2020
RESULTS

UPPER NORTH FARMING SYSTEMS ANNUAL RESEARCH AND EXTENSION COMPENDIUM

DISCLAIMER

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A Message from the Chair - 2020

2020 is certainly a year none of us will forget. With the global pandemic of COVID-19 drastically changing how we interact with each other; many people were forced into hard lockdowns with schools and workplaces shutting their doors. We had to continue life in ways we haven't considered. Working and educating our children from home and sporting and social events being cancelled meant we were faced with many challenges just to survive the day-to-day rigours. Fortunately for us in the agriculture sector being considered as "essential services" not a lot changed within our businesses. Our supply and export chains were relatively unaffected, and we were free to continue the day-to-day side of our businesses as we needed.

In July we said goodbye to Jamie Wilson who had been working with us for 12 months in a project managers role. I'd like to thank Jamie for his efforts, and we wish him the best for his future endeavours. I'd like to welcome Jade and Denni to the team. Jade Rose has taken on the Research Coordinator role and Denni Agnew the Engagement Coordinator role. They come to us with a fantastic skill set that the committee believe will help elevate the group further. Both are very committed to UNFS and are passionate about Agriculture and the community, they are approachable and are eager to hear from members.
The Upper North have a fantastic array of projects currently going with a good mix of trial work and extension. We were very fortunate to have the 'Fullerville Mega Site" last year, which was a collaboration with UNFS, SARDI and National NVT. It consisted of a great mix of small plot trials including our Barley Time of Sowing and Cereal Hay (Fodder) Options, the wheat NVT was there as well as SARDI Pulse disease and Novel Cropping Systems Trials. The Pulse Check Agronomy group continued last year, and the Sheep Technology Adoption group started, they both will continue for this year. There is much more going on behind the scenes with some exciting projects starting in 2021.

At UNFS we were faced with a few hard decisions. The committee decided to cancel the flagship event that is the Members Expo, with all the uncertainty around COVID-19 we felt that the risk of being shutdown at any time was a real one. The time of our staff and the costs associated with the event we felt that it was better to focus these resources into something that would be more responsible and have better outcomes for our members and the industry. This was the start of the 'Hubs in Pubs' and 'Crop Stomp' series. A series of small events sponsored by Grain Growers and the SA Government Connecting Drought Communities Fund where we had guest speakers and trial walks with researchers and industry reps. It was well supported by members and non-members with the aim to foster the farmer learning from farmers philosophy and interaction with industry researchers and reps. Some of these events were filmed and are available on our YouTube channel.

I'd like to thank the staff and the committee for their support during 2020, there was a lot of emails, phone calls and Zoom meetings going on in the background with all the uncertainty around COVID-19. The staff did an amazing job in getting the 'Hubs in Pubs' and 'Crop Stomp' series off the ground and ensuring that all of our trial milestones were met.
I'd also like to thank the funding bodies, project partners, collaborators and sponsors that have contributed to the UNFS group, with their support we can continue to run trials and extension activities of value to our members and the Ag industry. We pride ourselves on the high-quality work we are able to achieve with your support.

Thanks,

Matt Nottle
UNFS Chairman

Upper North Farming Systems

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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; Landscape South Australia Northern and Yorke; SARDI; University of Adelaide, AGT, SPAA, Birchip Cropping Group, Mallee Sustainable Farming, Ag Excellence Alliance; Rufous and Co., AgExtra, AIR EP, Ag Consulting Co., Elders, SAFECOM, Balco, Agbyte, Northern Ag, NR Ag, Pinion Advisory, Nutrien Ag, Seednet, Barenbrug, PBA, GIA, agrichem, Ag Communicators 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
85 989 501 980

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2020

	Note	2020 $	2019 $
INCOME			
Group Income			
Interest		287.77	1,173.69
Machinery Hire		-	3,072.30
Membership		5,658.83	5,022.48
Merchandise		-	112.27
Project Administration		3,128.35	14,077.90
Field Days		18,968.91	2,900.00
Commercial Paddock		5,535.80	4,775.51
Sponsorship		9,250.00	9,961.52
		42,829.66	41,095.67
Profit on sale of Fixed Assets		-	777.99
		42,829.66	41,873.66
OTHER INCOME			
Abnormal Income		10,000.00	-
Project Income			
Barley Grass Management Option		34,167.00	-
Vetch on Saline Soils		3,000.00	-
Regenerating Goyder's Line		50,000.00	-
Yield Prophet		-	150.00
GRDC Stubble Initiative		-	65,100.00
Ladies on the Land Workshop		2,132.00	2,700.00
Time of Sowing Trial		1,331.25	25,293.75
Pasture Options Demo		1,434.00	-
Micronutients in Upper North		48,165.00	30,600.00
Pulse Check		13,814.00	18,537.00
Cover Crop		37,000.00	5,000.00
Dryland Legumes		30,000.00	-
Weather Station Network		80,000.00	-
Barley Time of Sowing		28,875.00	-
Fodder Crop Trials		6,000.00	-
		335,918.25	147,380.75
		345,918.25	147,380.75
		388,747.91	189,254.41

The accompanying notes form part of these financial statements.

UPPER NORTH FARMING SYSTEMS
85 989 501 980

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2020

	Note	2020 $	2019 $
EXPENDITURE			
Group Expenses			
Administration		50,167.02	22,730.57
Audit Fees		2,050.00	2,750.00
Minor Equipment & Maintenance		218.68	908.17
Insurance		1,264.80	2,759.95
Advertising		562.22	-
Publications		6,881.02	1,686.64
Field Days		24,760.25	7,143.81
Commercial Paddock		12,977.15	1,418.86
Bank Fees		120.00	120.00
Depreciation Weather Station		7,211.00	5,270.00
Other Project Expense		2,584.85	750.00
Travel		295.50	916.25
WorkCover RTWSA		262.80	-
Total Wage Expense		379.58	20,086.24
Merchandise		1,248.64	-
		110,983.51	66,540.49
Project Costs			
Barley Grass Management Option		13,741.95	-
Vetch on Saline Soils		1,546.02	-
Ag Tech Hub		467.50	-
SARDI Research Site Management		170.00	-
Yield Prophet		-	5,009.75
Sheep Tech Group		85.00	-
Ladies on the Land		3,944.75	2,412.71
Time of Sowing Trial		29,832.67	15,463.49
Pasture Options Demo		2,346.25	2,323.73
Micronutrients in Upper North		8,100.61	15,664.98
Pulse Check		10,172.38	9,660.93
Cover Crop		14,823.36	2,527.25
Barley Grass Trial		-	212.50
Dryland Legumes		10,100.51	255.00
Weather Station Network		1,897.50	750.00
Barley Time of Sowing		8,105.25	2,000.00
Fodder Crop Trials		1,811.61	652.50
		107,145.36	56,932.84
		218,128.87	123,473.33

The accompanying notes form part of these financial statements.

UPPER NORTH FARMING SYSTEMS
85 989 501 980

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2020

	Note	2020 $	2019 $
Profit before income tax		170,619.04	65,781.08
Profit for the year		170,619.04	65,781.08
Retained earnings at the beginning of the financial year		326,635.53	260,854.45
Retained earnings at the end of the financial year		497,254.57	326,635.53

The accompanying notes form part of these financial statements.

UPPER NORTH FARMING SYSTEMS
85 989 501 980

BALANCE SHEET
AS AT 30 JUNE 2020

	Note	2020 $	2019 $
ASSETS			
CURRENT ASSETS			
Cash and cash equivalents	**3**	417,079.75	324,227.38
TOTAL CURRENT ASSETS		417,079.75	324,227.38
NON-CURRENT ASSETS			
Property, plant and equipment	**4**	91,307.00	3,517.00
TOTAL NON-CURRENT ASSETS		91,307.00	3,517.00
TOTAL ASSETS		508,386.75	327,744.38
LIABILITIES			
CURRENT LIABILITIES			
Trade and Other Payables	**5**	11,132.18	1,108.85
TOTAL CURRENT LIABILITIES		11,132.18	1,108.85
TOTAL LIABILITIES		11,132.18	1,108.85
NET ASSETS		497,254.57	326,635.53
MEMBERS' FUNDS			
Retained earnings	**6**	497,254.57	326,635.53
TOTAL MEMBERS' FUNDS		497,254.57	326,635.53

The accompanying notes form part of these financial statements.

NOTES TO THE FINANCIAL STATEMENTS
FOR THE YEAR ENDED 30 JUNE 2020

3 Cash and Cash Equivalents

	2020 $	2019 $
Freedom Bank Account 92540	157,206.81	34,642.21
Business Bank Account 93340	259,872.94	289,585.17
	417,079.75	324,227.38

4 Property, Plant and Equipment

	2020 $	2019 $
Plant & Equipment - at Cost	-	5,749.00
Less Prov'n for Depreciation	(9,443.00)	(2,232.00)
	(9,443.00)	3,517.00
Other Plant & Equipment	100,750.00	-
Total Plant and Equipment	91,307.00	3,517.00
Total Property, Plant and Equipment	91,307.00	3,517.00

5 Accounts Payable and Other Payables

	2020 $	2019 $
Current		
PAYG Withheld	72.00	-
Superannuation Liability	47.03	-
GST Account	11,013.15	1,108.85
	11,132.18	1,108.85

6 Retained Earnings

	2020 $	2019 $
Retained earnings at the beginning of the financial year	326,635.53	260,854.45
Net profit attributable to the association	170,619.04	65,781.08
Retained earnings at the end of the financial year	497,254.57	326,635.53

Upper North Farming Systems

Cashflow by Tag 1/7/19 to 30/06/2020

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**	**219 Ladies on the Land W orkshops**	**220 Time of Sowing Trial**	**222 Production Wise**	**223 Pasture Options Demo**	**224 Micronutrients**	**226 Pulse Check**	**227 Cover Crop**	**228 Barley Grass Mgt Options**	**229 Dryland Legumes**	**230 Vetch of Saline/Sodic soils**	**231 Weather Station Network**	**232 Barley TOS**	**233 Fodder Crop Trials**	**234 Ag Tech**	**235 Regenerating Goyder's Line**	**236 SARDI Research Site**	**237 Sheep Producer Tech Group**	**OVERALL TOTAL**
INFLOWS																					
Interest	287.77																				287.77
Events	0.00	0.00																			0.00
Machinery Hire_Vehicle Use	0.00																				0.00
Membership	5658.83																				5658.83
Merchandise																					0.00
Project Administration	2628.35																				2628.35
Project Income		9491.64	5535.80	2132.00	1331.25		1434.00	48165.00	13814.00	37000.00	34167.00	30000.00	3000.00	80000.00	28875.00	6000.00		50000.00			350945.69
Sale of Capital Items																					0.00
Sponsorship	9250.00	6477.27																			15727.27
Sundry Income	10601.70	3000.00																			13601.70
Transfer In	500.00																				500.00
TOTAL INFLOWS	28926.65	18968.91	5535.80	2132.00	1331.25		1434.00	48165.00	13814.00	37000.00	34167.00	30000.00	3000.00	80000.00	28875.00	6000.00	0.00	50000.00	0.00	0.00	389349.61
																					0.00
OUTFLOWS																					0.00
Administration	50087.02	3542.50		0.00	1128.35			0.00	0.00	0.00	85.00	85.00		85.00							55012.87
Advertising	562.22	344.13					0.00														906.35
Audit Fees	2050.00																				2050.00
Financial Management fees	80.00																				80.00
Grant Refund					17911.87																17911.87
Bank Fees	120.00																				120.00
Repairs & Maint	156.00																				156.00
Event Expenses																					0.00
Event Catering	185.00	4435.37		624.00					542.98												5787.35
Event Expense		2466.18		887.00																	3353.18
Field Day Expenses		826.70			2000.00			0.00													2826.70
Presenter	850.00	6244.55		2200.00					1800.00												11094.55
Hub Expenses		400.00																			400.00
Insurance	2129.30		146.11																		2275.41
Merchandise Exp	1248.64																				1248.64
Minor Asset purchase & repairs	62.68	1468.18																			1530.86
Project Expenses																					0.00
Communications									0.00												0.00
Consultants								0.00	0.00												0.00
Project Management		1190.00		233.75	2476.25		1296.25	2486.25	382.50	8550.00	13191.24	9162.20	1500.00	96062.50	7499.13	1583.13	467.50		170.00	85.00	146335.70
Travel	295.50	588.55			316.20		0.00	33.34	996.88	33.34	196.69	200.79			413.60	60.60					3135.49
Other Project Expenses	1550.85	3145.00	1565.04		0.00		50.00	3581.02	1194.02	6240.02	96.02	161.02	46.02	750.00	201.02	167.88					18747.91
Publications	6881.02	109.09			6000.00		1000.00	2000.00	0.00												15990.11
Transfer OUT			11266.00																		11266.00
Wages																					0.00
Computer_Data Allowance	6.00								390.00		8.00	46.00									450.00
Superannuation	340.58																				340.58
Wages Administration Officer											165.00	445.50									610.50
Wages Project Officer	33.00	0.00		0.00	0.00		0.00	0.00	4866.00												4899.00
Wages Project Manager									0.00												0.00
TOTAL OUTFLOWS	66637.81	24760.25	12977.15	3944.75	29832.67		2346.25	8100.61	10172.38	14823.36	13741.95	10100.51	1546.02	96897.50	8113.75	1811.61	467.50	0.00	170.00	85.00	306529.07
																					0.00
OVERALL TOTAL	-37711.16	-5791.34	-7441.35	-1812.75	-28501.42		-912.25	40064.39	3641.62	22176.64	20425.05	19899.49	1453.98	-16897.50	20761.25	4188.39	-467.50	50000.00	-170.00	-85.00	82820.54
																					0.00
OPENING BALANCE as at 1/07/19	213265.13	15374.89	23520.79	1813.29	28501.12	248.68	911.72	26959.78	17437.42	2472.75	-212.50	-255.00	0.00	-750.00	-2000.00	-652.50					326635.57
MOVEMENT	-37711.16	-5791.34	-7441.35	-1812.75	-28501.42	0.00	-912.25	40064.39	3641.62	22176.64	20425.05	19899.49	1453.98	-16897.50	20761.25	4188.39	-467.50	50000.00	-170.00	-85.00	82820.54
CLOSING BALANCE as at 30/06/2020	**175553.97**	**9583.55**	**16079.44**	**0.54**	**-0.30**	**248.68**	**-0.53**	**67024.17**	**21079.04**	**24649.39**	**20212.55**	**19644.49**	**1453.98**	**-17647.50**	**18761.25**	**3535.89**	**-467.50**	**50000.00**	**-170.00**	**-85.00**	409456.11

INDEPENDENT AUDITOR'S REPORT
TO THE MEMBERS OF UPPER NORTH FARMING SYSTEMS
85 989 501 980

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 2020, 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 2020 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.

