wheat (cv. Scepter). Wheat grain yield and grain protein were measured.

What happened?

In the pasture year (2018) significant differences in nodulation and N-fixation were measured amongst the legume species (Table 1). However, inoculation even at the high rate, did not improve legume nodulation, N-fixation or DM production (data not shown).

Trigonella had about 4 times the number of nodules (17 per plant), compared to the three medics whose nodulation was similar (≤ 5 nodules per plant). Among the 540 medic plants assessed, 76 plants (14%) had no nodules and 21 plants had ≥15 nodules. Medic nodulation was not increased by inoculation.

Although trigonella had the most nodules and was the most efficient legume for N-fixation (65% N-fixation and 27 kg fixed N/t shoot DM), it did not fix more nitrogen overall because it was less productive. PM-250 and Herald strand medics fixed most N (9.8 and 7.5 N kg/ha respectively), not accounting for root contributions (+8% DM).

Table 1. Nodulation, herbage production, total shoot N and N-fixation of four legumes sown at Minnipa, 2018.

Legume	Nodulation (No./plant)	Production (kg/ha)	Total N (kg/ha)	N-fixation (%)	N-fixed (kg N/t shoot DM)	N-fixed (kg/ha)
Herald medic	5.0	326	13.0	56	22.4	7.5
PM-250 medic	4.4	408	16.0	61	24.1	9.8
Trigonella	17.0	171	7.4	65	27.4	4.8
Z-2447 medic	4.4	252	10.0	49	19.8	5.0
LSD (P=0.05)	*0.7*	*58*	*2.4*	*3*	*1.6*	*1.6*

Table 2. Effect of legume inoculation treatment (2018) on the yield and protein content of Scepter wheat in 2019.

Inoculation rate	Grain yield (t/ha)	Grain protein (%)
Not inoculated	3.02	12.7
Standard inoculation	2.74	13.1
High inoculation	2.60	13.3
LSD (P=0.05)	*ns*	*0.4*

In the wheat (2019), responses were due to inoculation rate (Table 2) rather than legume type (data not shown). Wheat grain protein was significantly greater (13.3%) in the high inoculation rate treatment, compared to no inoculation (12.7%). Wheat grain yield was not significantly affected by treatment, however showed a trend of decreasing yield (–14%, P=0.099) as inoculation rate increased.

What does this mean?

Legume DM production, nodulation and N-fixation

The results demonstrate the importance of legume DM production to the total amount of N fixed. Although legume production was low in 2018 due to late establishment (27 June) and low growing season rainfall (150 mm), it was still a strong determinant of the amount of N-fixed. PM-250 produced most DM (408 kg/ha) and fixed the most N (9.8 N kg/ha). Trigonella was the least productive legume and fixed the least N.

Medic nodulation was low, but not improved by inoculation. Similarly, other measures of legume N-fixation were not improved by inoculation. This is consistent with the current understanding that at Minnipa and in similar environments where soil pH_{CaCl} is >7 (alkaline) and where large backgrounds of annual medic persist, the likelihood of an inoculation response is low.

Although strand medic forms fewer nodules than many other legume species, nodule number (mean of 4.5 nodules/plant) was below potential. Numerous plants had no nodules. Other plants had 20 nodules, providing an indication of what is possible. The lack of inoculation response points to factors other than rhizobial deficiency as the cause of poor nodulation. SU-herbicide residues were unlikely to be the cause since PM-250 is tolerant. A possible explanation lies in the level of available soil N at the site (61 mg/kg soil N, 0-10 cm), since medic nodulation is known to be sensitive to moderate levels of available soil N.

Neither of the new legumes (trigonella or Z-2447) provided an advantage over the PM-250 and Herald. Breeder's line Z-2447 was neither well nodulated or productive. Other medic lines selected for improved N-fixation capacity combined with agronomic performance are being tested.

Wheat crop impact

Wheat grain protein level was greater and yield trended lower, following legume inoculation. This result suggests there was an unmeasured impact of legume inoculation in the previous year.

A negative relationship between grain yield and grain protein is well established and generally thought to be a consequence of extra carbohydrate (yield) in the grain diluting the protein content and vice versa. Since there was no evidence of increased legume growth with inoculation, neither excessive available soil N or water use seem likely to have limited grain yield, although they were not measured. Further, if available soil N or water were implicated, significant effects of legume type should also have occurred, since differences in legume production were substantial. The high rate of inoculation may have affected some aspect of the soil microflora.

Whilst the relative economic benefit of grain yield and protein will depend on grain prices and grade premiums, the trend of reduced grain yield and inability to measure an inoculation response in the legumes, leads us to conclude that inoculation of medic provides no value at Minnipa. The fact that inoculation responses have been measured on Mallee soils in the SA/Vic Mallee may be the result of their lower pH. Further investigation is needed to understand the basis of low nodulation in medic.

Acknowledgements

The Dryland Legumes Pasture Systems project is supported by funding from the Australian Government Department of Agriculture as part of its Rural R&D for Profit program, the Grains Research and Development Corporation, Meat and Livestock Australia and Australian Wool Innovation. The research partners include the South Australian Research and Development Institute, Murdoch University, the Commonwealth Scientific and Industrial Research Organisation, the WA Department of Primary Industries and Regional Development, and Charles Sturt University, as well as grower groups. Project code: RnD4Profit-16-03-010.

Dryland Legume Pasture Systems: Evaluating pasture establishment methods for Mallee mixed farms

Bonnie Flohr[1], Rick Llewellyn[1], Therese McBeath[1], Bill Davoren[1], Willie Shoobridge[1], Roy Latta[2] and Michael Moodie[2]

[1]CSIRO Agriculture & Food, Waite Campus; [2]Frontier Farming, Mildura

Location
Waikerie
Schmidt Family
Rainfall
Av. Annual: 253 mm
Av. GSR: 164 mm
2019 Total: 161 mm
2019 GSR: 119 mm
Yield
Potential: Medic, 2 t/ha based on 20 kg/ha/mm from French (1981) for annual legume pastures
Actual: 0.7 t/ha
Soil type
Sandy loam
Soil test
pH CaCl2 7.8 0-10 cm, 7.7 70-100 cm
Nitrate N 0 -10 cm 18 mg/kg
Colwell P 0 -10 cm 13 mg/kg
S KCL 0-10 cm 6.9 mg/kg, 70-100 cm 6.5 mg/kg
OC 0-10 cm 0.42%, 70-100 cm 0.43%
Salinity Ec 1:5 0-10 cm 0.11 dS/m, 70-100 cm 0.11 dS/m
Plot size
1.68 m x 32 m x 4 reps
Trial design
Fully randomised block with time of sowing as main plots and pasture species as the sub plots
Yield limiting factors
Drought, weeds

Key messages

- **Field experiments located near Waikerie and Piangil are evaluating establishment methods (summer, twin and autumn sowing).**
- **Although the alternative pasture species established adequate plant numbers under the establishment methods, they may be less productive than medic.**
- **Serradella, Rose clover and Bladder clover performed well under summer sowing, however under twin sowing, establishment and production for all the legume species was poor at Waikerie.**
- **Further investigation is required to define the conditions where summer and twin-sowing practices are reliable.**

Why do the trial?

A significant obstacle to the adoption of pasture species is difficulty in successfully establishing high seed cost pastures, particularly in low-medium rainfall areas. The optimal establishment time for pastures in autumn is a compromise between early enough for sufficient rooting depth and biomass production, but late enough that the risk of a false break is low and high soil temperatures do not limit germination and seedling growth (Puckridge and French, 1983). Unfortunately, this sowing window coincides with the optimal sowing window for the main cropping program on mixed farms (Flohr *et al*., 2017).

Together with improved pasture cultivar options, systems need to be developed to help mixed farmers overcome logistic and economic issues surrounding pasture establishment. In Western Australia, summer and twin sowing methods have shown promise but these alternative establishment methods have had limited evaluation in south-eastern Australia (Revell *et al*., 2012). A feature of some of the legumes under investigation is their aerial seeded habit and retention of seed, allowing seed to be farmer harvested and re-sown. This project is examining the potential of different pasture legume species to be established more efficiently, to provide growers with greater flexibility in moving between crop and pasture phases by avoiding clashes with peak crop sowing times, reduce establishment costs and increase early season feed.

How was it done?