INDEPENDENT AUDITOR'S REPORT
TO THE MEMBERS OF UPPER NORTH FARMING SYSTEMS
85 989 501 980

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 2nd day of October 2020

UNAUDITED Cash Flow by Group Management/Project

Upper North Farming Systems

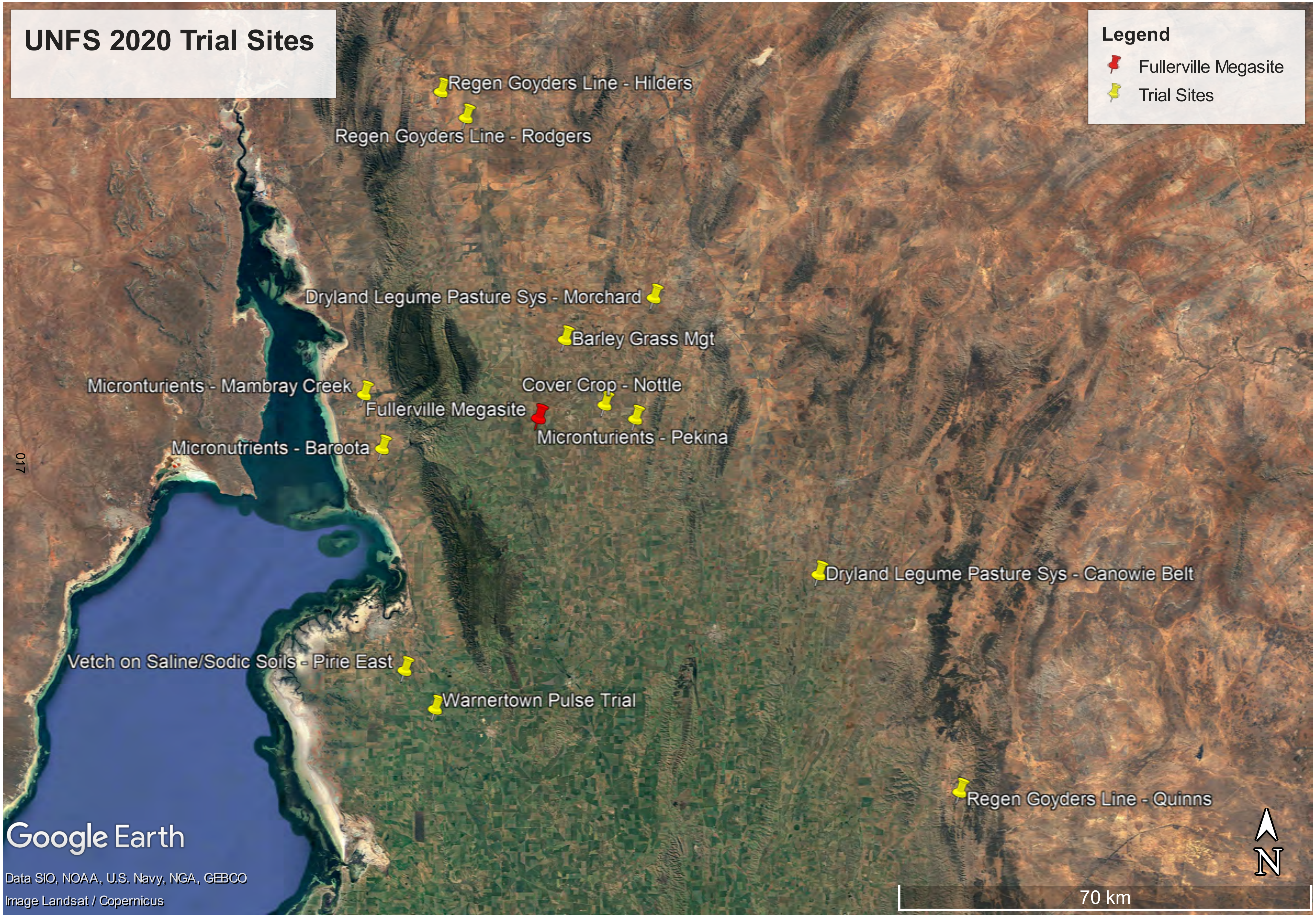
1st July 2020 to 31st December 2020

	101 - Group Management	103 - Field Days & Tours	104 - Commercial Paddock	224 - Micronutrients	226 - Pulse Check	227 - Cover Crop	228 - Barley Grass Mgmt Options	229 - Dryland Legume Pasture Systems	230 - Vetch of Saline/Sodic Soils	231 - Weather Station Network	232 - Barley TOS	233 - Fodder Crop Trials	234 - Ag Tech	235 - Regenerating Goyder's Line	237 - Sheep Producer Tech Group	238 - Soil Pathology	Total
Income																	
Donations Received	$500.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$500.00
Grants (State) Operating Non Recurring	$0.00	$5,745.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10,000.00	$0.00	$0.00	$15,745.00
Membership	$5,090.69	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$5,090.69
Project Administration	$5,116.50	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$5,116.50
Project Income	$0.00	$0.00	$8,430.38	$0.00	$11,629.00	$0.00	$0.00	$10,000.00	$2,000.00	$20,000.00	$28,875.00	$0.00	$0.00	$0.00	$12,500.00	$1,000.00	$94,434.38
Transfer In	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$595.00	$0.00	$0.00	$0.00	$595.00
Total Income	**$10,707.19**	**$5,745.00**	**$8,430.38**	**$0.00**	**$11,629.00**	**$0.00**	**$0.00**	**$10,000.00**	**$2,000.00**	**$20,000.00**	**$28,875.00**	**$0.00**	**$595.00**	**$10,000.00**	**$12,500.00**	**$1,000.00**	**$121,481.57**
Gross Profit	**$10,707.19**	**$5,745.00**	**$8,430.38**	**$0.00**	**$11,629.00**	**$0.00**	**$0.00**	**$10,000.00**	**$2,000.00**	**$20,000.00**	**$28,875.00**	**$0.00**	**$595.00**	**$10,000.00**	**$12,500.00**	**$1,000.00**	**$121,481.57**
Plus Other Income																	
Govt Cashflow boost	$10,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10,000.00
Interest Income - Unrestricted	$65.48	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$65.48
Sponsorship	$9,409.09	$2,150.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$11,559.09
Total Other Income	**$19,474.57**	**$2,150.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$21,624.57**
Less Operating Expenses																	
Accounting Fees	$2,150.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,150.00
Administration	$18,470.10	$2,087.50	$0.00	$4,816.50	$0.00	$0.00	$0.00	$0.00	$150.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$25,524.10
Advertising & Marketing	$35.19	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$35.19
Board and Governance Expenses	$4,071.26	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,071.26
Business Planning, Reporting and Evaluat	$2,272.73	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,272.73
Employment Support and Supervison Cos	$6,597.23	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$6,597.23
Event Catering	$0.00	$2,226.19	$0.00	$0.00	$466.16	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$308.00	$0.00	$3,000.35
Event Expense	$0.00	$3,846.88	$0.00	$0.00	$1,406.27	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$200.00	$0.00	$5,453.15
Financial Management Fees	$630.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$630.00
Hub Expenses	$0.00	$595.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$595.00
Industry Representation	$154.55	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$154.55
Insurance	$377.05	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$377.05
Insurance - Public Liability	$1,971.60	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,971.60
Membership Fees Paid	$45.45	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$45.45
Merchandise Exp	$2,679.95	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,679.95
Office Expenses	$369.27	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$369.27
Other Project Expenses	$85.00	$0.00	$1,061.98	$0.00	$0.00	$0.00	$0.00	$2,600.00	$0.00	$0.00	$840.00	$336.00	$0.00	$0.00	$85.00	$0.00	$5,007.98
Postage, Freight & Courier	$1,038.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,038.00
Presenter	$272.73	$500.00	$0.00	$0.00	$285.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,840.00	$0.00	$2,897.73
Printing & Stationery	$60.80	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$60.80
Project Development	$3,272.50	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$85.00	$3,357.50
Project Expenses	$0.00	$0.00	$0.00	$8,460.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$8,460.00
Project Management	$0.00	$0.00	$0.00	$425.00	$85.00	$2,420.00	$255.00	$510.00	$1,200.00	$340.00	$2,625.00	$1,542.50	$127.50	$637.50	$212.50	$0.00	$10,380.00
Publications & Information Resources	$2,145.68	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$750.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,895.68
S&W - Computer Data Allowance	$600.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$600.00
S&W Superannuation	$1,866.33	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,866.33
Salaries & Wages - Engagement Coordina	$3,550.73	$1,579.27	$0.00	$0.00	$0.00	$0.00	$101.21	$0.00	$0.00	$40.49	$0.00	$0.00	$0.00	$2,546.32	$0.00	$181.98	$8,000.00
Salaries & Wages - Project Officer	$280.50	$99.00	$0.00	$0.00	$3,069.00	$0.00	$396.00	$231.00	$0.00	$0.00	$0.00	$0.00	$0.00	$115.50	$2,128.50	$82.50	$6,402.00
Salaries & Wages - Research Coordinator	$1,932.54	$2,969.89	$0.00	$493.47	$0.00	$227.76	$132.86	$0.00	$0.00	$0.00	$341.64	$151.84	$0.00	$0.00	$0.00	$0.00	$6,250.00
Transfer Out	$0.00	$0.00	$0.00	$0.00	$2,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,000.00
Travel	$1,765.58	$1,391.52	$0.00	$202.80	$273.00	$135.18	$396.55	$156.00	$0.00	$0.00	$338.80	$0.00	$0.00	$0.00	$148.20	$0.00	$4,807.63
Total Operating Expenses	**$56,694.77**	**$15,295.25**	**$1,061.98**	**$14,397.77**	**$7,584.43**	**$2,782.94**	**$1,281.62**	**$3,497.00**	**$2,100.00**	**$380.49**	**$4,145.44**	**$2,030.34**	**$127.50**	**$3,299.32**	**$4,922.20**	**$349.48**	**$119,950.53**
Net Profit	**-$26,513.01**	**-$7,400.25**	**$7,368.40**	**-$14,397.77**	**$4,044.57**	**-$2,782.94**	**-$1,281.62**	**$6,503.00**	**-$100.00**	**$19,619.51**	**$24,729.56**	**-$2,030.34**	**$467.50**	**$6,700.68**	**$7,577.80**	**$650.52**	**$23,155.61**
OPENING BALANCE as at 1/07/2020	$ 175,553.97	$ 9,583.55	$ 17,179.30	$ 67,024.17	$ 21,079.04	$ 24,649.39	$ 20,212.55	$ 19,644.49	$ 1,453.98	-$ 17,647.50	$ 18,761.25	$ 3,535.89	-$ 467.50	$ 50,000.00	-$ 170.00	-$ 85.00	$ 410,307.58
MOVEMENT	-$ 26,513.01	-$ 7,400.25	$ 7,368.40	-$ 14,397.77	$ 4,044.57	-$ 2,782.94	-$ 1,281.62	$ 6,503.00	-$ 100.00	$ 19,619.51	$ 24,729.56	-$ 2,030.34	$ 467.50	$ 6,700.68	$ 7,577.80	$ 650.52	$ 23,155.61
CLOSING BALANCE as at 31/12/2020	$ 149,040.96	$ 2,183.30	$ 24,547.70	$ 52,626.40	$ 25,123.61	$ 21,866.45	$ 18,930.93	$ 26,147.49	$ 1,353.98	$ 1,972.01	$ 43,490.81	$ 1,505.55	$ -	$ 56,700.68	$ 7,407.80	$ 565.52	$ 433,463.19

UNFS Projects and Funding

UNFS Project #	Other Names/ References	Full Name	Funding Source/Contact	Project Manager	Project Delivery	Project Total (GSTEXCL)	2017 /2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/2022	2022/2023	In Kind Cont. PA	Start Date	End Date
104	Commercial Paddock			Joe Koch						5000	5000	5000			
224	Micronutrients in the Upper North	Increasing the knowledge and understanding of micronutrient deficiency in the UN - UNF117	SAGIT	Jade Rose	Matt Foulis/ Jonno Mudge	104800	23500	30600	50700					1/07/2017	30/06/2021
226	Pulse Check	Southern Pulse Extension Project	GRDC, Subcontracted by BCG	Denni Russell	Rachel Trengove	48466	17488	18900	12118					28/08/2017	31/03/2020
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	Jade Rose	Elders Jamestown - Darren Pech	47000		27000	15000	5000				1/01/2019	7/03/2022
228	Barley Grass	Barley Grass Management Options	GRDC/University of Adelaide - Gurjeet Gill/Amanda	Jade Rose	2019 Matt McCallum 2020 Beth Sleep	72500			10417	23750	38333			1/09/2019	30/12/2021
229	Dryland Legumes	Dryland legume pasture systems project	Rural R&DfP/MSF/Naomi Scholz	Jade Rose	Morchard - Andrew Catford Yr2, Canowie - Beth Sleep Yr 1	60000			20000	20000	20000			2019	2022
230	Vetch on Saline and Sodic Soils	Species selection for Saline and Sodic Soils in UN	UNFS Commercial Paddock	Jade Rose	Stefan Schmitt				-1500	-3500				2019	2020
231	Weather Station Network	Upper North Fire Danger Index Alerting Weather Station Network Project	Safecom/NSS	Denni Russell	Leeton Wilksch	95000		45000	50000					1/05/2019	30/06/2020
232	Barley Time of Sowing	Upper North Barley Time of Sowing; Frost / Heat Stress Effects	SAGIT	Jade Rose	Steph Lunn - Agxtra	88825			28875	28875	31075			1/04/2019	30/08/2022
233	Fodder Crop Trial	Cereal alternatives to oats for hay production in the Upper North	Pirsa Grower Group Award 2018, Balco 2019 and 2020.	Jade Rose	Steph Lunn - Agxtra	12000			6000	6000					
234	Ag Technology Hub		None Secured	Denni Russell		TBC								1/07/2020	Ongoing
235	Regenerating Goyders Line	Regenerating Goyders Lins - re-establishing productive pasture in once cropped land	National landcare Program; Smart farming Partnerships iniative round	Denni Russell	Partners - Anne Brown - Native veg Council, Jack desbioselles	50000				50000				1/07/2020	31/10/2022
236	SARDI NVT, Southern Pulse Agronomy, Fodder Options	Site Management Support to SARDI Research Sites in the Upper North	SARDI/Penny Roberts, Sarah Day	Jade Rose		TBC								1/03/2020	Ongoing
237	Sheep Tech Group	Red Meat and Wool Growth Program - Producer Technology Group, Upper North Farming Systems Incorporated	PIRSA/Jodie Reseigh Obrien	Denni Russell	Rachel Trengove	25000				25000				1/07/2020	30/05/2022
238	Soil Pathogen Project	Soilborne cereal pathogens national extension project	GRDC via FarmLink/Allan Umbers. Also SAGIT via SARDI/Katherine Lindsell and Belinda Cay	Denni Russell		TBC				$	$	$		1/07/2020	30/06/2023