Three establishment methods were evaluated at Waikerie (SA) and Piangil (Vic) in 2019 using legume pasture species/cultivars that have not been traditionally grown in the Mallee region (Table 1). Growing season rainfall in Waikerie in 2019 was 119 mm (long-term average 164 mm) and in Piangil 100 mm (long-term average 220 mm).

Establishment methods evaluated were:

- Twin-sown, where "hard" pasture seed/pod was sown with wheat seed in 2018 for 2019 pasture establishment.
- Summer-sown, where "hard" seed/pod was sown in summer and softened to establish on the autumn break.
- Autumn-sown (control treatment), where "soft" seed was sown on the break of the season.

In Waikerie twin-sown treatments were sown on 5 June 2018, summer-sown treatments were sown on 14 February 2019, and autumn-sown treatments on 23 May 2019. In Piangil twin-sown treatments were sown 28 June 2018, summer-sown treatments were sown on 7 February 2019, and autumn-sown treatments on 13 May 2019. Indicative sowing rates are in Table 1, and all pastures were sown with a base level of either 45 kg/ha of MAP in Waikerie or 50 kg/ha of MAP in Piangil.

At each site plant number/m^2 was recorded in June, and two measures of biomass production were recorded.

The experiment was a general treatment structure in randomised blocks with sowing method and cultivar as treatment factors with four replications, and designed and analysed using Genstat.

What happened?

Establishment

In Waikerie the seasonal break (> 15 mm) occurred on 9 May with 20 mm rainfall. Summed rainfall prior to 9 May 2019 was 22 mm. In Piangil, the seasonal break occurred on 2 May with 19 mm rainfall, with summed rainfall prior to 2 May of 17 mm. At both sites all establishment treatments emerged within 2 weeks of each other. Sowing method had a significant effect on plant density at both sites (Figure 1). The targeted population for sown pastures is typically 150-200 plants/m^2.

Production

Treatment differences in dry matter production were measured at Waikerie, despite production being limited by rainfall (Figure 2). Production was greatest for summer and autumn-sown PM-250 medic. Although Serradella and Rose clover produced more dry matter when summer sown, the overall production was lower. Dry matter was lowest in twin-sown treatments, consistent with lower plant numbers.

Table 1. Indicative sowing rates of pod or seed (kg/ha) and equivalent amount (kg/ha) of viable hard seed sown in twin and summer sown treatments; and sown rate of germinable seed (kg/ha) in the autumn sown treatment.

Legume	Twin and summer sown treatments (kg/ha)	Autumn sown treatment (kg/ha)
PM-250 medic	30 pod, 8 viable hard seed	8
Trigonella balansae	11 seed, 5 viable hard seed	5
Bladder clover	18 seed, 16 viable hard seed	8
Rose clover	74 seed, 11 viable hard seed	8
Biserrula	9 seed, 5 viable hard seed	4
French serradella	30 pod, 8 viable hard seed	8
Gland clover	Not measured	4

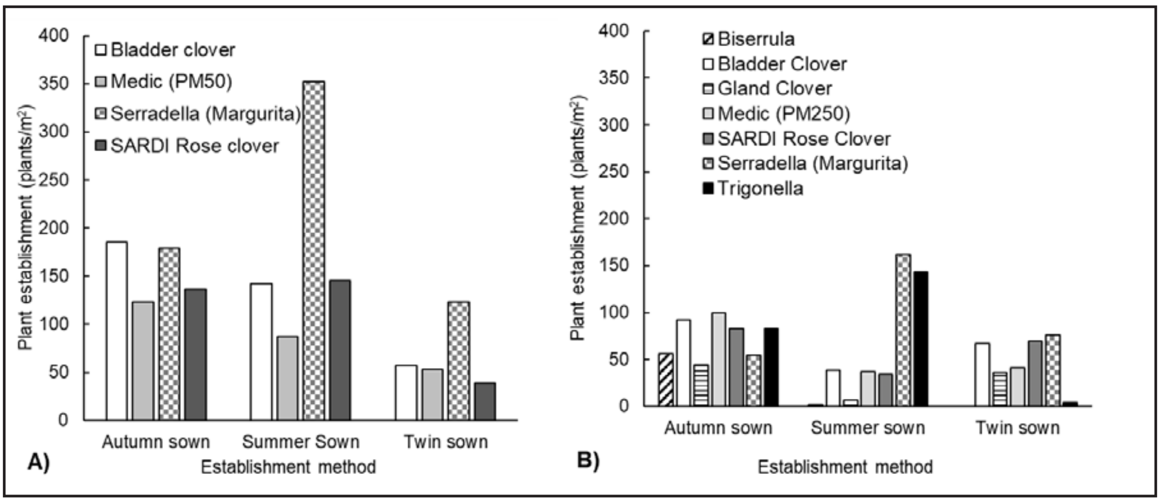

Figure 1. Plant establishment resulting from different establishment methods at a) Waikerie on 25 June 2019, vertical line is LSD (5%)=41, P <0.001 and b) Piangil on 5 June 2019, vertical line is LSD (5%)=27, P <0.001.

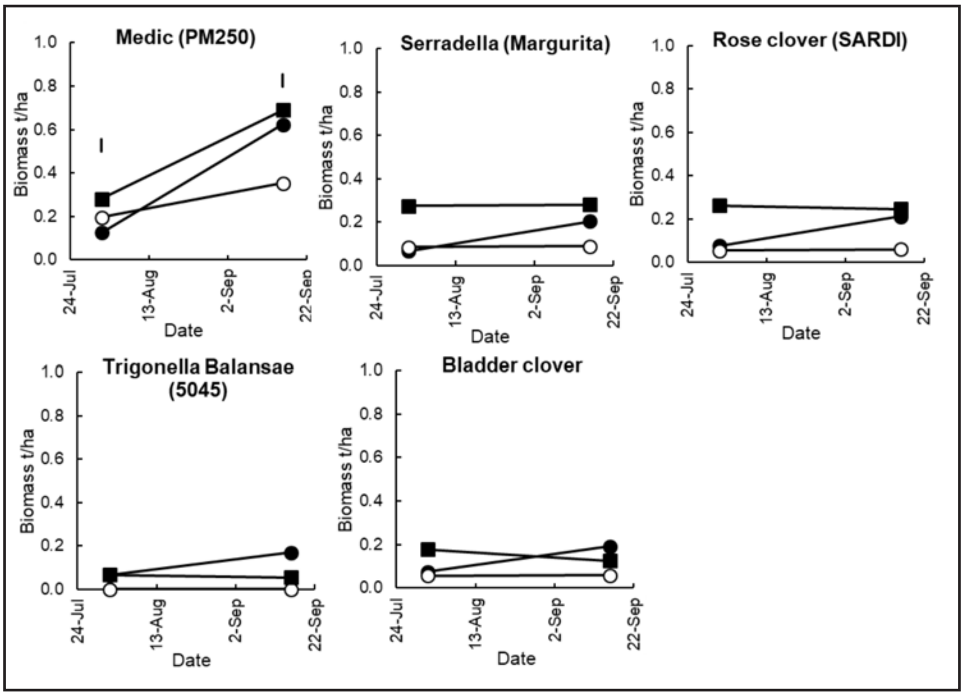

Figure 2. Biomass production (t/ha) in 2019 at Waikerie in the establishment treatments autumn sowing (●), twin-sowing (❍) and summer-sowing (■), vertical line is LSD (5%) = 0.1, P<0.001.

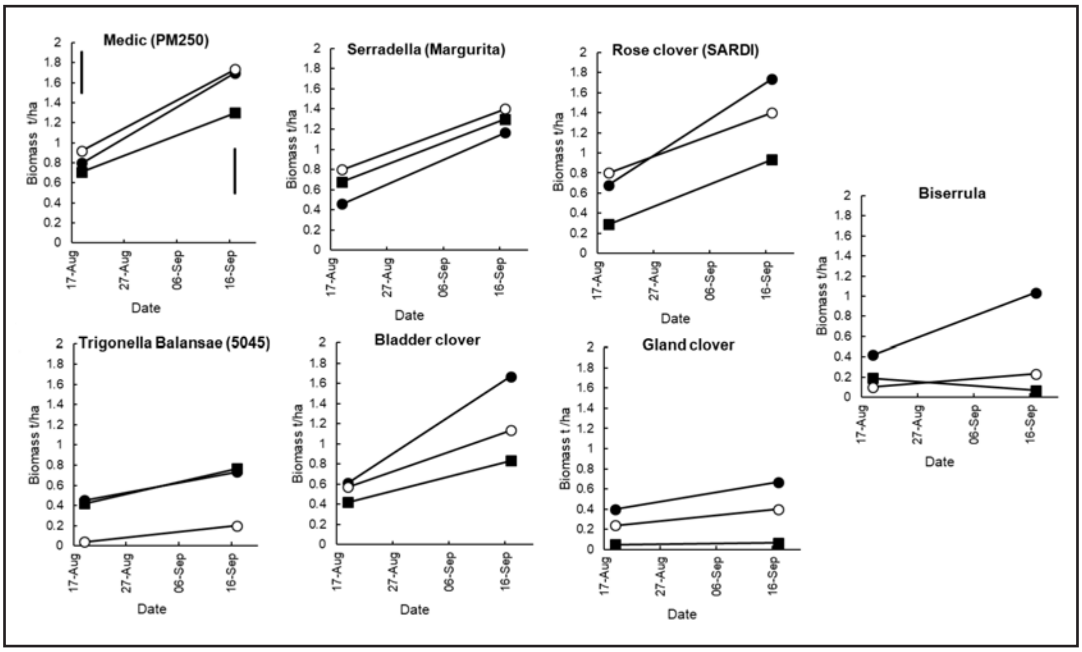

Figure 3. Biomass production (t/ha) in 2019 at Piangil in the establishment treatments autumn sowing (●), twin-sowing (❍) and summer-sowing (■), vertical line is LSD (5%) = 0.41, 0.44 respectively, P<0.05.

While establishment counts were higher for summer and autumn sowing at Waikerie, biomass production tended to be higher at Piangil (Figure 3). The twin sown treatments at Piangil had establishment counts similar to the other sowing techniques, however plant density did not necessarily directly relate to biomass production. For example, there was higher plant density in summer-sown Serradella, but twin-sown treatments produced similar biomass. Medic produced similar biomass in the autumn- and twin-sowing treatments. Production of Trigonella and Gland clover was generally low, indicating they are not as well adapted to the soil type.

Results from 2019 indicate that twin and summer-sowing may be viable establishment methods for the Mallee region, however they might not be suitable for all legume species. In both environments, Margurita Serradella gained the greatest advantage from the alternative establishment methods. Results for PM-250 medic were inconsistent, with twin-sowing inferior at Waikerie and summer-sowing inferior at Piangil. Given that all treatments emerged on similar dates, and there was very little summer rainfall in 2019, further exploration of the methods are required under a range of growing seasons such that risks and/or benefits associated with earlier seasonal or false breaks can be evaluated. This experiment will be repeated in Lameroo, SA in 2020.

Weed management

An important consideration with twin- and summer-sowing is weed control. At Waikerie, there were significantly more broad-leaved weeds in the twin- and summer-sown plots compared to autumn-sown plots (data not shown). On 1 August weed dry-matter was 3.6 vs. 44 vs. 50 g/m^2 for autumn, summer and twin treatments respectively ($P<.001$). Autumn-sown plots received a knock down spray at sowing, while twin and summer sown plots did not. Twin- and summer- sowing methods should only be considered for paddocks with low weed levels.

Seasonal analysis

To understand the likely suitability of summer and twin-sowing to Mallee environments, historic climate records (1970-2018) were analysed to reveal the distribution of when the seasonal break occurred. Using the APSIM model (version 7.10) and historic weather records, the mean break of a season was predicted (7-day period where rainfall exceeds evaporation, Unkovich 2010). The analysis revealed that Lameroo has the earliest median break and a higher probability of a break occurring before 25 April, while Piangil and Waikerie typically have a later seasonal break. In environments with a greater probability of an early seasonal break, summer-sowing will likely be more beneficial as a longer growing season can be exploited more often (Figure 4). In environments where the seasonal break is often later, there is greater risk of seed losses or burial, rhizobia death and exposure to pathogens.

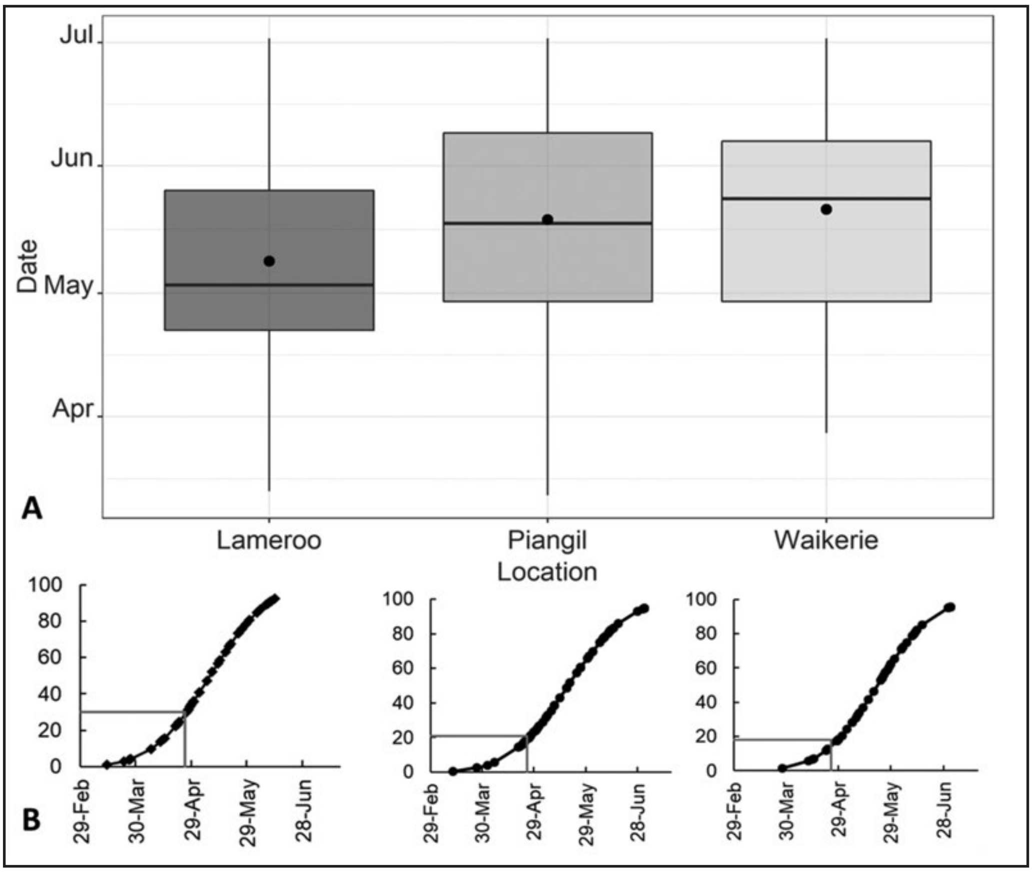

Figure 4. a) Box and whisker plots showing 25th-75th percentiles of when the autumn break occurred in the historic data set 1970-2018 using the Unkovich (2010) rule, b) the probability of the seasonal break occurring on 25 April.

What does this mean?

Alternative establishment methods have demonstrated potential in the Mallee, however they are not suitable for all legume species. The alternative legume species Serradella, Rose clover and Bladder clover have demonstrated potential for summer sowing, however establishment and production under twin sowing was low at Waikerie. While PM-250 medic was the highest biomass legume, it is not yet clear which establishment technique will consistently give the best results. This is worthy of further investigation given the potential to provide growers with greater sowing flexibility and reduced seed costs.

Acknowledgements

This work is in collaboration with the SARDI team; Ross Ballard, David Peck and Jeff Hill. The research reported in this paper is made possible by significant contributions of growers through both trial cooperation and the support of GRDC (GRDC project code 9175959). We thank the Schmidt and Haydon families for hosting the field experiments.

The Dryland Legumes Pasture Systems project is supported by funding from the Australian Government Department of Agriculture as part of its Rural R&D for Profit program, the Grains Research and Development Corporation, Meat and Livestock Australia and Australian Wool Innovation. The research partners include the South Australian Research and Development Institute, Murdoch University, the Commonwealth Scientific and Industrial Research Organisation, the WA Department of Primary Industries and Regional Development, and Charles Sturt University, as well as grower groups. Project code: RnD4Profit-16-03-010.