UNFS 2020 Trial Sites



The Fullerville MegaSite 2020
A UNFS and SARDI collaboration

Author(s): Jade Rose
Funded By: Numerous
Project Duration: *2020*
Project Delivery Organisations: *Upper North Farming Systems, SARDI*

Background

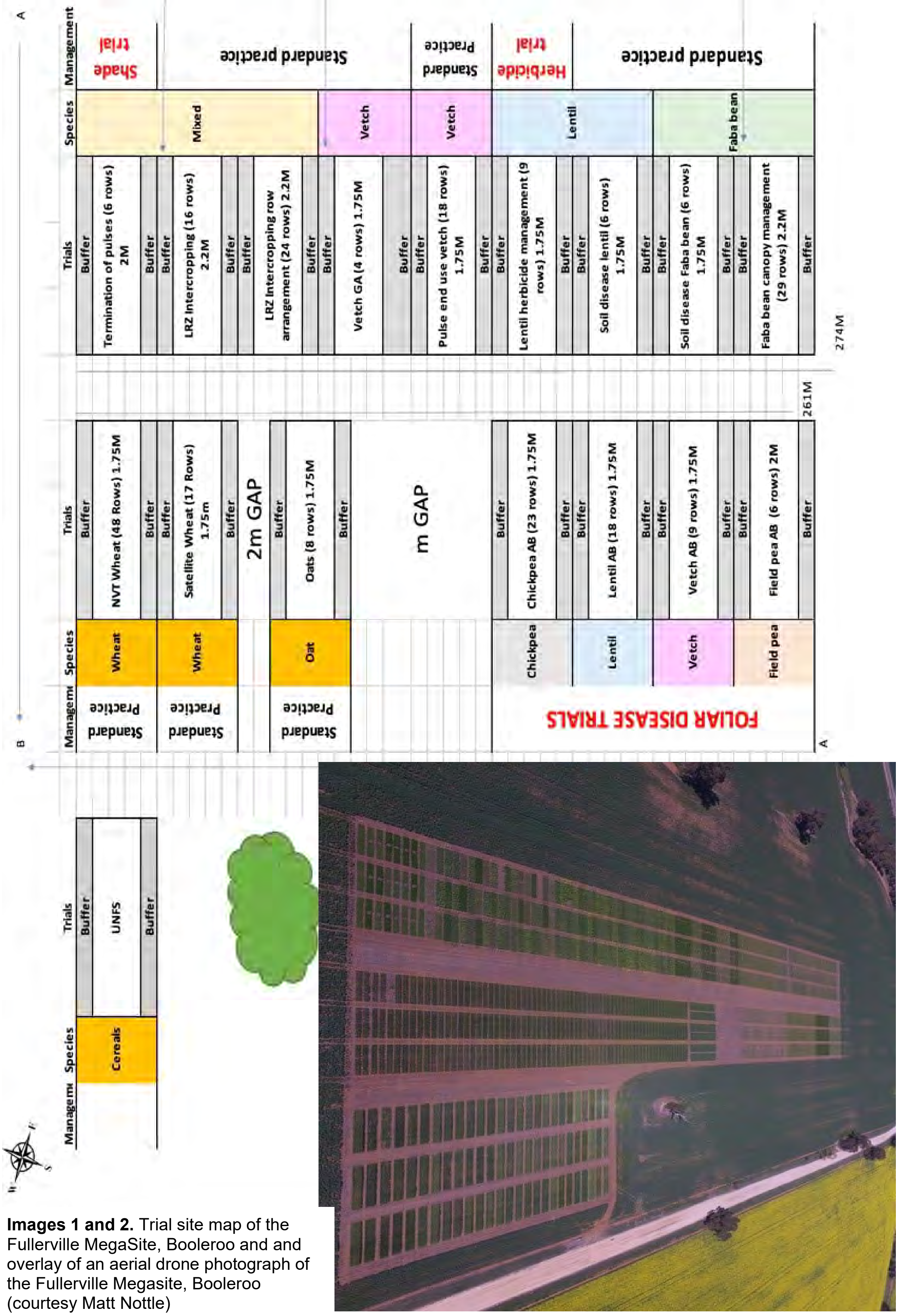
The Fullerville Megasite located at the Orrocks property, Booleroo was a collaboration between UNFS and SARDI, Clare where over 10 research trials were located including over 220 plots (Table 2).

Table 1. Site description, 2020.

Site	*Booleroo (-32.898583, 138.286250)*
Growing season rainfall	344
Yearly rainfall	472
Soil type	Clay on limestone
Stubble	Oaten hay

Table 2. Trials located at the Fullerville Megasite with funding and management details.

Trial name	*Funded*	*Managed*
Termination of pulses	GRDC	SARDI
Field pea blackspot	GRDC	SARDI
Vetch GA trial	GRDC	SARDI
Lentil herbicide management	GRDC	SARDI
Pulse end use trial	GRDC	SARDI
Chickpea ascochyta blight	GRDC	SARDI
Vetch ascochyta blight	GRDC	SARDI
Lentil ascochyta blight	GRDC	SARDI
Faba bean canopy management	GRDC	SARDI
LRZ Intercropping And LRZ Intercropping Row Arrangement	GRDC	SARDI
Soil Disease	GRDC/SAGIT	SARDI
Wheat NVT	GRDC	SARDI
Barley Time of Sowing	SAGIT	UNFS (AgXtra)
Fodder Variety Trial	Balco	UNFS (AgXtra)



Images 1 and 2. Trial site map of the Fullerville MegaSite, Booleroo and and overlay of an aerial drone photograph of the Fullerville Megasite, Booleroo (courtesy Matt Nottle)

Images 3 - 6
Spring Crop Walks at Fullerville MegaSite (Top left, bottom right), the Low Rainfall Zone Inter-cropping trial (bottom right) and the Barley Time of Sowing Trial (bottom Pg 21)

Acknowledgements

- **A special thankyou to Todd and Brooke Orrock and the Orrock family for providing this wonderful site, the trial sowing, management, and support provided**
- This research was possible due to the investment from SAGIT, Balco and GRDC
- Thankyou to SARDI, Clare for collaboration, management and support in these trials.
- Thankyou to seed providers AGT, Intergrain, Seednet, Pulse Breeding Australia and Grains Innovation Australia for supply of seed, Agrichem for supply of liquid phosphorus fertiliser
- Thank you to SARDI Plant Pathology and Soil Biology groups for their scientific input and assistance with research

Funding and Delivery Partners

SAGIT

Government of South Australia
Primary Industries and Regions SA

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC
Grains Research & Development Corporation
Your GRDC working with you

AGT

Balco Australia
Taking hay to the next level

gia
GRAINS INNOVATION AUSTRALIA

Seednet

agrichem

INTERGRAIN

PBA
PULSE BREEDING AUSTRALIA

2020 UNFS EVENT SUMMARY

A challenging year for running extension events. We kick started the year with the Dealing with the Dry GRDC Farm Business Regional Forum in Booleroo Centre on the back of a run of very challenging years. It was a great event and one the group should be proud of. The GRDC representatives all commented on the positive vibe of the group. There were great take home messages for all that were in the room. The Pulse Check Group was in its final year in 2020 and wrapped up in early 2021. A great series of workshops and the full details can be found later in this compendium. The team adapted the extension program to COVID19 with skill and their ability to pull off 20 great events in this year with a massive 493 people attending and receiving quality information to take home and use to adapt their enterprises is a remarkable feat. Thank you to the sponsors and partners that make delivering these events to the regions farmers and agribusinesses possible. The highlights were the Crop Stomp Series and the Hubs in the Pubs. Small events aimed at quality information and the ability to network and learn together in a safe environment in a year when interaction and networking was a rare and treasured thing. 2020, the first year the Members Expo didn't happen, but we made up for it in so many other ways.

Date	Event	Location	Participants	Details
February				
5	Dealing with the Dry	Booleroo Centre	89	GRDC Farm Business Regional Forum: Growers were invited to attend a dry-time regional forum which offered practical advice on production decisions including nutrition, budgeting and application, soil, fallow and residue herbicide management, sheep management and feeding strategies, financial strategies and use of government services. Presenters included Randall Wilksch, Dr Sean Mason, Dr Chris Preston, Daniel Schuppan, Mike Krause, Mary-Anne Young, Dennis Hoiberg and UNFS staff and Board Members.
27	Pulse Check Group pre-seeding mtg	Napperby	23	Penny Roberts & Sarah Day (SARDI, Clare) presented trial results from 2019 for Warnertown and Willowie trial sites. Sam Trengove presented results from his GRDC Sandy Soils impact trials. Stefan Schmidt presented results from his Vetch trials - Alternative herbicide options in Vetch & Vetch variety performance on challenging soils and response to grazing
July				
15	Ladies on the Land - Crop Walk	Belalie East	25	Crop Walk - Intro to Agronomy - Crop ID, Growth Staging, Pesticides, Plant Nutrition, Harvest Quality. Speakers - Beth Sleep, UNFS and Steph Lunn, AgXtra
22	Booleroo Hub - SARDI Megasite tour	Fullerville	17	Informal tour of 2ha SARDI Megasite, speakers Sarah Day, SARDI and Steph Lunn, AgXtra, networking event.
August				
28	Warnertown Trial Site Pulse Check	Nurom	46	Penny Roberts, Dylan Bruce and Navneet Aggarwal lead a walk through the crop trials. Pulse trials discussed Included - Intercropping, Time of sowing, Diseases, new varieties and Navneet spoke on weed control in pulses
September				
9	LOTL - Accidental Counsellor	Jamestown	37	Accidental Counselling' workshop listening to Emma Scharkie (Phycologist) will walk us through how to best identify people that may need help, what we should say and do in that type of situation and who to reach out to for further help.
11	JAPS	Bundaleer North	6	Trial Walk led by Shafiya Hussein from Long Reach Plant Breeders. Have a look and discuss TOS awnless wheat variety trial.
11	Crop Stomp Spring series 1	Fullerville	9	Insight into novel farming systems (intercropping) and pulse production and management in low rainfall environments with Penny Roberts and Sarah Day (SARDI)
14	Gladstone Hubs in the Pubs	Laura	14	Zoom mtg with Sardi Entomologist Rebecca Hamdorf followed by viewing "Time of Sowing Trial Results" UNFS video.
16	Booleroo Hubs in the Pub	Booleroo Centre	15	Wayne Davis from Davis Grain to talk about Grain export

17	Crop Stomp Spring series 2	Belalie East	10	“Looking at suitable legume pasture species in marginal rainfall cropping environments” Speakers - Stuart Nagel (PIRSA/SARDI) - Vetch Breeder and Rehn Freebairn (S&W Seeds Company)
18	LOTL - Accidental Counsellor	Booleroo Centre	18	Accidental Counselling' workshop listening to Emma Scharkie (Phycologist) will walk us through how to best identify people that may need help, what we should say and do in that type of situation and who to reach out to for further help.
21	Technology Hubs in the Pub	Booleroo Centre	25	Ag Tech Hub Launch with guest speakers Leighton Wilksch (Agbyte) speaking on 'LoRaWan' and Andrew Sargent on 'Opensensing'
23	MOPBL Hubs in the Pubs	Orroroo	25	Wool Market- Elders Paul Noble, wool manager 'To Sell or Not to Sell' and Rye Grass resistance/ Russian aphid- Northern Ag Andrew Catford & Nutrien Tom Moten
24	Crop Stomp Spring Series 3 Pulse Check Group	Fullerville	19	Matt Foulis (Northern Ag), Daniel Hillebrand (YP Ag) and Larn McMurray (Grains Innovation Australia) lead a walk through the crop trials. Larn McMurray's presentation was recorded on video by Joby from MyBigDay to be posted on UNFS youtube channel
28	Nelshaby Hubs in the Pubs	Port Pirie	30	Great Event enjoyed by all. Chris Davey from WeedSmart spoke about all weed seed control. Had some great interaction from the crowd and created some good conversation. Event was sponsored by GrainGrowers
29	Sheep Tech Group	Orroroo	22	Guest Presenters: Daniel Schuppan, Animal Production Specialist, Nutriens Ag Solutions, Dayna Grey, Livestock Assurance Coordinator, Thomas Foods International. Presentations via Zoom: Elke Hocking, Private Livestock Consultant, Elke Hocking Consulting. Dr Benjamin Holman & Dr Stephanie Fowler, Research Scientists, NSW Department of Primary Industries (DPI), Centre for Red Meat and Sheep Development, Cowra Research Centre
October				
1	Crop Stomp Spring Series 4	Fullerville	10	Jenny Davidson and Blake Gontar (SARDI) speaking on pulse diseases - foliar and root
13	UNFS Annual General Meeting	Booleroo Centre	22	Our Annual General Meeting was held separately from our Expo this year due to COVID restrictions. Returning Chairman Matt Nottle presented his report. The Finance Officer presented her report followed by elections of Office Bearers, Strategic Board, Committee Members and Hub representatives. Congratulations to Jim Kuerschner and Kym Fromm on receipt of their 10year Service Awards.
19	Crop Stomp Spring Series 5	Fullerville	31	Cereal Variety and Time of Sowing Trial Inspections: Wheat, Barley and Oats - seed retention, variety selection, managing frost and heat stress risk with Steph Lunn, Josh Reichstein and Dan Vater
TOTAL		20	493	


UPPER NORTH FARMING SYSTEMS INC PRESENTS

Hubs in the Pubs

Good food, mates and the latest updates in ag. To be held across the region in September and October 2020. Make sure you check in with your hub rep to find out when yours is on! Full details on the UNFS website and social media pages. www.unfs.com.au

Kindly Supported by Grain Growers


September and October 2020

UPPER NORTH FARMING SYSTEMS

CROP STOMP SPRING SERIES

Join us for trial walks and Q&A sessions with the experts. Small groups, great trials and researchers at your fingertips. Events will be advertised individually. All welcome. Registration will be required.

www.unfs.com.au

Upper North Farming Systems Ag Tech Hub - Hub Rep 2020 – Joe Koch

The Upper North Farming Systems (UNFS) Group's mission is leading the Primary Producers of the Upper North of SA to improve sustainability, profitability, and viability. The group took this mission to new territory with the launch of the UNFS Ag Tech Hub.