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Dryland Legume Pasture Systems: Grazing trial

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Location
Minnipa Agricultural Centre, paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Paddock history
2018: Various legume species or Scepter wheat
2017: Scepter wheat
2016: Medic pasture
Soil type
Red sandy loam
Soil test
$pH_{(H20)}$ (0-10 cm) 8.4
Plot size
2 hs x 3 reps

Key messages

- **Pasture legumes sown in 2018 were allowed to regenerate in 2019 and were grazed with ewe hoggets.**
- **Sheep live-weight increased on average by 13.8 kg (+26%, ~180 g/day) and was similar for all legume treatments, but differences between the sown legumes may have been masked by volunteer pasture species in the plots.**
- **Sown legume intake ranged from 401 kg/ha (*Trigonella balansae*) to 1461 kg/ha (Harbinger medic). Sheep showed some grazing preference for medic over trigonella.**
- **The site will be sown with wheat in 2020. Crop growth, grain yield and quality will be measured. Stubbles will be grazed. It will return to pasture in 2021.**

Why do the trial?

In southern Australian mixed farming systems, there are many opportunities for pasture improvement. The Dryland Legume Pasture Systems (DLPS) project aims to boost profit and reduce risk in medium and low rainfall areas by developing pasture legumes that benefit animal and crop production systems. A component of the DLPS project aims to quantify the impacts of different pasture legume species on livestock production and health. Included are widely grown legumes (strand medics and vetch) and legumes with reasonable prospects of commercialisation (trigonella).

A five-year grazing system trial was established at the Minnipa Agricultural Centre (MAC) in 2018. It is the main livestock field site for the DLPS program in southern Australia.

How was it done?

The large-scale (36 ha) grazing system experiment was established in paddock South 8 at MAC in July 2018. The trial, which consists of six treatments, is arranged in a randomised block design with three replications. The treatments are: Scepter wheat (Control 1; wheat measurements not until 2020); Volga vetch (Control 2), locally sourced harbinger strand medic; PM-250 strand medic with powdery mildew resistance and SU herbicide tolerance; SARDI rose clover; and *Trigonella balansae*, a new aerial-seeded legume closely related to medic. Each 'plot' is 2 ha in size, to allow grazing during pasture phases and on stubbles after harvest in cropping years. Four set sampling points are located within each plot to facilitate consistent pasture measurement over time. Because poor seasonal conditions limited legume growth and the priority was to optimise legume seed set, the plots were not grazed in 2018. Legume dry-matter (DM) production, seed set, nitrogen (N)-fixation and nutritive value (at maximum biomass) were measured.

The pasture treatments were allowed to regenerate in 2019. The trial was rolled with a light steel roller a week after a 10 mm rainfall event on 30 April 2019 to ensure sufficient seed to soil contact, which was followed up by 15.8 mm in the 24 hours following rolling. The vetch and cereal treatments were re-sown on 4 and 16 May respectively, in line with the planned rotation sequence below:

- 2018 pasture establishment year (aim to maximise seed set)
- 2019 pasture allowed to regenerate (monitor regeneration, graze, measure livestock production)
- 2020 wheat (measure crop yield and quality, graze stubbles)
- 2021 pasture allowed to regenerate (monitor regeneration, graze, measure livestock production)
- 2022 assessment of pasture regeneration.

Soil sampling for water content, basic nutrition, nitrogen and soil borne disease tests was completed on 4 May.

Total rainfall received for April at Minnipa was 11 mm, with May recording 57 mm and June 56 mm, providing a good start to the 2019 season. Plant emergence counts were completed between 21 and 29 May 2019.

On 29 July, eight 1-year-old ewe hoggets (equivalent to current district practice of 7 DSE/ha) were introduced into each treatment paddock after weighing and condition scoring. Four grazing exclusion cages (1 m x 1 m) were placed in each 2 ha plot (treatment) area. Pasture biomass cuts were taken within and outside the cages to enable the estimation of feed on offer (FOO), pasture DM production and composition (sown legume content and volunteer species, the latter comprising mostly naturalised medic). Pasture intake by the sheep was calculated as the difference in DM within and outside the exclusion cages. Livestock weights and pasture production were measured when the sheep were introduced (29 July) and then on 26-27 August and 3 October. Legume samples are still being processed to determine nutritive value, N-fixation level and seed production for 2019.

What happened?

2018

Legume production, N-fixation and nutritional results for the 2018 season are shown in Table 1. Vetch was the most productive legume. It produced double the DM of PM-250 medic and SARDI rose clover. Rose clover fixed the least N (10%) and had the lowest DMD and crude protein. Vetch had the highest N-fixation percentage (72%) and fixed most shoot N (21 kg/ha).

Despite a late start to the season and below average rainfall (150 mm GSR), each of the pasture species set a large number of seed/m^2 in the absence of grazing (Table 1).

The legume treatments did not significantly affect volumetric soil water content at the end of the season. Soil N results are pending.

2019

The pasture legumes differed in their regeneration density (295 to 757 plants/m^2), but were generally satisfactory (>500 plants/m^2) (Table 2). Vetch density was lower, but adequate for this larger seeded legume.

No significant differences were measured for FOO, pasture production or intake. At the commencement of grazing, FOO ranged between 1963 kg DM/ha (PM-250 medic treatment) and 1086 kg DM/ha (rose clover treatment) with volunteer pasture components (mainly naturalised medic) comprising on average 24% of the total DM (data not shown). All legume treatments had flowered by mid-August, with growth noticeably slowing due to low rainfall in that month (19 mm). Total pasture production to 3 October ranged between (3153 kg/ha, 73% vetch) and (1920 kg DM/ha, 95% Harbinger medic) (Table 2). Intake of the sown legume component ranged between 1461 kg DM/ha (Harbinger medic) and 401 kg DM/ha (*Trigonella balansae*).

No significant (P=0.3) treatment differences in livestock performance were measured. Sheep weight increased by between 26% and 30% (Table 2) and condition scores remained stable (data not shown).

Table 1. Pasture herbage and seed production, N-fixation, nutritive value for five legumes grown at Minnipa in 2018.

Legume	DM Prod'n (kg/ha)	Seed Prod'n (#/m^2)	Nitrogen fixation (%)	Nitrogen fixed (kg/ha)	DMD (%)	Crude protein (%)
Volga vetch	1297	9	72	21	68	14
Trigonella balansae	744	8208	49	11	67	19
SARDI Rose clover	541	6621	10	1	63	14
Harbinger medic	822	7639	45	9	66	18
PM-250 medic	514	4177	54	8	69	20
LSD (P=0.05)	*134*	*237*	*12*	*2*	*1.3*	*1.1*

Table 2. Legume regeneration density, total and sown legume DM production, total and sown legume intake and sheep live-weight, for five legume treatments at Minnipa in 2019.

Treatment	Sown legume density (plants/m²)	Total production (kg/ha)	Sown legume production (kg/ha)	Total Intake (kg/ha)	Sown legume intake (kg/ha)	Sheep weight 29 July (kg)	Sheep weight 10 Oct. (kg)	Weight change kg (% gain)
Volga vetch	95	3153	2315	2014	1295	50.4	65.0	14.6 (30)
Trigonella balansae	551	2375	1572	941	401	51.5	66.0	14.5 (29)
SARDI Rose clover	295	2584	1466	1917	1116	50.3	63.3	13.0 (26)
Harbinger medic	635	1920	1902	1474	1461	49.3	63.2	13.8 (28)
PM-250 medic	757	2065	1721	1469	1398	50.4	63.5	13.1 (27)
LSD (P=0.05)	*93*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

What does this mean?

Sheep weight increased in all treatments, with an average gain of 14 kg/head at the end of the 73 day grazing period. A good quantity and quality of feed supported rapid growth as the animals matured as hoggets. No adverse effects of the different legume treatments on sheep performance were measured or observed. Vetch was the most productive legume in both years and fixed most N in 2018. It is the best option where a sown legume of one year duration is preferred, but comes with a higher input cost as it needs to be sown each season, whereas ley pasture species self-regenerate.

Observation of the standing feed in late September indicated limited grazing of trigonella after flowering and overall the intake of this species was least (401 kg/ha) and final FOO highest (1434 kg/ha) compared to the other legumes. However, this was not reflected in sheep performance, probably because volunteer pasture species, mainly naturalised medics, contributed significantly to total pasture production (34% of DM in the trigonella treatment) and provided the sheep with an alternative feed source. The avoidance of mature trigonella by sheep may allow it to achieve higher seed yields under grazing, but in a pure sward this aspect may equally limit sheep production.

A benefit of medic PM-250, which is scheduled for commercial release in 2021, is its powdery mildew tolerance. Powdery mildew was not observed in 2019. Reports suggest that where susceptible medics are affected by powdery mildew, grazing by sheep is reduced. In the presence of powdery mildew, the production of PM-250 has previously been found to be up to 49% greater, compared to susceptible medics. PM-250 is also expected to be more palatable to sheep in years where conditions are conducive to the development of powdery mildew. PM-250 is also tolerant of SU and Intervix herbicide residues whereas the other legume cultivars are not.

The site will be cropped with wheat in 2020. If differences in N-fixation measured in 2018 were similar in 2019 (results pending), then effects on crop performance are anticipated. The site will be allowed to regenerate to pasture in 2021. This will provide critical information on the persistence of the sown legumes through the cereal crop and provide the opportunity for further grazing studies.

Acknowledgements

The Dryland Legumes Pasture Systems project is supported by funding from the Australian Government Department of Agriculture as part of its Rural R&D for Profit program, the Grains Research and Development Corporation, Meat and Livestock Australia and Australian Wool Innovation. The research partners include the South Australian Research and Development Institute, Murdoch University, the Commonwealth Scientific and Industrial Research Organisation, the WA Department of Primary Industries and Regional Development, and Charles Sturt University, as well as grower groups. Project code: RnD4Profit-16-03-010. Ashley White for pasture sampling,

Demonstrating Improved Pasture Options for the Upper North

Author: Cox Rural Jamestown, Beth Sleep
Funded By: UNFS and Cox Rural Sponsorship
Project Title: Demonstrating Improved Pasture Options for the Upper North
Project Duration: 2019
Project Delivery Organisations: Upper North Farming Systems (UNFS) and Cox Rural Jamestown
Trial Location: Andrew Kitto's Property, McKenzie Rd, Caltowie .

Key Messages

- This demonstration showed there are many options for improved pasture production in the Upper North. The nature of the demonstration and the 2019 seasonal conditions make sound recommendations on pasture selection difficult from the data collected.
- Bouncer forage brassica exhibited the greatest early growth among all pasture species, showing potential to aid in filling early feed gaps experienced in our local growing region, however, observations across the region found this species is significantly slowed in frost prone growing regions
- Lucerne showed the highest tolerance to the dry finish, with limited moisture stress symptoms in contrast to the other legume species which showed an early senescence, it is however difficult to measure success of Lucerne within this timeframe.
- Sowing seeds too deep significantly reduced the success of all grass species early in the season in combination with wind burn occurring at the two-leaf stage outlining the importance of best practice agronomy
- The mixed species plot exhibited the highest biomass throughout the main growing season, browning off when rain fall reduced in early spring much sooner than monoculture plots.
- All plots were affected by moderate to high volunteer cereal and vetch competition, resulting in reduced plant populations and biomass

Background

The Upper North growing region is characterised by medium to low growing season rainfall conditions and a mixture of arable and non-arable land (Aust. Government 2019). These factors, in combination with the growing need for risk mitigation techniques due to volatile markets and fluctuations in climate, mean that farming systems are primarily mixed operations running livestock in collaboration with a cropping enterprise. There has been a growing movement toward pasture break crops such as vetch and forage brassicas, allowing for a disease break in the typical cereal rotation, giving low-cost herbicide opportunities to control grass weeds, fixing nitrogen and providing fodder for livestock throughout the season to potentially fill feed gaps. This gives growers across the region options for high protein, high energy, early feed to wean lambs onto or to get breeding stock through poorer seasons (Kandulu et al. 2012).

Long-term improved pastures are also common throughout the district, with perennial, deep rooted species such as lucerne and phalaris sown to provide a long-term forage option on land less suited to cropping. Other common options include clover and medic species, with growers promoting a seed bank to ensure the longevity of the species within the system. The region experiences many climatic and environmental factors which limit pasture options such as frost events, prolonged heat and moisture stress, soil constraints such as salinity and pH imbalances and many more (Hall et al. 2009). Another important consideration when effectively managing farming systems in our region includes matching feed curves, feed on offer and stocking rates accordingly throughout the season (Jafari et al. 2007).

For this reason, Upper North Farming Systems (UNFS) saw it necessary to investigate possible improved pasture options, in the form of a demonstration plot, for our surrounding growing region. This saw fifteen pasture species sown and monitored throughout the 2019 growing season with overall results summarised below.

Pasture List

Origin Fescue is a deep-rooted perennial grass option which exhibits excellent persistence and is an alternative to phalaris or ryegrass. Fescue can grow in moderately saline, acidic, dry, frosty conditions well and is not prone to false breaks, being truly dormant over the summer months.

Currie Cocksfoot is an older cocksfoot variety, typically grown in medium to high rainfall areas and shows moderate drought tolerance. Maturity is approximately one month later than Kasbah and is a Mediterranean type meaning if the season permits it will show some growth throughout summer and has an indeterminate flowering. This species can become competitive if grazing management is not employed, eventually dominating the pasture mix.

Kasbah Cocksfoot is a tetraploid perennial grass meaning it exhibits high levels of sugars making it highly palatable for livestock. This species shows good drought tolerance, early establishment and is best suited to light, well-drained, low-fertile and acidic soils. The growth habit is semi-erect to erect with maximum herbage production throughout autumn and winter, being a continental type, with high early tillering.

Holdfast GT Phalaris is suited to medium rainfall environments and can withstand heavy grazing pressures due to the growing crown being underground. This also allows the plant to spread via production of daughter tillers. The highest biomass production occurs throughout late Autumn, Winter and early Spring. This cultivar exhibits higher forage production in contrast to older phalaris varieties.

Balance Chicory is a rapid to establish, leafy herb with a deep taproot. This species is best suited to a fertile soil that is free draining with a pH between 5.5 and 8. Chicory can be grazed intensely in a rotational system as its growing point is close to the ground and it exhibits fast regrowth in warmer climates. Growth can be slow in cold conditions.

Bouncer Hybrid Forage Brassica is a cross between tetraploid turnip and Chinese cabbage, which exhibits high early growth and fast potential for re-grazing with an average of 8 weeks to grazing and 3 to 4 weeks between grazing events. This species has vigorous summer growth with a high energy content and leaf to stem ratio. One limitation of this species is its susceptibility to several common insect pests due to limited resistance genes.

Leafmore Forage Brassica is a cross between Winfred and Emerald exhibiting an early maturity like that of bouncer. Leafmore also shows excellent regrowth post grazing allowing for 4 or more grazing intervals. One advantage of Leafmore is its increased tolerance to cold growing conditions and the occurrence of frosts in comparison to Bouncer.

The above forage brassicas produce a beneficial chemical compound called glucosinolates. This compound acts as a natural soil-borne pathogen control effectively controlling plant diseases such as take-all and presence of nematodes. These species will produce a purpling of the leaves, signalling the correct timing to introduce livestock.

Cobra Balansa Clover is a hard-seeded clover variety which can be grown in low rainfall growing regions (~200mm). This species shows excellent winter growth in contrast to other clover varieties available.

Mawson Sub Clover is a variety developed by SARDI exhibiting a long persistence and improved forage yields in comparison to older varieties. This variety is suited to low-medium rainfall zones and has an intermediate growth habit.

Lynx Barrel Medic (Pasture Genetics) contains a new 'leaf holding gene' which has increased the persistence of foliage. This species is suited to medium rainfall environments, bred with a high leaf to stem ratio suiting it well to hay making.

Scimitar Medic (Heritage Seeds) is an early to mid-season medic, adapted to a wide range of soil conditions. Scimitar exhibits a high percentage of soft seededness (24%) with an erect growth habit.

SARDI Grazier Lucerne (Heritage Seeds) is a grazing tolerant Winter Lucerne which can persist under set stocking rates once established for up to two months. This variety has been found to flourish across a wide range of environment from low to high rainfall.