Agricultural technologies, commonly referred to as Ag Tech, is a broad term that refers to a range of tools that help farmers make better informed decisions. It has the potential to make primary production more productive, profitable, and sustainable. Some examples of Ag Tech include the use of robots, temperature and moisture sensors, aerial images, GPS technology and connected technologies such as the Internet of Things (IoT).

The Ag Tech Hub is the newest addition to the UNFS Hub network. This network aims to meet a social, engagement and educational need within the Upper North with a focus on farmer-to-farmer learning. The Ag Tech Hub was officially launched on Monday September 21st, 2020, at the Booleroo Hotel. As part of the launch Leighton Wilksch, Director of AgByte, talked about the LoRaWAN system and Andrew Sargent presented on his experience as a 2019 Nuffield Scholarship recipient and his work with SA technology company Opensensing.

UNFS Chairperson, Matthew Nottle said *"We have lots of problems on farm, and there is technology out there that can help solve those problems. Through the Ag Tech Hub, we hope to demonstrate and evaluate the tech before we encourage others to adopt it in their farm businesses."*

The Ag Tech Hub's first project is the installation and testing of a LoRaWAN system on Mount Robert, supported by Agbyte. LoRaWan stands for Long Range Wide Area Network. *"The system is designed to allow low powered devices to communicate with Internet connected applications over long-range wireless connections."* Matthew said, *"The launch of the LoRaWAN system up here will allow local farmers to utilize technology in ways they haven't been able to previously due to connectivity."*

A LoRaWAN system is a gateway that allows relay messages between end-devices and a central network server. The gateways are connected to the network server via standard IP connections and function as a transparent bridge, simply converting RF packets to IP packets and vice versa. The wireless communication takes advantage of the Long-Range characteristics of the LoRa physical layer, allowing a single-hop link between the end-device and one or many gateways.

We have a gateway tower set up on Mount Robert which allows for up to 30km communication if there is a clear line of sight.

Currently there are nodes on four features:

- tank level sensor
- flow metre monitor
- rain gauge
- temperature and humidity sensors

Appila / Booleroo Hub Report – Hub Rep 2020 - James Heaslip

Season 2020 will certainly be one to remember for me. A global pandemic, strong grain yields matched with solid prices and a very challenging year for hay. Overall, the season for Appila was positive receiving 509 mm with 170mm falling in September and October. Social distancing requirements made it difficult to organise and hold any hub events this year but we still managed to hold one event. The great idea of "hubs in the pubs" lead to us holding an event at the Booleroo Centre Pub. Guest speaker Wayne Davis, from Davis Grain, spoke to attendees about the current state of the grain market and gave some great general grain marketing advice. All that attended enjoyed a counter meal, pint and a good yarn. Thanks to PIRSA, GrainGrowers and Davis Grain for supporting this event.

Wayne Davis, Davis Grain presenting at the Hub in the Pub event

Wilmington Hub Report – Hub Rep 2020 - John Carey

No hub events held

Well above average rainfall - 446 mm, unfortunately only 24 mm for June/July.Crop establishment was disappointing, although there were eight rainfall events in May there was nothing much to show as 5 mm was the highest recording. Russian aphids appeared to thrive on moisture stressed crops in August. Seed coating will be the go in 2021. Dry and early sown crops held an advantage as an end result, although crown rot played a role in many paddocks that had not had a rotational break from cereals due to two years of drought. Summer weed control is evident.

Under ground water levels have improved from wet Sep/Oct, some of the wells are now holding water again because the previous 14 months the wells have been dry.

Livestock in this district are looking good, supplement feeding has been a feature of many systems over summer.

Jamestown Hub Report - Hub Rep 2020 - Luke Clark

The 2020 season kicked off to a slow start, but with a lot of end season rainfall received, ended on a positive note. Cereals, legumes, and canola yields were above average. However, due to the high rainfall received in the spring; the quality of the hay cut was impacted. The stock and commodity prices were up throughout the year, so overall a generally good year for 2020.
Due to COVID, many of the planned events for the Jamestown hub could not go ahead however, we are keen to hold more events in the 2021 season.

Quorn Hub Report – Hub Rep 2020 - Paul Rodgers

Last season's rain was too late for crops but gave good dry cover over summer. As a result, more stock are coming back into the district. Regenerating Goyder's Line Project has 2 sites in the region with work due to start in 2021.

Ladies on the Land Hub Report – Hub Reps 2020 - Beth Sleep, Steph Lunn and Jess Koch

Written by Beth Sleep

12th July – Sunday Crop Inspection

Ladies on the Land kicked off our year on the outskirts of Jamestown, at a Bundaleer SAGIT funded Longreach variety trial site. The site showcased awnless wheat varieties, with three different sowing times. 22 ladies attended on a wintery July day, where we learnt about all things cereal agronomy, where Steph and I shared our agronomy knowledge. The day included conversation around crop ID, growth staging cereals, when and why different pesticides are used, plant nutrition and how nutrition can determine harvest quality. The presentations were well received, with great discussion resulting. Attendees then put newly learnt knowledge to the test, looking through the trial site and growth staging the different sowing times.
The day was finished with afternoon tea and drinks, where attendees met other like-minded ladies, building our ladies on the land network.

9th and 18th September – Accidental Counselling

Emma Scharkie, a local farmers daughter and psychologist presented at two sessions at Jamestown and at Booleroo, upskilling our local ladies in accidental counselling. We felt this was particularly important coming out of two consecutive poorer seasons, in combination with the isolation COVID presented country communities. The hour presentation, followed by a meal, was designed to help attendees feel more comfortable responding to and supporting others when they are facing challenges or having difficulties coping. Emma covered the signs and symptoms someone might display when struggling, tips to help listen and communicate, resources that may help and where to refer someone that is struggling and finally, the importance of looking after yourself when supporting others. Skills we can all utilise on a daily basis. The events were well attended by ladies from all aspects of the community, including farmers wives/partners and daughters, hair-dressers, chemist staff and many more, with fantastic conversation resulting from each event.

We extend a huge thankyou to Emma for sharing her knowledge and skills, she is just one example of the fantastic range of skills we have in our community. Thank you also to the Mid North Suicide Prevention Network for funding Emma and to GrainGrowers for funding the venue and catering.

December – Buy from the Bush Campaign

Throughout December we called all local businesses to submit short stores and videos to feature our local talent in the lead up to Christmas. This aimed to promote the great range of gifts available across our region, in line with the #buyfromthebush campaign. Our Facebook page featured a new business daily in the lead up to Christmas, with a fantastic response from the local community in supporting our local shops and businesses.

Steph, Jess and myself would like to thank all our lovely ‘Ladies on the Land’ for their continued support of our hub and we look forward to another year of great events, upskilling our local ladies!

Gladstone/Laura Hub Report – Hub Rep 2020 - Andrew Kitto

Despite Covid 19 forcing lockdowns the Laura- Gladstone Hub/ Laura Ag Bureau was very active, holding numerous events online and in person as well as a major project.

To start the new year the Laura Ag Bureau launched a Facebook page to promote upcoming events, you can follow our activities on https://www.facebook.com/Laura-Ag-Bureau-100722784807837. The first event of the year was in two parts. On Monday 17th February 6Bs -Blokes Bonding Beyond Booleroo Big Bus 'mystery tour" took people from less drought affected areas and going to more drought affected areas, leaving Gladstone with pick-ups along the way via Appila and stops at Booleroo Centre and Morchard before returning. While the group visited a few farms the main aim of the day was to support mental health and resilience in the recent dry times by "bonding on the bus". This was supported by the Rotary SA Districts Drought Relief Project for projects that lift community spirits.

The following day Laura Ag Bureau and Natural Resources Northern and Yorke held a conference on sustainable and innovative agriculture: 2020 vision for Farming in 2040. Guest speakers included Ray Harrington spoke on the next 20 Years of Farming and Craig Davis on Sustainable Agronomy. It was great to hear from NSW grower and agronomist talking about grower's experience using GM canola.

The group was concerned that this would end up being the last event for 2020 as the state headed into lockdown and social distancing became the new norm- but we embraced technology and trialed our first Zoom meeting. Guest Jack Flavel, former Gladstone farmer and former head of the Adelaide University Agricultural Student Association joined from his new home in the Mallee region of Victoria. Jack talked about his personal experience, getting his first job straight out of Uni and moving interstate.

At the end of June, with strict covid restrictions and limited numbers there was a sticky beak day to local farmers around Laura, then a presentation by GPSA on the Grains Blueprint.

The Laura Ag Bureau AGM was held on July 27. This event was well attended and a great reason to get people together again. There was a covid Safe BBQ and fire in the sheering shed and Steven Kitschke presented to the group via zoom about a new product to use when bailing hay, Hay king. The product is designed to put a bacteria on the hay to prevent ignition and hay shed fires.

On 14 September we hosted an event as part of UNFS Hubs in the Pubs series. About 30 of us gathered at the Laura Hotel and heard from SARDI Entomologist Rebecca Hamdorf, she talked about beneficial bugs and the Russian wheat aphid.

In early October we had another Sticky Beak day where we visited Russell Zwar's farm. We looked at his Reefinator, a rock crushing machine and Seed Terminator, an attachment to the combine harvester that terminated weed seeds before they become weeds. We also looked at a part of his land that is reclaimed Wirrabara forest land, now sown to wheat.

The Laura Ag Bureau's main project in 2020 was to help other local farmers. We worked with Jodie Bowlie, Grant Chapman and Orroroo Carrieton Council to donate barley straw. This project resulted in approx. 1500 bales, 17 trucks and road trains convoy delivered to farmers in need on December 21st. The delivery was filmed by National Drought and North Queensland Flood Response and Recovery Agency. Information and a link to the YouTube video can be found here https://recovery.gov.au/stories/straw-run-sa-farmers-helping-farmers

Morchard /Orroroo/Pekina/Black Rock/Carrieton/Willowie Hub Report – Hub Reps 2020 – Gilmour Catford and Jim Kuerschner.

Report by Gilmour Catford.

2020 was a much better year for this Hub with 300mm-650mm rainfall across the area. Good summer followed by substantial spring rain gave us a good foundation. However north of Goyder's line the extremely dry winter caused substantial stress to the crops which allowed RWA to flourish reducing yields to average. Inside Goyder's Line growers reported well above average yields.

As we all know Covid disrupted everyone's plans in 2020 so we were only able to hold one meeting. The Hubs in the Pubs initiative was well attended by 25 farmers from within the Hub held at the Orroroo Commercial Hotel. This dinner meeting included Guest speakers Paul Noble Elders Wool, Geoff Power on the progress of the Dog fence and Tom Moten & Andrew Catford on Agronomy issues including Cow Pea Aphid in vetch and RWA. Andrew Kitto also spoke on the success of the Hay and Straw distribution managed by the Laura Ag Bureau and donated by Georgetown and Gladstone farmers. This initiative was much appreciated by all the recipients within the area. Andrew also thanked members who were involved with the 6B's Men's bus trip to our area in February.

2021 will be my 20th year as part of UNFS and my last as Hub Rep. I have enjoyed my involvement with UNFS seeing it grow to the organisation it is today. Morchard /Orroroo/ Pekina/Black Rock/Carrieton/Willowie Hub was the foundation of the UNFS and it would be great to see it still represented.
I encourage any farmer out there from the area who is interested in becoming involved to take on Hub rep for this area as farming close to Goyder's line has its own challenges and rewards.

Melrose Hub Report - Hub Rep 2020 - Andrew Walter

This season saw the first decent rains since spring 2017 shut off on us and is hopefully the end of that dry spell. Some good rains in Jan/Feb helped to put some moisture in the ground ready for the excellent opening rains in April/May. June and July were unfortunately dry, which set a lot of crops back, but once the spring rains started, they didn't stop. This caused a lot of headaches for the hay market, with people trying to dodge the continual rain fall events meaning a lot of hay got cut much later than optimal and lots of hay was downgraded due to rain. Hay rakes were definitely earning their pay this year! As a result, there is still a lot of downgraded hay available for sale in our area. This, combined with China deciding to play their games with the export hay market, has seen a big reduction in area planted to hay in 2021.

But while the spring rains were a nightmare for hay, they were a blessing for crops, with a lot of barley that had been struggling re-tillering. This of course caused some head scratching when it got towards harvest as there was ripe barley ready to reap with a thick crop of green underneath it. However, with the stored moisture that they had available, a lot of the green crops matured and added extra yield. Lentils were a standout, showing how they will continue to grow and flower every time there is a rain event and there were some exceptionally good yields from these. A couple of bad wind events in Late Nov/Early Dec saw a lot of grain lost, with oats and lentils particularly susceptible, but bad enough that wheat had grains blown out of the head and a lot of barley heads ended up on the ground. Paddocks that were halfway through being harvested had a clear line on the yield map when reaping resumed.

Barley heads on the ground after reaping

Russian aphids caused havoc early in the season with a lot of acres sprayed for these. Definitely the biggest impact we have seen from these little critters since their arrival in Australia and something we will have to keep an eye on in the future. No sign of them yet this season which is positive.

The previously mentioned wind events have been causing issues this season as well, no summer rain coupled with the very late break in the season this year meant that a knockdown spray on the volunteers wasn't possible, so there were some pretty dirty crops, incredibly reliant on chemicals this year to tidy these up. Could still be some quality issues when it comes to delivering grain.

Barley head remnants in April after grazing (over 15cm2 area)

COVID was obviously the other big topic for the year, mostly because it was an unknown and people were unsure what impact it was going to have on their businesses. Fortunately, the direct impact was quite negligible with Ag listed as an essential service peoples' operations were able to continue as normal. A scare at the start of harvest with the state getting thrown into lockdown had us worried for a day or so regarding if the silos would remain open, fortunately they did and even more fortunately the lockdown only lasted 3 days. It seems that these events are the new normal for the foreseeable future though.

All up it was a season that put smiles back on a lot of people's faces and lifted the general spirits of the farmers in the area which is great to see. With 2021 season showing potential, hopefully those dry years are behind us, and we can use it as a learning experience to structure ourselves in a way to deal with them better when they arise in the future.

Nelshaby Ag Bureau Hub – Hub Rep 2020 – Nathan Crouch

In 2020 the Nelshaby Ag Bureau had 4 significant meetings:

3rd August a meeting was held at the Port Pirie Road Museum that had just opened, where we were able to have a tour. There was a huge range to look at and would highly recommend anyone to go for a look. At the meeting we also had Peter Cousins come and talk to us about spray drift and using the Mesonet weather stations to make decisions on when and when not to spray with inversions. It was a great night enjoyed by all including a barbeque tea.

28th August We had our yearly Sticky beak Day which was also in conjunction with the UNFS Pulse Check Group in-season meeting. Starting the morning at the Warnertown trial site with SARDI Researchers Penny Roberts and Dylan Bruce walking us through the site and discussing pulse intercropping, early sown pulse crops and a wide range of trial results. Going on from that the bureau then moved to Brendon Johns big shed where we stopped for lunch and had many grain marketing reps come to discuss the upcoming year prospects for grain marketing. The day then moved to some deep ripping and spading trials on Brendon's property with Sam Trengrove and Stuart Sherriff as guest speakers who have been managing the trials with some great results. To finish the day, we went and visited some local vetch Trials with Stefan Schmitt as guest speaker talking about different varieties of vetch as well as different Pre-emergent herbicides. A great day enjoyed by all.

28th September In conjunction with the UNFS the Bureau went to the Sporties Tavern for the Hubs in the Pubs Event. We enjoyed a meal and a few beverages while we had Chris Davey talk about Harvest weed seed control. Again, another great night with much interaction and discussion among members. We also thank UNFS for part organising the event and for gaining funding to subsidise meals.

14th Dec we had our yearly Ag Bureau Christmas Tea which was at the Sporties tavern. A night enjoyed by all with much to talk about with what went right and what went wrong over harvest.

The Nelshaby Ag Bureau is looking forward to a wet 2021 season with some good sub soil moisture in the profile. We hope that everyone has a safe and successful 2021 season.

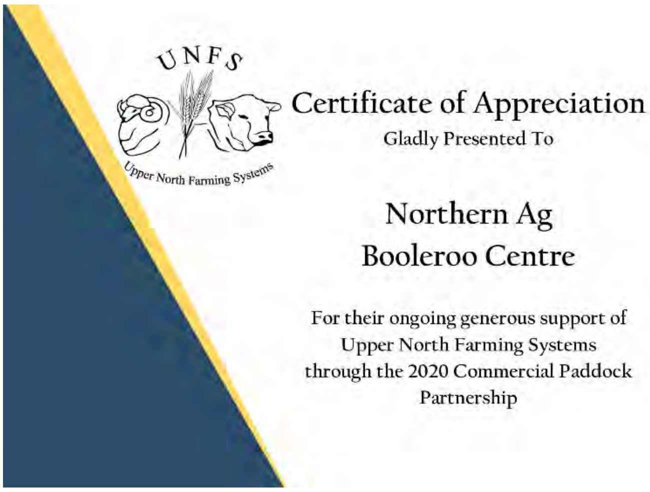
UNFS 2020 Commercial Paddock Report

The Commercial Paddock is the result of very generous donations of land, time and resources from the community that support Upper North Farming Systems and its impact to the group is nothing short of amazing.

The Paddock is located on the outskirts of Booleroo Centre and is owned by Northern Ag, the local NRI business in Booleroo Centre. Northern Ag has been supporting the group since its beginning and when the use of the paddock was brought up they were very generous to offer its use as sponsorship to the group.

UNFS members now sow, spray, spread, harvest, cart and sell the grain produced from the paddock in order to generate income for the group that is not tied to funding bodies or grants. This means that the group has the capacity to undertake events and research activities in a timely manner when weather events or economic impacts occur, it also enables us to undertake research that is a significant priority for the Upper North but is not for the State or National funding bodies at this time.

We would like to take this opportunity to thank Dustin Berryman and the team at Northern Ag for making it possible for us to fundraise in this way and giving back to your local community so generously.



UNFS

Upper North Farming Systems

Certificate of Appreciation

Gladly Presented To

Northern Ag
Booleroo Centre

For their ongoing generous support of
Upper North Farming Systems
through the 2020 Commercial Paddock
Partnership

Thank you to all those involved in making the 2020 Commercial Paddock Barley Crop a success.

Sowing – Matt Nottle
Spraying – Tim Arthur and JP Carey
Spreading – Todd Orrock
Harvesting – Joe Koch
Carting – Geoff Zanker
Selling – Pinion Advisory Grain Marketing

All those involved donated time, machinery and inputs to the paddock resulting in $5922.56 in profit from the sale of the grain to go directly towards events and trial work in the Upper North.

In 2020 the funds from the 2019 Commercial Paddock were used to support the following projects:

I. Hub Events and Network
II. Vetch on Saline and Sodic Soils – Variety and Agronomy Trials
III. Weather Station Network Management and Maintenance
IV. Pasture Options Trial

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

Understanding trial results and statistics

Jim Egan
SARDI, Port Lincoln

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 “$P\leq0.05$”. This means there is a 5% probability or less that the observed difference between treatment means occurred by chance, or we are at least 95% certain that the observed differences are due to the treatment effects.

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

Results from replicated trial

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

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

Treatment	**Grain Yield (t/ha)**
Control	1.32 a
Fertiliser 1	1.51 a,b
Fertiliser 2	1.47 a,b
Fertiliser 3	1.70 b
Significant treatment difference	$P\leq0.05$
LSD (P=0.05)	*0.33*

Statistical analysis indicates that there is a fertiliser treatment effect on yields. $P\leq0.05$ 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.

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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 100 m)
1 acre = 0.4047 ha (1 chain (22 yards) by 10 chain)
1 ha = 2.471 acres

Mass

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

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

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

Wheat = 60 lb, Barley = 48 lb, Oats = 40 lb
1 bu (wheat) = 60 lb = 27.2 kg
1 bag = 3 bu = 81.6 kg (wheat)

Volume

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

Speed

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

Pressure

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

Yield

1 t/ha = 1000 kg/ha

Yield Approximations

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

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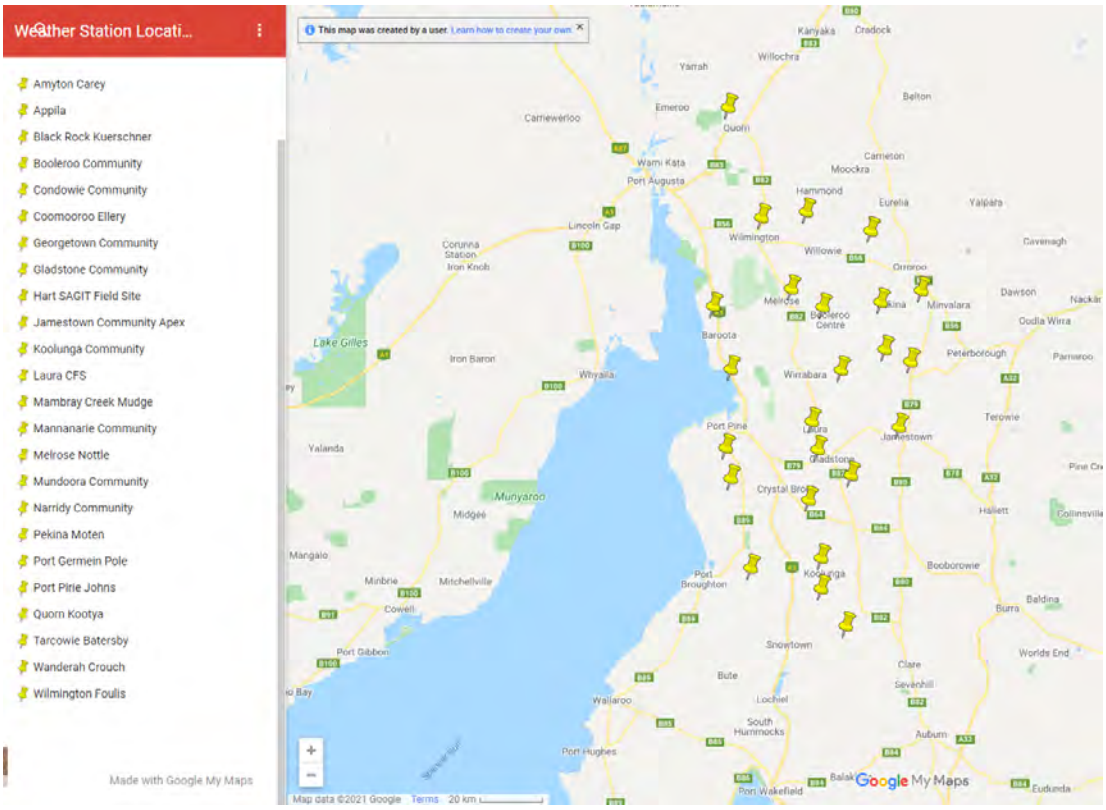
UNFS WEATHER STATION NETWORK

UNFS has a network of 22 weather stations that are managed by AgByte and were installed in a grant aimed at improving community access to data for better decision-making during fire danger season.

There are additional sites available through the AgByte network that tie into the UNFS sites and together they provide a comprehensive network across the Upper North Region of South Australia.



Weather Station Locati...

- Amyton Carey
- Appila
- Black Rock Kuerschner
- Booleroo Community
- Condowie Community
- Coomooroo Ellery
- Georgetown Community
- Gladstone Community
- Hart SAGIT Field Site
- Jamestown Community Apex
- Koolunga Community
- Laura CFS
- Mambray Creek Mudge
- Mannanarie Community
- Melrose Nottle
- Mundoora Community
- Narridy Community
- Pekina Moten
- Port Germein Pole
- Port Pirie Johns
- Quorn Kootya
- Tarcowie Batersby
- Wanderah Crouch
- Wilmington Foulis

The weather station data can be accessed through the UNFS website, www.unfs.com.au under Resources. Full details on interpreting the data can also be found on the website. We continue to receive positive feedback about the sites, particularly around decision making at harvest time with the fire risk.

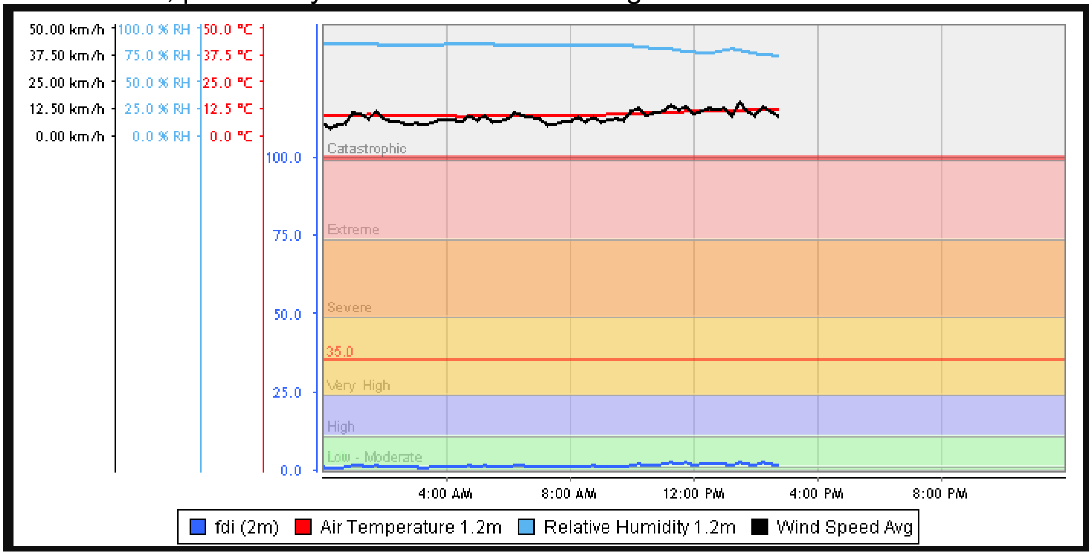


Image: Fire Danger Index Graphs have proven handy tools for Harvest Decision making. With an FDI of 0 today…harvest would be a soggy affair but on days when it is nearing or over the red 35 FDI line it is time to pull stumps and find another job for the next few hours…and make sure to let the neighbours know that magic FDI number when you do it.

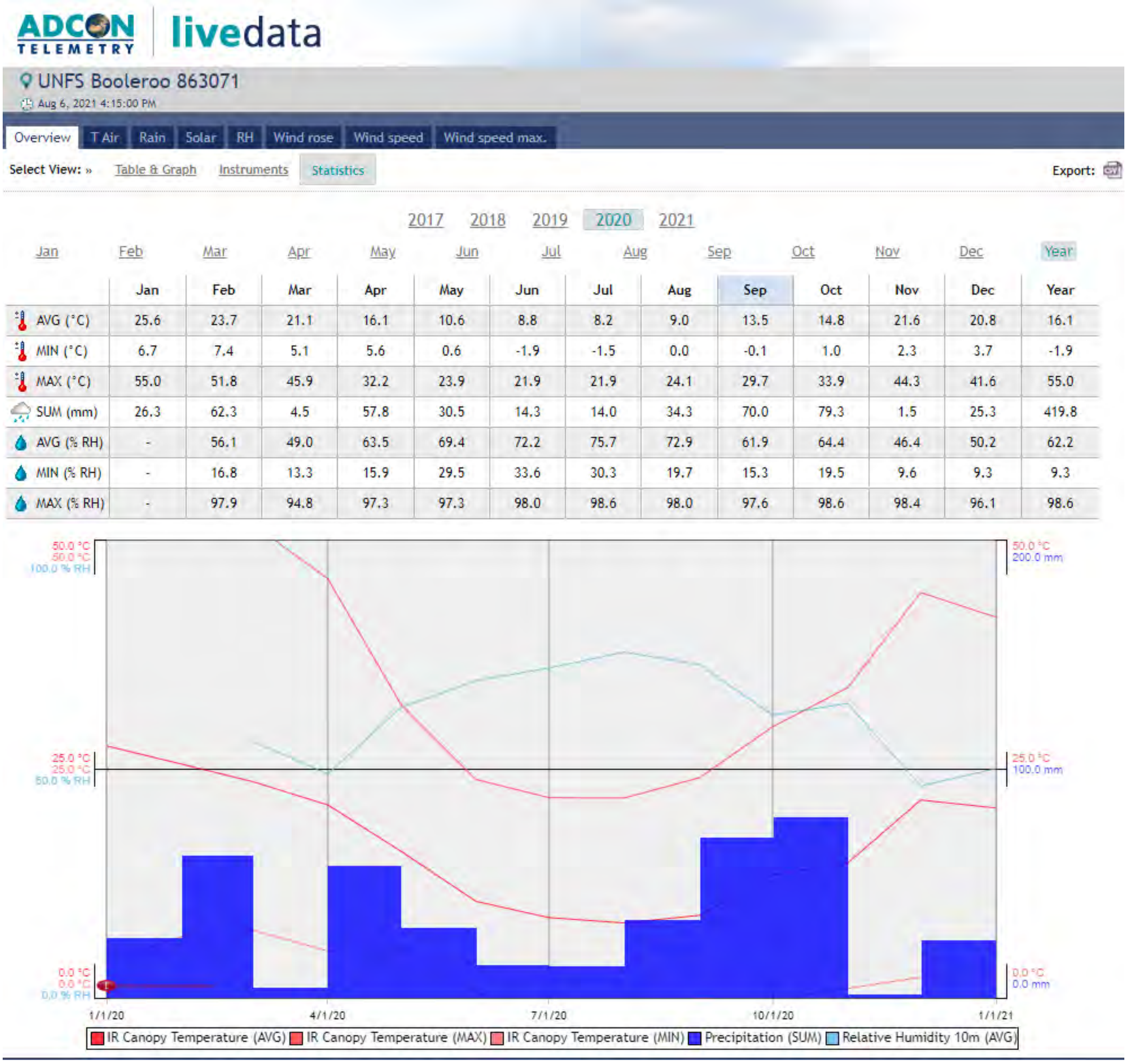
We continue to seek funds to upgrade this system with 10m towers enabling measurement and warning of inversion layers to provide data to improve spray condition decision making the next priority for the network.