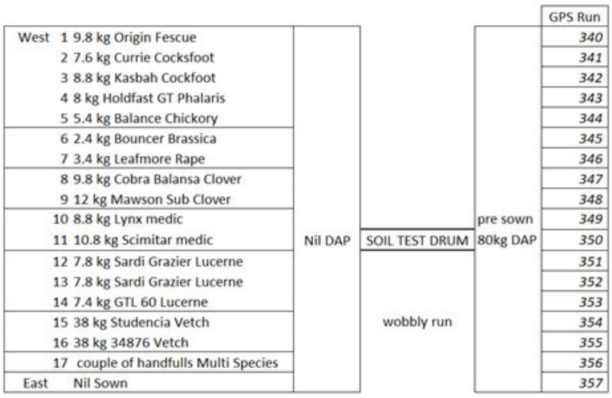
GTL 60 Lucerne (Pasture Genetics) is very similar to the above variety, with a low set crown allowing increased grazing intensities.

Studenica Vetch (Pasture Genetics) is a new line of vetch bred to withstand frost events. This is an early flowering variety, producing significantly more bulk early in the season in contrast to older varieties.

Methodology

The demonstration site was sown on the 1st of May with limited rainfall events prior and thus low stored soil moisture after a dry summer and overall poorer season in 2018. The total for May rainfall was 32mm with warm days which promoted an early germination and establishment across all broad leaf species. It was noted that due to limitations imposed by seeding equipment grasses took much longer to germinate.

Plots were all sown at a consistent depth of 25mm on a row spacing of 10” (250mm). Half of each plot was sown into 80 kg/ha MAP (10:22:0:1) with the other half sown into no starting fertilizer. Soil test results showed no major constraints overall, with adequate plant available nutrients. There was some boron toxicity associated with saline conditions in the sub-soil, which was not considered a major limiting factor.



Species were planted alongside one another, with the 17th row being sown to a mix (Fig. 1)

***Figure 1**. Trial map illustrating how plots were positioned at the Caltowie trial site.*

Non-legume plots were fertilized with a further 50kg/ha Urea on the 28th August ahead of a rain front. Legumes were all assessed for nodulation at the same time, with limited nodules observed, except for vetch species. Therefore, this limitation needs to be considered in the below results.

The previous year’s crop was sown to barley, with wheat and vetch in prior years and best practise agronomy adhered to.

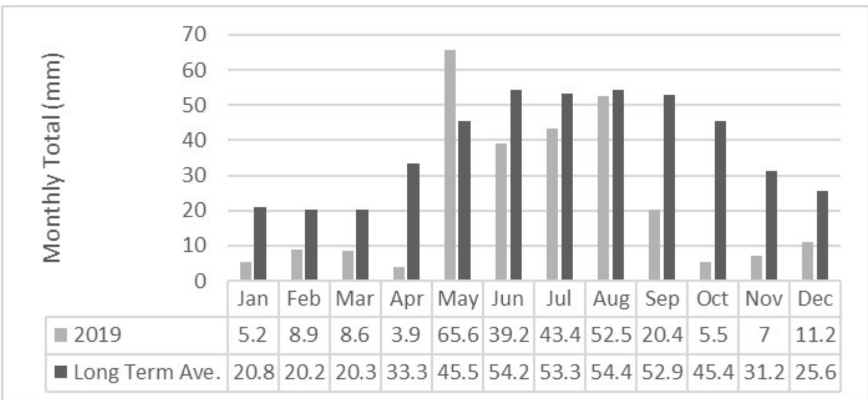


***Figure 2.** 2019 season rainfall data against long term averages for the region to date, taken from BOM.*

Growing season rainfall (April to October) tallied to 230.5 mm, with all months except May receiving below the long-term average (Fig. 2).

Overview of Observations

Sporadic germination was observed in all small seeded species due to depth of sowing pro-longing germination in addition to a slight soil crusting as a result of moderate levels of salinity observed in the paddock. This favoured volunteer vetch and barley plants resulting in a high level of competition in some grass plots. Additionally, some younger leaves experienced wind damage, with strong winds occurring the week starting 6th May, shortly after seeding. These events highlighted the importance of best practise agronomy in the establishment of perennial grasses, which are typically harder to establish in contrast to annual species.

Opportunity for early feed was observed among all annual species, with bouncer forage brassica being significantly more advanced than all other species in the two months following seeding. However, later in the season it was observed that Leafmore Forage Brassica and Studencia Vetch both outcompeted Bouncer with regards to biomass totals. This is illustrated in the below graph (Fig. 3) at two sampling dates. Many of the perennial species were unable to be sampled at the first sampling date due to lack of vigour, hence why sampling also occurred a month later.

All perennial species showed excellent establishment and went on to set seed later in the season. Standouts included Cobra Balansa Clover, Scimitar Medic and both Lucerne varieties. The Lucerne plots showed the highest tolerance to moisture stress experienced later in the season in contrast to all other plots. The mixed species plot was first to show moisture stress, as would be expected, however also showed a significantly higher amount of biomass. Therefore, it was observed that an annual mixed species pasture shows good adaption to in-season feed options, however cannot be expected to persist under agronomic stresses throughout spring.

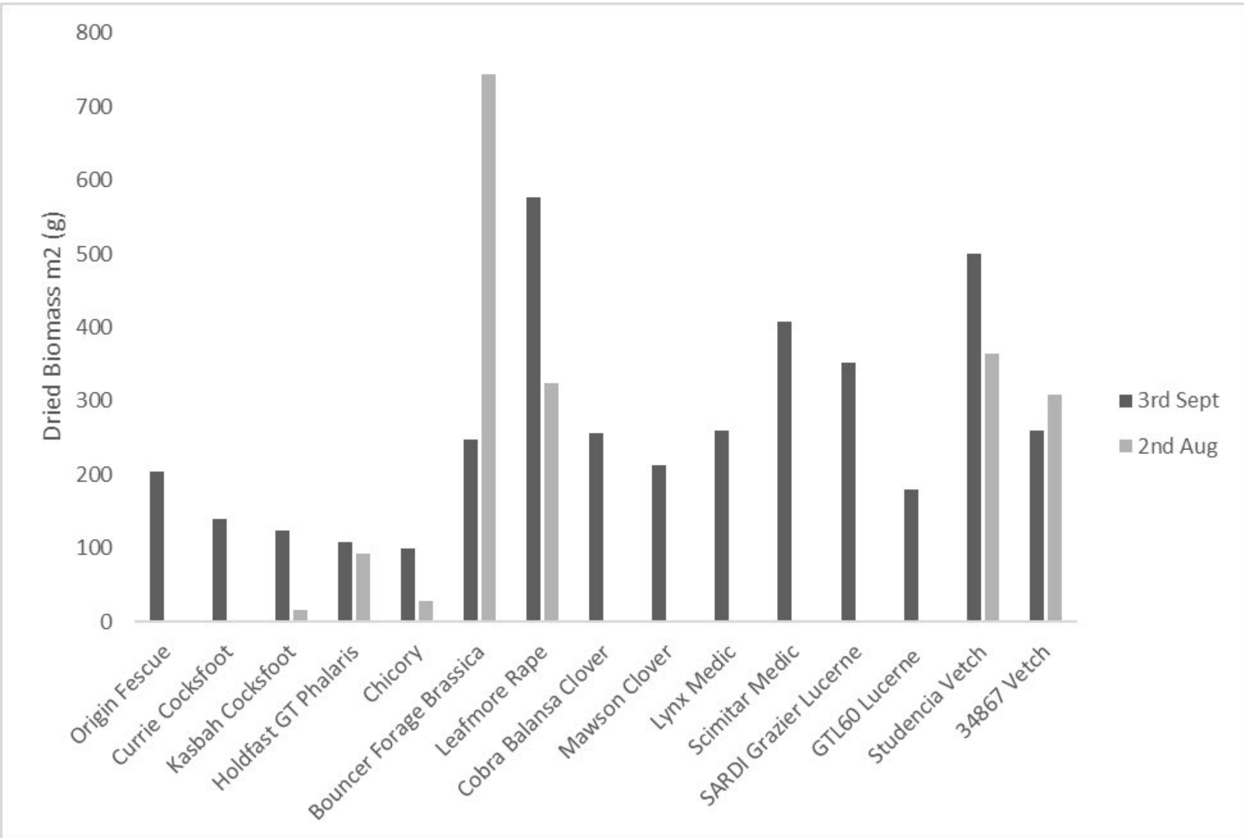


Figure 3. *Dried biomass taken at four and five months after sowing. (NB. August sampling of some plots was not possible due to lack of early biomass.)*