Booleroo Community Site Summary

As a central location to the district and situated at the Northern Ag/UNFS Community Paddock the Booleroo Community Site Station has been selected as a demonstration of the year that was climatically in the Upper North in 2020.

Full temp, precipitation, humidity and wind data from the year can be downloaded from the website, but a summary is shown below. In addition, this site had a soil moisture probe installed in 2020 and the data is summarised below:

The soil probe site at Booleroo had barley planted last season following wheat the year before. At time of planting last year there was significantly more soil moisture than the year before, but we then entered into a prolonged dry period over winter & early Spring. There was very little net change during this period of soil moisture with the plant roots only actively drawing down moisture towards the end of August. The stacked sensor graph shows the diurnal fluctuation of the daily transpiration & extraction of moisture during September with root activity to ~65cm. Mid September through to October there were well received rainfall events which helped fill grain and it is evident that root activity at depth stopped as there was moisture much more freely available at the surface. At this site, infiltration from these rainfall events did not penetrate much further than 10cm, however, because the barley roots didn't extract moisture from below 60cm last year, there is actually some moisture in reserve from over a year ago. With a kinder season this year, plant roots should be able to extract this during grain fill.



UNFS Booleroo 863071

Aug 6, 2021 4:15:00 PM

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
AVG (°C)	25.6	23.7	21.1	16.1	10.6	8.8	8.2	9.0	13.5	14.8	21.6	20.8	16.1
MIN (°C)	6.7	7.4	5.1	5.6	0.6	-1.9	-1.5	0.0	-0.1	1.0	2.3	3.7	-1.9
MAX (°C)	55.0	51.8	45.9	32.2	23.9	21.9	21.9	24.1	29.7	33.9	44.3	41.6	55.0
SUM (mm)	26.3	62.3	4.5	57.8	30.5	14.3	14.0	34.3	70.0	79.3	1.5	25.3	419.8
AVG (% RH)	-	56.1	49.0	63.5	69.4	72.2	75.7	72.9	61.9	64.4	46.4	50.2	62.2
MIN (% RH)	-	16.8	13.3	15.9	29.5	33.6	30.3	19.7	15.3	19.5	9.6	9.3	9.3
MAX (% RH)	-	97.9	94.8	97.3	97.3	98.0	98.6	98.0	97.6	98.6	98.4	96.1	98.6

Barley Time of Sowing Trial

Author: Steph Lunn
Funded By: South Australian Grains Industry Trust
Project Title: Frost and Heat Stress Effects of Barley Time of Sowing – UNF119
Project Duration: 2019-2022
Project Delivery Organisations: Upper North Farming Systems, AgXtra, SARDI

Key Points:

- Leabrook consistently had higher biomass in both TOS 1 and TOS2.
- Maximus consistently had higher biomass in TOS3.
- All yields were statistically equivalent across the times of sowing due to the mild seasonal conditions at the site.

Background

The Barley Time of Sowing trial was conducted at the Fullerville “Megasite” 7km West of Booleroo Centre. The initial aims of this trial 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

This trial was sown with 3 replicates in a complete randomised block design. The plots were 15m long x 2.5m wide and sown with the UNFS plot seeder.

There were 3 times of sowing:
TOS1: 14th April
TOS2: 9th May
TOS3: 27th May

The varieties sown were:
V1: Planet
V2: Leabrook
V3: Maximus CL
V4: WI4592
V5: Spartacus
The buffer plots were sown to Fathom.

Table 2. Frost and Heat Event Summary.

Days below 0C		Days above 30C
5	June	0
6	July	0
1	August	0
1	September	0
0	October	5
0	November	22

All treatments were sown with an up-front fertiliser application of 60kg DAP (N: 9kg/ha, P: 10kg/ha) and 20kg Urea (N: 9.2kg/ha). Pre-emergent chemical was applied at TOS1 and consisted of Boxer Gold @ 2.5L/ha and Weedmaster Argo @ 1.5L/ha. Paradigm @ 25g was applied as a post emergent chemical for Broad leaf weed control.

0-10cm and Deep N soil testing was completed to determine the soil as a neutral loam with acceptable levels of trace elements and exchangeable ions, with slightly low nitrate and ammonium N.

Throughout the growing season growth stages (BBCH) of the plots were observed and recorded. Biomass cuts were taken at milk development and green weights recorded. The samples were then dried in an oven for 48 hours at 60 degrees and dry matter weights measured. The trial was then harvested and grain yields taken. All data was analysed on ARM software.

Results and Discussion

Table 1. Booleroo Centre weather station data 2020, supplied by AgByte.

Booleroo Weather Station Data 2020

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
🌡	AVG (°C)	25.6	23.7	21.1	16.1	10.6	8.8	8.2	9	13.5	14.8	21.6	20.8	**16.1**
🌡	MIN (°C)	6.7	7.4	5.1	5.6	0.6	-1.9	-1.5	0	-0.1	1	2.3	3.7	**-1.9**
🌡	MAX (°C)	55	51.8	45.9	32.2	23.9	21.9	21.9	24.1	29.7	33.9	44.3	41.6	**55**
🌧	SUM (mm)	26.3	62.3	4.5	57.8	30.5	14.3	14	34.3	70	79.3	1.5	25.3	**420**
💧	AVG (% RH)	-	56.1	49	63.5	69.4	72.2	75.7	72.9	61.9	64.4	46.4	50.2	**62.2**
💧	MIN (% RH)	-	16.8	13.3	15.9	29.5	33.6	30.3	19.7	15.3	19.5	9.6	9.3	**9.3**
💧	MAX (% RH)	-	97.9	94.8	97.3	97.3	98	98.6	98	97.6	98.6	98.4	96.1	**98.6**

The Booleroo Centre weather station data (Table 1) shows that the daily temperatures for 2020 were not as extreme as they were in 2019. Frost events were not significant or at the time of flowering, therefore there were no significant frost observations to be made during the growing season. This means frost would have had little to no impact on yield regardless of Time of Sowing.

Heat events were also minimal (Table 2) and majority occurred in November when the crop was mature. This is compared to 2019 when September recorded 11 days over 30C and had more significant effect on flowering periods.

Good rainfall was recorded throughout the whole growing season of the trial. Growing Season Rainfall totalled to 300mm and Total Annual Rainfall totalled 420mm (compared to 124.5mm and 158.5mm respectively in 2019). This is above the long term annual average rainfall for Booleroo which is 390.7mm (BOM data).

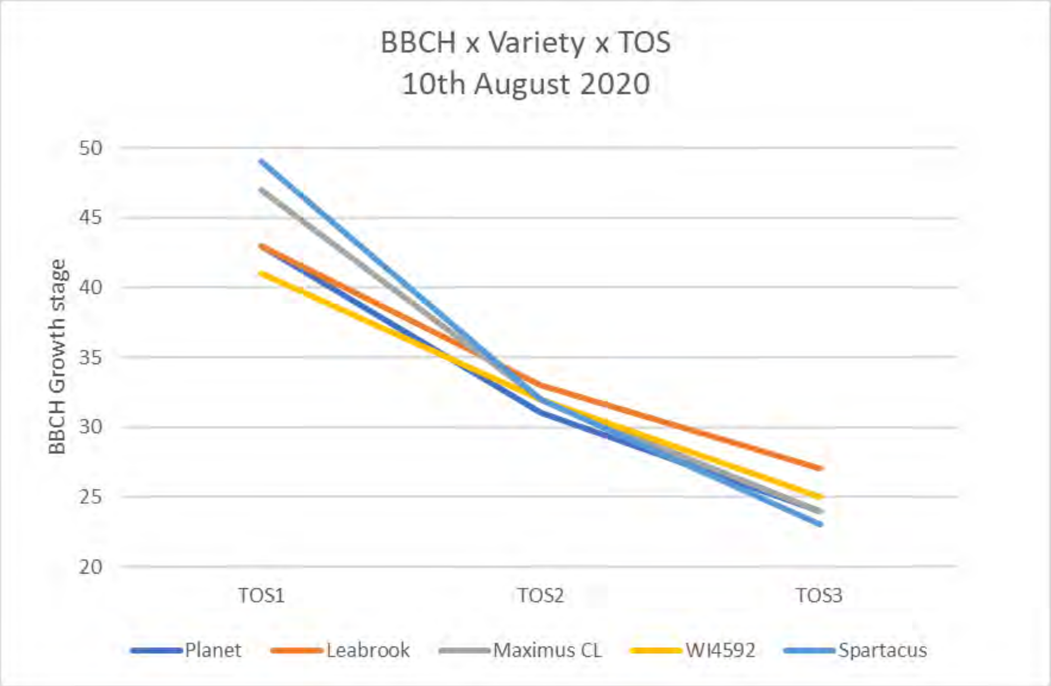


Figure 1. BBCH Growth Stage by Time of Sowing by Variety for 10th August 2020

Growth stages of each treatment were taken 7 times throughout the growing season. Given the year and consistent rainfall, all of the varieties developed and matured as expected based on their time of sowing.

Table 3. Summary Table of Means of Yield and Biomass data.

Crop Name		Spring barley		Spring barley		Spring barley	
Crop Variety		Various		Various		Various	
Description		Biomass - fresh		Biomass - dry		Yield	
Assessment Date		15-Sep-20		15-Sep-20		30-Nov-20	
Part Assessed		WEIFRE C		WEIDRY C		PLOT C	
Assessment Type		WEFRRE		WEDRRE		YIELD	
Assessment Unit		g		g		T-MET	
Reporting Basis		1.0 PLOT		1.0 PLOT		1 PLOT	
Crop Stage Majority/Min/Max		49 77 71		49 77 71		99 - -	
Plant-Eval Interval		111 DP-1		111 DP-1		187 DP-1	
ARM Action Codes						TY1	
Trt No.	Treatment Name	19		20		22	
1	TOS 1 - 14 April 2020 Barley cv. Planet	572.7	ab	261.3	b	1.74	-
2	TOS 1 - 14 April 2020 Barley cv. Lebrook	591.7	a	288.3	a	1.70	-
3	TOS 1 - 14 April 2020 Barley cv. Maximus	436.3	cde	227.3	c	1.66	-
4	TOS 1 - 14 April 2020 Barley cv. WI4592	481.3	a-e	229.0	c	1.79	-
5	TOS 1 - 14 April 2020 Barley cv. Spartacus	512.3	a-d	247.7	bc	1.76	-
6	TOS 2 - 09 May 2020 Barley cv. Planet	478.7	b-e	196.7	d	1.78	-
7	TOS 2 - 09 May 2020 Barley cv. Lebrook	543.7	abc	225.7	c	2.14	-
8	TOS 2 - 09 May 2020 Barley cv. Maximus	447.7	cde	195.7	d	1.59	-
9	TOS 2 - 09 May 2020 Barley cv. WI4592	426.7	de	181.7	de	1.85	-
10	TOS 2 - 09 May 2020 Barley cv. Spartacus	419.3	de	184.7	de	2.04	-
11	TOS 3 - 27 May 2020 Barley cv. Planet	418.3	de	128.0	g	1.77	-
12	TOS 3 - 27 May 2020 Barley cv. Lebrook	420.7	de	161.7	ef	1.63	-
13	TOS 3 - 27 May 2020 Barley cv. Maximus	475.7	b-e	172.0	def	1.82	-
14	TOS 3 - 27 May 2020 Barley cv. WI4592	421.0	de	155.7	f	2.04	-
15	TOS 3 - 27 May 2020 Barley cv. Spartacus	397.3	e	155.7	f	1.61	-
LSD P=.05		112.37		25.24		0.483	
Standard Deviation		67.18		15.09		0.289	
CV		14.31		7.52		16.1	
Grand Mean		469.56		200.73		1.795	
Bartlett's X2		17.718		27.269		11.606	
P(Bartlett's X2)		0.22		0.018*		0.638	
Rank X2		.		.		.	
P(Rank X2)		.		.		.	
Skewness		0.2175		0.3814		-0.2292	
Kurtosis		-0.6385		-0.5507		-1.2299	
Analyzed as		RCB		RCB		RCB	
Replicate F		2.747		7.770		4.797	
Replicate Prob(F)		0.0814		0.0021		0.0162	
Treatment F		2.452		26.393		0.967	
Treatment Prob(F)		0.0210		0.0001		0.5075	

Up until the 10th August, growth stages within their times of sowing were consistent. On the 10th of August however, Spartacus and Maximus CL in TOS1 were further developed than the other varieties (Figure 1) which then meant earlier flowering. In TOS3 on the 10th August, Leabrook was further ahead in maturity. This did not correlate to earlier flowering however, with Spartacus and Maximus CL still flowering before the other varieties for TOS3.

Biomass cuts were taken and the fresh weights weighed. Leabrook at TOS1 had the numerically highest biomass of all treatments (Table 3). This was statistically equivalent to all other varieties in TOS1 except Maximus which had lower mean biomass. Leabrook in TOS2 was also significantly equivalent. In TOS3 however, Maximus had significantly higher biomass fresh weights than the other varieties.