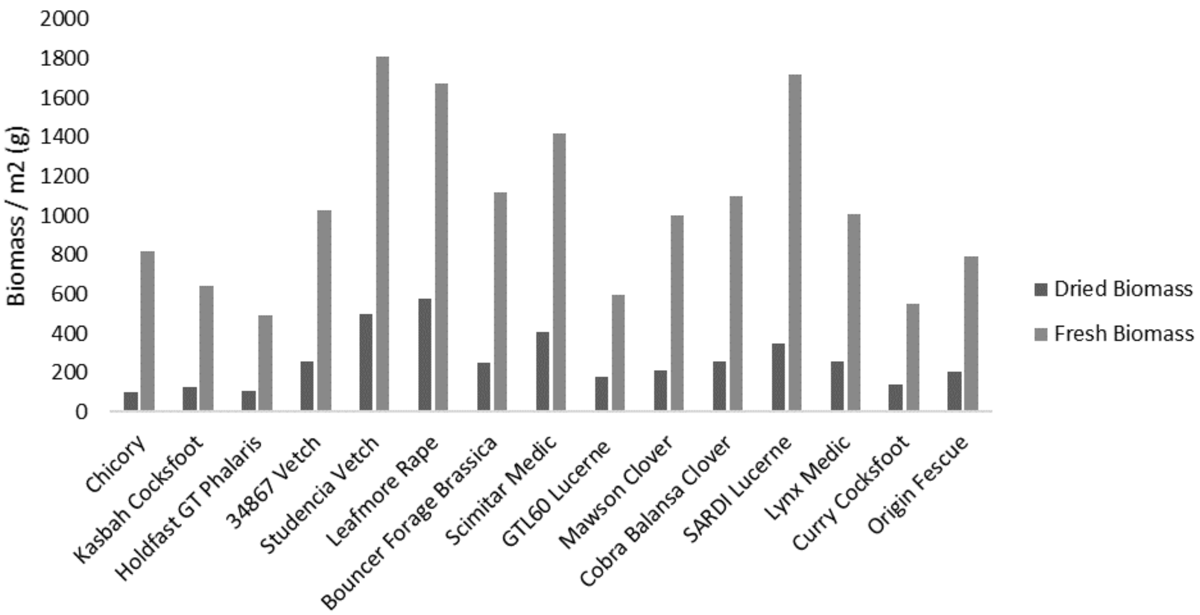


Figure 4. *Dried weight compared to moisture content for each pasture species, collected on the 3rd September*

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Value of standing crops for lamb production and soil protection

Alison Frischke[1], Genevieve Clarke[1] and San Jolly[2]

[1]Birchip Cropping Group; [2]Productive Nutrition

Location
Karyrie
Rainfall
2019 Total: 418 mm
2019 GSR: 197 mm
Paddock history
2018: Fallow
2017: Lentil
Soil type
Clay loam

Key messages

- **A standing cereal crop is a low risk option for feed; it is a familiar crop grown on winter rainfall, with lower grain handling efforts and its end-of-season result can be flexible with seasonal and market conditions.**
- **With a protein supplement, lambs can be finished faster and turned off earlier, leaving more groundcover for soil protection than other pasture paddocks. Background**
- **Have you considered using a standing crop for grazing in spring or summer? Feeding sheep over the late spring feed gap when pastures are unproductive and before stubbles are ready or during summer months once stubbles are exhausted and you could be taking a break, is time consuming and requires extra resources and double handling of feed.**
- **A 'standing crop' is a crop that has been held as a fodder bank for grazing later in the year once it becomes reproductive, from head formation in the boot to full grain maturity. The standing crop can be a cereal, or a combination of a cereal with a pasture legume or grain supplement to satisfy higher protein demands of growing lambs.**
- **A standing crop can offer improved nutrition and groundcover compared to other annual pasture paddocks at these times. Systems growing autumn/winter drop lambs with genetic potential for growth rates >300 g/day, need to be maintaining high growth rates to achieve target sale weights for marketing. The standing crop can be a useful way to help finish these lambs faster at three to six months of age, enabling you to sell earlier and take stocking pressure off your farm.**
- **A standing crop can also be useful for ewes to regain condition pre-joining, during pregnancy and lambing.**

Why do the trial?

To demonstrate the value of standing crops for sheep production and soil protection.

How did we do it?

Single plots of cereal varieties (wheat, barley, oats, Table 1) were sown using knife points, press wheels and 30 cm row spacing as a demonstration on 17 May 2019, targeting a plant density of 130 plants/m². Assessments included GS30 biomass, GS65 (anthesis) biomass, grain yield and quality (harvested 5 December 2019). Feed tests were conducted on GS30 and GS65 biomass and grain for selected varieties in Table 2.

Granulock® Supreme Z fertiliser + Flutriafol (200 mL/100 kg) fungicide @ 60 kg/ha was applied at sowing, and urea was top-dressed on 24 June @ 100 kg/ha, 25 July @ 100 kg/ha, and 26 August @ 100 kg/ha.

Weeds, pests and disease were controlled according to best management practice.

Table 1. Sowing rate (kg/ha) to achieve 130 plants/m², GS30 and GS65 biomass (t/ha) and grain yield (t/ha) for standing cereal crops, Karyrie 2019.*

Cereal type	Variety	Sowing rate (kg/ha)	GS30 biomass (t/ha)	GS65 biomass (t/ha)	Grain yield (t/ha)
Oats	Wintaroo	47	0.8	13.8	2.9
	Mulgara	64	1.1	11.3	1.4
	Yallara	50	0.9	10.4	2.6
	Mitika	53	0.8	8.9	2.9
	Bannister	41	0.7	9.3	4.5
	Outback	40	0.8	9.7	0.7
Mulgara	Moby	47	1.6	9.9	0.1
	Rosalind	62	1.2	10.7	5.0
	Spartacus CL	67	1.4	10.8	4.9
	Scope CL	66	1.2	9.2	3.5
	Compass	73	1.1	11.0	1.8
	Fathom	54	1.6	10.0	2.6
	RGT Planet	81	1.6	12.1	5.5
Yallara	Scepter	76	1.1	12.7	5.3
	Trojan	64	0.8	10.6	5.6
	Longsword	40	0.7	11.5	3.9
	Wedgetail	59	0.9	11.5	4.9
	DS Bennett	49	1.1	12.1	5.3

*Demonstration data only

What happened?

Feed production

Early biomass measured at GS30 indicated 0.7-1.1 t DM/ha for oats, 1.1-1.6 t DM/ha for barley and 0.7-1.1 t DM/ha for wheat (Table 1).

If left ungrazed until GS65, biomass results showed oats produced 8.9-13.8 t DM/ha, barley 9.2-12.1 t DM/ha and wheat 10.6-12.7 t DM/ha (Table 1).

The demonstration indicated that if sheep were able to graze the grain of mature crops in 2019, they would have had access to 1.4-4.5 t/ha oats, 1.8-5.5 t/ha barley and 3.9-5.6 t/ha of wheat grain (Table 1).

The site experienced strong winds on 21 November, resulting in lodging of Wintaroo and Mulgara. It also caused head loss in Moby which had very few remaining attached at harvest. This impacted on final yield, however the grain is easily grazed off the ground by sheep.

Feed value

When GS30 was reached, all crops tested had high digestibility, protein and metabolisable energy (ME) levels (Table 2).

By anthesis (GS65) and milky dough stage, nutritional values begin to vary so a feed test is recommended to better understand the crop value. In this trial, crude protein and metabolisable energy dropped towards dry ewe maintenance values (8% protein, 8 MJ ME/kg DM), so supplements are needed for production.

Grain quality

Samples were analysed externally using NIR. Feed quality of grain is stated in Table 2. Note the range of values, reinforcing the need to feed test to understand how crop type, variety, location and season has influenced its value. Oats are generally lower in protein, but higher in fibre than wheat and barley.

On-farm profitability

Extensive head loss occurred in some barley varieties this season. The following example can be used to calculate feed value of lost heads (Table 3).