The biomass cuts were then fully dried and the weights recorded. Leabrook at TOS1 was significantly higher than all other varieties across the three times of sowing (Table 3). Leabrook also had a significantly higher biomass than the other varieties in TOS2 only. In TOS3 only, Maximus was numerically higher in biomass dry weight and statistically equivalent only to Leabrook.

There were no significant differences in yield across all treatments (Table 3). Numerically, Leabrook in TOS2 recorded the highest average yield. The effect of time of sowing on yield in this season (cool wet finish) was minimal. For similar seasons, the ability to plant barley later and out of a frost window would be beneficial.

Acknowledgements

- A special thankyou to Todd and Brooke Orrock and the Orrock family for providing this wonderful site, the trial sowing, management, and support provided.
- This research was possible due to the investment from the South Australian Grains Industry Trust (SAGIT).
- Thankyou to seed suppliers AGT, Intergrain, Seednet, Barenbrug for providing seed for these trials
- Thankyou to the SARDI, Clare team for maintenance and harvest
- Thankyou AgXtra for site assessments and management

Cereal Hay Options in the Upper North Farming Region

Author: Steph Lunn and Jade Rose
Funded By: Balco Australia Pty Ltd
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: 2020
Project Delivery Organisations: Upper North Farming Systems, AgXtra, SARDI

Key Points

- Above average rainfall and minimal extremes in temperature meant there was little impact on the growth and yield of varieties.
- Kingbale Oats recorded significantly higher biomass compared to all other varieties.
- Kingbale produced the best profit for grain and hay production, followed by Brusher oats in this season.

Background

The 2020 Fodder Variety trial was conducted at the Fullerville Megasite, 7km West of Booleroo Centre. The aim of this trial is to assess 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. It is the second year of this trial in the Booleroo Centre Region with 2019 providing very different climatic conditions.

Methodology

This trial was sown on the 9th of May with 3 replicates in a complete randomised block design. The plots were 15m long x 2.5m wide and sown with the UNFS plot seeder.

The varieties sown in this trial were:
V1: Bennett Wheat
V2: AGT Wheat - SUN9440
V3: AGT Wheat - SUN945A
V4: Kingbale Oats
V5: Brusher Oats
V6: Dictator 2 Awnless Barley
The buffer plots were sown to Fathom Barley.

All treatments were sown with an up-front fertiliser application of 60kg DAP (N: 9kg/ha, P: 10kg/ha) and 20kg Urea (N: 9.2kg/ha). Pre-emergent chemical was applied at TOS1 and consisted of Boxer Gold @ 2.5L/ha and Weedmaster Argo @ 1.5L/ha. Paradigm @ 25g was applied as a post emergent chemical for Broad leaf weed control.

0-10cm and Deep N soil testing was completed to determine the soil as a neutral loam with acceptable levels of trace elements and exchangeable ions, with slightly low nitrate and ammonium N

Throughout the growing season growth stages (BBCH) of the plots were observed and recorded. Biomass cuts were taken at milk development and green weights recorded. The samples were then dried in an oven for 48 hours at 60 degrees and dry matter weights measured.

The trial was then harvested and grain yields taken. All data was analysed on ARM software.

Results and Discussion

The Booleroo Centre weather station data (Table 1) shows that the daily temperatures for 2020 were not as extreme as they were in 2019. Frost events were not significant or at the time of flowering, therefore would have had little to no impact on yield regardless of Time of Sowing.

Heat events were also minimal. This is in compared to 2019 when September recorded 11 days over 30°C and had more significant effect on flowering periods.

Table 1. Booleroo Centre weather station data 2020, supplied by AgByte.

Booleroo Weather Station Data 2020														
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
🌡	AVG (°C)	25.6	23.7	21.1	16.1	10.6	8.8	8.2	9	13.5	14.8	21.6	20.8	**16.1**
🌡	MIN (°C)	6.7	7.4	5.1	5.6	0.6	-1.9	-1.5	0	-0.1	1	2.3	3.7	**-1.9**
🌡	MAX (°C)	55	51.8	45.9	32.2	23.9	21.9	21.9	24.1	29.7	33.9	44.3	41.6	**55**
🌧	SUM (mm)	26.3	62.3	4.5	57.8	30.5	14.3	14	34.3	70	79.3	1.5	25.3	**420**
💧	AVG (% RH)	-	56.1	49	63.5	69.4	72.2	75.7	72.9	61.9	64.4	46.4	50.2	**62.2**
💧	MIN (% RH)	-	16.8	13.3	15.9	29.5	33.6	30.3	19.7	15.3	19.5	9.6	9.3	**9.3**
💧	MAX (% RH)	-	97.9	94.8	97.3	97.3	98	98.6	98	97.6	98.6	98.4	96.1	**98.6**

Good rainfall was recorded throughout the whole growing season of the trial. Growing Season Rainfall totalled to 300mm and Total Annual Rainfall totalled 420mm (compared to 124.5mm and 158.5mm respectively in 2019). This is above the long term annual average rainfall for Booleroo which is 390.7mm (BOM data).

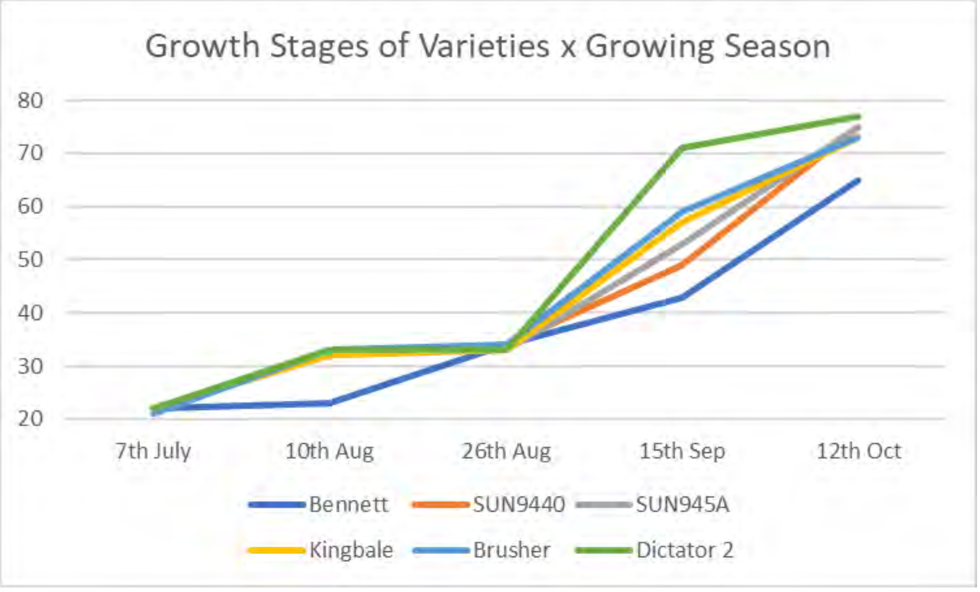


Figure 1. Growth Stages of Varieties as scored at different times over the growing season.

Growth stages were taken six times throughout the growing season. Dictator 2, the only barley variety, was the fastest in development after stem elongation (Figure 1). Bennett wheat was the slowest in development and was very late to flower compared to the other crop types and varieties.

Table 2. Summary Table of Means of Yield and Biomass data.

Crop Name	Spring cereals	Spring cereals	Spring cereals
Crop Variety	Various	Various	Various
Description	Biomass - fresh	Biomass - dry	Yield
Assessment Date	15-Sep-20	15-Sep-20	30-Nov-20
Part Assessed	WEIFRE C	WEIDRY C	PLOT C
Assessment Type	WEFRRE	WEDRRE	YIELD
Assessment Unit	g	g	T-MET
Reporting Basis	1.0 PLOT	1.0 PLOT	1 PLOT
Crop Stage Majority/Min/Max	39 71 55	39 71 55	99 - -
Plant-Eval Interval	111 DP-1	111 DP-1	187 DP-1
ARM Action Codes			TY1
Trt Treatment No. Name	16	17	19
1Wheat cv. Bennett	381.7b		1.03-
2Wheat cv. SUN9440	348.0b	147.7c	1.04-
3Wheat cv. SUN945A	349.0b	138.0c	0.89-
4Oat cv. Kingbale	618.7a	226.3a	1.56-
5Oat cv. Brusher	545.3a	198.7b	1.27-
6Barley cv. Dictator 2	406.3b	173.7b	1.03-
LSD P=.05	75.69	25.20	0.951
Standard Deviation	41.60	13.38	0.523
CV	9.42	7.57	45.96
Grand Mean	441.50	176.87	1.137
Bartlett's X2	7.525	4.462	11.291
P(Bartlett's X2)	0.184	0.347	0.046*
Rank X2	.	.	.
P(Rank X2)	.	.	.
Skewness	0.8612	0.3859	0.0466
Kurtosis	-0.7804	-1.328	-1.3946
Replicate F	1.151	1.101	0.453
Replicate Prob(F)	0.3548	0.3783	0.6481
Treatment F	22.286	22.180	0.626
Treatment Prob(F)	0.0001	0.0002	0.6843

Biomass cuts were taken and the fresh weights weighed. Kingbale and Brusher oats were significantly higher in weight than all of the other varieties (Table 2, Figure 2). There was no significant difference in wet weights between the other varieties.

The biomass cuts were then fully dried in the oven and the weights recorded. The dry weight data showed that Kingbale was significantly higher in weight than all other varieties (Table 2, Figure 2). Brusher and Dictator2 were statistically equivalent, as were SUN9440 and SUN945A but at a lower value. There was discrepancy in the dry weights for Bennett wheat which had cuts done later due to slower development, so this data has been removed to eliminate bias.

There was no significant difference in yield across all of the varieties (Table 2). Numerically Kingbale had the highest average yield and SUN945A recorded the lowest.

Figure 2. Gross margin values for seed and hay production 2020. Price assumptions based on the PIRSA Gross Margin Guide 2021 prices (2020/2021) forecast for a LOW rainfall zone and total variable costs for each cereal type (hay production based on “Export Oaten Hay” or seed).

Variety	***Yield (t/ha) for seed production***	***Yield (t/ha) for hay production***	***Gross Margin/ha for seed production ($)***	***Gross Margin/ha for hay production ($)***
Bennett	1.03	-	71.55	-
SUN9440	1.04	1.47	74.4	- 112.5
SUN945A	0.89	1.38	31.65	-135.0
Kingbale	1.56	2.26	183.0	85.0
Brusher	1.27	1.98	110.0	15.0
Dictator 2	1.03	1.73	-5.1	-47.5

Acknowledgements

- A special thankyou to Todd and Brooke Orrock and the Orrock family for providing this wonderful site, trial sowing, management, and support provided.
- This research was possible due to the investment from Balco Australia Pty Ltd
- Thank you to seed suppliers AGT, Intergrain, Seednet, Barenbrug for providing seed for these trials
- Thank you to the SARDI, Clare team for maintenance and harvest
- Thankyou AgXtra for site assessments and management

Funding and Delivery Partners

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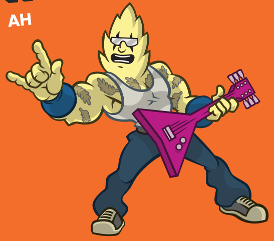

HIGH YIELDING AH CHARACTERS YOU CAN'T GO PAST IN 2021

VIXEN PBR
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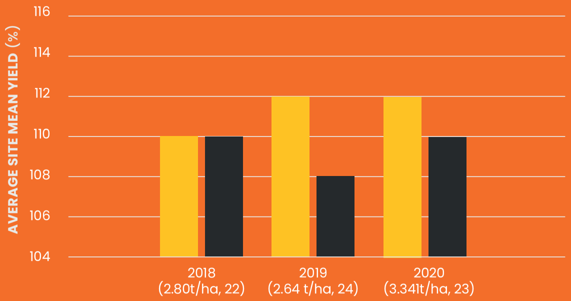
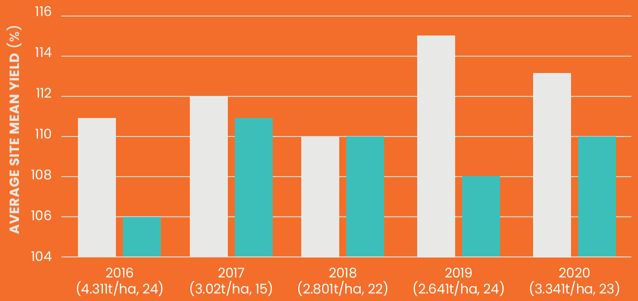


(Average Yield t/ha, Trial Number)

2018-20 SA main season NVT MET yield performance, represented annually as a % of average site mean yield***

(Data accessed from the NVT Online website on 03/02/2021)

🟨 **ROCKSTAR** ⬛ **CATAPULT**



(Average Yield t/ha, Trial Number)

2016-20 SA main season NVT MET yield performance, represented annually as a % of average site mean yield**

(Data accessed from the NVT Online website on 03/02/2021)

⬜ **VIXEN** 🟦 **SCEPTER**

FARMER TO FARMER TRADE APPROVED

Josh Reichstein
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Disclaimer: Refer to intergrain.com/disclaimer.aspx for more information. **Only years represented where Vixen is present in trials. ***Only years represented where RockStar is present in trials.

Barley Grass Management Options
2020 Paddock Summary

Author: Jade Rose

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 with delivery support from Elders Jamestown.

Key Points:

- The trial was in its natural regenerative stage for 2020, therefore minimal results for the trial in this year.
- No observable difference between hay and grain treatments – possibly due to inability to cut for hay and remove weed seeds because of the poor season in 2019 resulting in minimal biomass.
- Buffer strips have increased populations relative to treatments.

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
c. 2021 herbicides- All- Pre-emergent Trifluralin 1.5 l/Ha, Avadex 2 l/Ha

Plans for 2021 include sampling of crop plant density, barley grass plant density, barley grass panicle density, barley crop head density and crop grain yield.

Image 1. The barley grass management trial site, Booleroo (July, 12 2021) (Right)

Acknowledgements:

- A special thank you to the McCallum family
- Thankyou to Beth Sleep (Elders) for management of this trial
- 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.