The example valued the grain at $245/t and used a grazing wastage loss of 20% - an estimate of trampling and burying that could vary between 15 and 40%. Therefore, for a 1.26 t/ha crop, there will be about 1 t/ha grain available for sheep production.

What does this mean?

Based on current barley, wool and lamb prices, converting 1 t of standing crop grain into sheep production produces a gross margin for grazing higher than the gross value of the grain before production costs have been deducted (Table 3). This suggests that grazing a standing cereal crop offers a great conversion of grain value and can be a more profitable alternative than harvesting.

If the standing crop is a two-year option, the wastage factor can be discounted as any grain trampled or buried in year one will be eaten as regenerated cereal in year two.

Commercial practice

The advantage of grazing a standing crop to finish lambs is that it is a low cost, low risk proven practice that can be either planned or opportunistic. There is no need to learn new skills, it just involves using the crop for a different purpose.

Table 2. Feed value of standing cereal crops.

Crop variety	Plant growth stage	Crude protein (%)	Metabolisable energy (MJ/kg DM)	Neutral detergent fibre (%)	Digestibility (DMD) (%)
Mulgara oats	GS30	30.3	12.5	38.0	82.3
	GS65	8.3	9.2	53.5	62.7
	Grain	16.8	12.6	30.3	74.5
Yallara oats	GS30	28.6	12.5	39.4	81.8
	GS65	7.6	10.2	43.4	68.5
	Grain	14.0	12.1	32.0	71.4
Moby barley	GS30	28.1	12.2	44.5	80.4
	GS65	10.6	9.4	56.6	63.9
	Grain	13.0	13.0	17.1	84.9
Fathom barley	GS30	28.8	12.3	44.3	81.2
	GS65	9.0	8.4	61.6	58.2
	Grain	13.5	13.2	15.4	87.1
Scepter wheat	GS30	32.5	12.1	42.3	79.8
	GS65	7.2	8.9	53.1	61.1
	Grain	15.6	14.4	10.0	95.9

Table 3. Estimating grazing value of a standing crop of barley ($/ha).

Grain yield (t/ha)	Gross grain value ($/ha)	DSE grazing days*	Gross margin Prime lamb/Merino ewe enterprise Grazing value ($/ha)**
1	245	1500	288
2	490	3000	575

**DSE grazing days = (DM (kg/ha) – wastage) x feed test ME (we used 12 MJ)/ 8 MJ (1 DSE requires 8 MJ/day)*
***Gross margin grazing value = DSE grazing days x (GM/DSE/365)*
2020 Prime lamb/Merino ewe GM/DSE = $70, pers. comms. Barry Mudge, PIRSA Farm Gross Margin and Enterprise Planning Guide

The standing crop is sown and grown as a winter crop would be managed for harvest. In spring, the crop can be assessed for its best end-use/return opportunity, and a responsive decision made according to market and seasonal conditions. If the decision is made to graze a standing crop, grain handling and labour costs over spring and summer are lower because any supplementary feeding will be for a shorter time.

What cereals should I grow for grazing as a standing crop?

The first option is to use a cereal variety that is already on hand. It will be a variety that performs well in the local area that can easily be managed. By sowing and managing the paddock as for a normal crop, responsive decisions can be made to graze, cut for hay or harvest grain based on lamb and grain prices and seasonal conditions or events such as heat stress or frost that may have compromised grain production. Alternatively, choose a variety that is fit for purpose. Examples include:

- Winter grazing: early maturing Moby barley that has good early biomass.
- Spring/summer grazing: longer season Outback oats.
- Finishing lambs: grain varieties with good protein.
- Grass control: choose herbicide tolerance for ryegrass and silver grass control.

Does plant structure or growth stage affect sheep preference for grazing?

From grower experience, sheep will eat any cereal, regardless of whether it has awns, rough texture, is green or dry. They will preferentially graze varieties for palatability (mouth feel, sweetness and digestibility) if they are given a choice, but when there is only one variety available they will eventually consume it.

During milky dough stage, crops can become unpalatable but sheep will graze if there is no alternative. If sheep are put in earlier, the crop will ripen at different stages as it is grazed, so there will be something good to eat somewhere in the paddock. Supplement with protein during this time, especially if weaning lambs.

Supplements

Sheep protein requirements range from 8% for a dry ewe to 18-20% for lambs growing at 200 g/day. If there has been a dry finish and the crop protein is 14-16%, wait until the crop heads have been eaten off before supplementing with more protein. In favourable seasons, protein can fall to 8-10% and a supplement of legume grain would be beneficial.

All cereal grains are low in calcium and sodium, so supplement with a limestone 80%: salt 20% loose mix. There is no need for magnesium supplementation on a mature crop. Provide supplements to sheep before they enter the standing crop, so they are used to it and ready to consume it when they enter.

Introducing animals to the standing crop

The standing crop can be used at any time but take care if introducing animals to the crop once grain has set. Barley and wheat contain high levels of readily digested starches and low levels of fibre so care must be taken to prevent grain poisoning or acidosis.

It is safe to introduce lambs during head emergence, milky dough stage of crop and early grain fill as it ensures that they are grazing the crop when it matures and grain develops, and rumen microbes can gradually adjust to the change in nutrition.

If grain has set, the usual rules when introducing sheep to grain apply:

- Check pulpy kidney vaccinations are up to date and vaccinate before entering the crop if necessary. Repeat after four weeks if trading lambs and vaccination history is unknown.
- Train sheep onto the grain gradually. Begin by trail feeding in their current paddock before introducing to the crop.
- During the introduction phase, feed grain daily. Start with 50 g per head on the first day, followed by increases of 50 g every day until a full ration is reached.
- Fibre stimulates saliva production, which contains the natural buffer bicarbonate. Provide fibre or a bicarbonate supplement if paddock feed is low while trail feeding. There will be adequate fibre once in the standing crop.
- Alternatively, move sheep in and out of the standing crop over 10 days of adjustment. To avoid gorging, introduce to the paddock late in the day with full bellies, and only leave on for a short time initially, then gradually increase the time each day.
- Providing vetch/legume hay during introduction to the crop is also an acidosis prevention strategy, supplying an alternative feed as well as protein.
- Lambs will initially be more hesitant to graze as they familiarise themselves with the standing crop and are less likely to gorge themselves than ewes with previous experience.
- Monitor the flock for signs of scouring, unhappiness, lethargy, disjointed gait or lameness which will indicate the amount of grain is being increased too soon.

Wheat and triticale have the highest risk of acidosis due to high starch and low fibre levels. Barley is not as dangerous, but has a huge range of nutrient values, so be familiar with the grain analysis. Oats are safest due to their higher fibre levels and lower starch levels and sheep can go straight onto the crop. Scope barley and forage cereals (less grain) also have lower acidosis risk. At times sheep can be put onto rations quicker than the guidelines, at other times it might take longer.

Grazing behaviour of sheep in tall crops

Mow 1-2 header widths around the edge of the paddock to the trough, but not through the crop – they will make walking tracks and rut it out. Sheep will move across the standing crop paddock as they graze over time.

If the crop has been left to mature, first graze with lambs. They will eat approximately 75% of the grain and 25% leaves. Once heads have been knocked to the ground, Merino lambs are reluctant to eat them, but British or crossbred lambs will eagerly continue grazing. Start topping up lambs with legume grain to finish or shift to another paddock. Once upright heads have gone, turn in the ewes to graze the remainder.

Standing crop paddock management

Ideally leave 1-1.5 t/ha residue to provide adequate groundcover, protecting the soil from wind and water erosion and reducing evaporation of stored water over summer. Because the bulk of biomass provided by the standing crop is much larger than a finished pasture or stubble, the standing crop will provide better paddock protection for longer over the summer months.

A system suggested for a standing crop paddock is to plan to graze the paddock for two years. Sow the standing crop in April and put lambs on it to graze from milky dough stage through grain maturity. Once lambs are finished and removed from the paddock, there will still be a lot of grain remaining the next autumn to germinate on early rains. The germinating cereal seed can be used for lambing, then sprayed out and sown to vetch for the second year – or the paddock can be cleaned up further with ewes or wethers to use more straw, then destocked to germinate the residual cereal seed for a second season of cereal pasture.

Sowing the standing cereal crop into a lucerne stand or a regenerating clover or medic-based pasture will provide added protein nutrition for lamb production and help the pasture legumes persist in the rotation.

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