Demonstrating adaptive cropping systems to improve crop competition

Amanda Cook[1,2], Ian Richter[1], Jake Hull[1], Bruce Heddle[3], Andrew Polkinghorne[4], Tim Polkinghorne[4], Wade Shepperd[1] and John Kelsh[1]

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Location
Minnipa Agricultural Centre
Airport paddock
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2020 Total: 367 mm
2020 GSR: 255 mm
Soil type
Red sandy loam
Paddock history
2019: Lentils
2018: Scepter wheat
2017: Lentils
Demonstration size
27 m x 1500 m x 3 locations
(3 paddock seeder strips (27 m each) wide).
Yield: 12 strips with plot harvester in each seeding system of 8.8 m x 1.7 m

Location
Lock - A&J Polkinghorne and T&E Polkinghorne
Rainfall
Av. Annual: 336 mm
Av. GSR: 250 mm
2020 Total: 287 mm
2020 GSR: 272 mm (72 mm in Oct)
Soil type
Red loam flats and sand hills
Paddock history
2020: Wheat
2019: Self-regenerating medic pasture
2018: Wheat
Demonstration size
8 rows of splitter boot x 4 measurements on each soil type.
Yield: 4 plant cuts (50 cm x 50 cm) x three strips threshed.

Key messages

- **A split row seeding system lowered initial ryegrass numbers on red loam at Lock but did not reduce final grass weed numbers and weed seed set.**
- **A small number of grass weeds escaping through the farming system will increase the weed seed bank for future seasons.**

Why do the trial?

A NLP2 Smart Farms grant (4-BA9KBX5) was received in October 2019 to demonstrate adaptive cropping systems. Two demonstration sites were established in 2020 to show the benefits of improving crop competitiveness against weeds by increasing the distribution of seed. The sites were:

- Minnipa, 30 cm row spacings or a no-row spacing seeding system.
- Lock, Stilletto® splitter boot (25 cm row spacing) or a Seedhawk® on 30 cm single row spacing on two different soil types.

How was it done?

In 2020 a demonstration was undertaken on the Minnipa Agricultural Centre (MAC) comparing 30 cm row spacing Horwood Bagshaw PSS® with a press wheel seeding system (Jake Hull, MAC farm manager) and a no-row seeding system consisting of a sweep system with a splitter boot (Bruce Heddle - Minnipa farmer). The no-row system was chosen to increase crop competition against grass weeds.

The MAC demonstration was in the Airport paddock and consisted of three strips, each of three seeder widths (27 m), for each seeding system. Scepter wheat was sown at 70 kg/ha on 12 May, with GranulockZ fertiliser at 70 kg/ha and 1000 g/ha of Rapisol ZMC. Pre-seeding herbicides were Trifluralin @ 1.5 L/ha and Paraquat @ 1 L/ha. In-crop herbicides were Tigrex @ 750 ml/ha and Lontrel Advance @ 35 ml/ha.

The second demonstration site was undertaken at Lock by Andrew and Tim Polkinghorne. The demonstration was sown using a standard Seedhawk sowing system on 30 cm row spacings with standard boots or with Stilletto splitter boots resulting in 25 cm split row spacing. This combination was evaluated on two different soil types, a red loam and a sandy rise. The paddock was sown with Trojan wheat at 70 kg/ha on 26 April with 15 L phosphoric acid/ha (85% P), 25 L/ha of UAN, 1 kg/ha of Mn-sulphate, 1 kg/ha of Zn-sulphate and 100 gm/ha Cu-sulphate. Herbicides used pre-seeding were glyphosate @ 1.2 L/ha, Ester 680 @ 300 ml/ha and Trifluralin @ 2.0 L/ha. In-crop herbicide was Amine @ 1 L/ha with an insecticide. Trace elements of 1 kg/ha of Mn-sulphate, 1 kg/ha of Zn-sulphate and 125 g/ha Cu-sulphate were also applied in a separate spray application.

Crop establishment, grass weed numbers (early and late), dry matter, grain yield and grain quality were assessed during the growing season. Soil moisture was taken for both seeding systems at harvest. The paddock demonstration at MAC was harvested with a plot header on 13 October. Hand harvest cuts were taken at Lock on 22 October.

What happened?

Good opening rains were received in late April/early May at both sites which enabled seeding within the ideal sowing window. The rest of May, June and July had below average rainfall resulting in very little crop growth until August and later in the season, with October having above average rainfall.

The grass weed counts pre-seeding at MAC Airport were low (Table 1), which supports previous research showing that the MAC barley grass genotype has delayed germination due to a vernalization requirement. Early crop establishment resulted in 143 plants/m^2 on the 30 cm row spacing system and 95 plants/m^2 in the no-row spacing system. The lower establishment in the no-row system may have been due to Trifluralin herbicide or lower seed-soil contact. Crop dry matter and yield were similar in both systems (Table 1). There were still low levels of grass weeds in both seeding systems in the later grass weed count at Minnipa.

At Lock, wheat establishment was similar in both seeding systems (Table 1). Early ryegrass numbers were lower with the splitter boot system compared to the single 30 cm row spacing on the red loam. Dry matter of wheat was similar in both seeding systems (Table 1).

There were no differences in the grain yield of wheat at Lock between different soil types but there was a difference of yield for the seeding systems with the Stilletto splitter boots yielding 1.4 t/ha compared to the single row of 1.04 t/ha (Table 2).

Grain protein at Minnipa was similar for both seeding systems (average of 9.6%) but screenings were higher in the 30 cm single row compared to the no-row system. Grain protein at Lock was lower on the sand at 12.1% compared to on the red loam at 13.8%. Screening levels were low on both soil types. There were no differences in soil moistures at harvest at either location between the seeding systems.

Table 1: Crop performance and grass weeds in two seeding systems at two EP sites. Grass weeds were barley grass at Minnipa and ryegrass at Lock.

Soil type	Seeding system	Wheat (plants/m^2)	Early grass weeds/m^2	Early wheat dry matter (t/ha)	Late grass (weeds/m^2)	Grass weed seed set (seeds/m^2)	Yield (t/ha)
Red Loam (Minnipa)	30 cm single row	143	0	0.8	0	0	2.2
	No row seeding system	95	0	0.3	4	745	2.4
LSD (F prob=0.05)		*12*	*ns*	*ns*	*ns*	*ns*	*ns*
Red Loam (Lock)	30 cm single row	113	52	0.8	10.8	1205	1.0
	Stilletto splitter boot	117	32	0.9	8.3	850	1.1
Sand (Lock)	30 cm single row	104	7	0.6	0	0	1.1
	Stilletto splitter boot	104	4	0.9	0	0	1.7
LSD (F prob=0.05)		*ns*	*11*	*ns*	*ns*	*ns*	*ns*

Table 2: Grain yield (t/ha) of two seeding systems at Lock, 2020.

Lock	**30 cm single row**	**Stilletto splitter boot**
	1.04	1.40
LSD (F prob=0.05)		*0.35*

Figure 1. Two different seeding systems at Minnipa in November 2020. LHS, 30 cm single row Horwood Bagshaw PSS with press wheel and RHS No row seeding system.

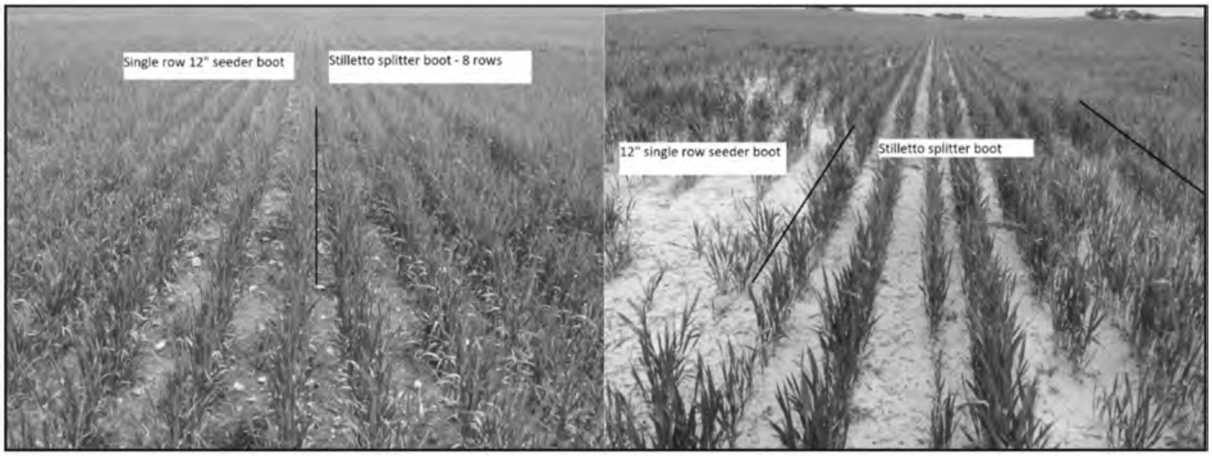

Figure 2. Two different seeding systems at Lock in 2020 on a red loam and sandy soil.

What does this mean?

The barley grass population at Minnipa was lower than expected. The no-row seeding system possibly had Trifluralin damage or lower seed soil contact at seeding which reduced initial crop numbers. Late grass seed set showed how a minimal number of plants escaping through the farming system will impact on the seed bank for future seasons.

Early ryegrass numbers were lower in the split row seeding system on the red loam at Lock supporting previous research that increasing crop competition is a management tool to lower grass weed numbers. Late grass weed numbers and seed set were similar in both seeding systems, which may have been due to high moisture stress during winter.

These demonstrations will be undertaken again in the 2021 season.

Acknowledgements

Thanks to the growers for implementing and hosting the seeding systems demonstrations. This extension demonstration was possible via NLP2 SFSG2 grants investment in project 4-BA9KBX5. Thank you to Katrina Brands and Steve Jeffs for processing samples.

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

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[1]SARDI Minnipa Agricultural Centre; [2]University of Adelaide Affiliate Associate Lecturer, [3]University of Adelaide.

Location
Minnipa Agricultural Centre, paddock S3
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2020Total: 367 mm
2020 GSR: 255 mm
Soil type
Red Sandy loam
Paddock history
2019: Compass barley
2018: Scepter wheat
2017: Volga vetch
Plot size
27 m x 620 m x 3 replicates (3 paddock seeder strips (27 m each) wide)

Key messages

- **In 2019 the IMI system had the lowest barley grass plant numbers and the lowest weed seed set.**
- **In 2019 the desiccated Compass barley hay cut at a higher seeding rate reduced the barley grass weed seed set by 75%. Using a hay cut and hay freeze may be an important management option for paddocks with high barley grass populations.**
- **Using only clethodim and a wetter at higher rates is important to maximise the efficacy and coverage and get the best conditions for killing the grass weeds. The broadleaf spray at MAC is now done separately several days after the grass weed control, not in the same tank mix.**
- **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 a higher risk rotation strategy 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?

At the beginning of the project a meeting was held with growers, MAC staff, consultants 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).

The management strategies will be tested over the three year rotation with the focus on barley grass weed management and weed seed set. For the 2019 management of the trial refer to 'Demonstrating integrated weed management strategies to control barley grass in low rainfall zone farming systems', EPFS 2019 Summary, p 175.

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-SU sown medic pasture (IMI tolerant)	Razor CL wheat (IMI tolerant)
Higher cost herbicide	Compass barley (desiccated) 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).

The trial is composed of three replicated broad acre strips of three seeder widths (27 m wide) of each treatment in MAC paddock S3. In 2020 the paddock was sprayed on 25 March with 1.5 L/ha glyphosate, 0.45 L/ha 2,4-D LV Ester 680, 50 ml/ha Hammer and 100 ml/ha LI700 for early weed control.

The Two Year Break system had Trident TT canola sown on 26 April at 1.8 kg/ha, with Granulock Z fertiliser at 80kg/ha, and 1.5 L/ha glyphosate, 0.8 L/ha trifluralin, 800 gm/ha Simazine and 50 ml/ha Hammer and an insecticide on the 4 May and 4 September. On the 3 June the canola was sprayed with 330 ml/ha clethodim and 0.75 L/ha Hasten for grass weeds. On the 11 June it was sprayed with 30 ml/ha of Lontrel advance and 800 gm/ha of Atrazine.

The IMI system, following Scope barley in 2019, was sown with Sultan-SU (IMI tolerant) medic pasture at 7 kg/ha with 50 kg/ha of GranulockZ fertiliser on the 26 April, with 1.5 L/ha glyphosate and 50 ml/ha Hammer pre-sowing. On the 25 May all pasture treatments were sprayed with 25 gm/ha Broadstrike and 0.75 L/ha Hasten for broadleaf weed control, and on the 3 June 330 ml/ha clethodim and 0.75 L/ha Hasten for grass weed control. Karate Zeon insecticide was sprayed on the 4 September. Scepter wheat was sown on the 12 May at a seeding rate of 70 kg/ha, with GranulockZ fertiliser at 70kg/ha, and 1.6 L/ha glyphosate, 1.5 L/ha trifluralin and 50 ml/ha Hammer. It was sprayed with 1 L/ha Amicide 625 for broadleaf weeds on 28 August. Unfortunately, the Gp K herbicide Sakura was not applied pre-sowing.

Crop establishment, barley grass numbers, barley grass seed set, grain yield and quality were assessed during the growing season. Late barley grass samples were taken and panicles sent to Roseworthy for the assessment of barley grass seed set. The 27 m strips were harvested with the plot header (3 times) per treatment on 19 October for canola and 3 November for wheat, and the grain quality was assessed.

What happened?

In 2019 the IMI system had no barley grass weed seed set at harvest (Table 2). The Compass barley in 2019 in the District Practice and Cultural Control systems produced similar barley grass weed seed set with 377 seeds/m^2 and 360 seeds/m^2 respectively. The desiccated compass barley hay cut at a higher seeding rate of 95 kg/ha reduced the overall barley grass weed seed set to 88 seeds/m^2 (Table 2). The Two Year Break self-regenerating pasture system had the higher barley grass numbers during the 2019 season, but the late paraquat application in early September in the pasture phase lowered weed seed set to 216 seeds/m^2 (Table 2).

In 2020 the majority of the barley grass again germinated later in the season during mid July and August avoiding the early weed control with pre-sowing herbicide applications. The residual carryover in the IMI system resulted in the lowest pre-seeding germination and low barley grass numbers/m^2 (Table 2). The different crops all established well but a lower than average rainfall in May, June and July resulted in very slow crop growth until August and September.

The chemical applications applied in the break crop systems of the canola and medic crops reduced the late barley grass plant numbers (Table 2), with the TT Canola system giving the best later barley grass weed management. Despite the lower numbers of barley grass there were differences in the number of barley grass seed heads per plant (Table 2) with the Higher Cost Chemical system sown with Scepter wheat having more seed heads per plant late in the season. The 2020 late barley grass weed seed set at harvest is still being assessed at Roseworthy.

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

2020 Barley grass weed control strategy and crop variety	**2019 Pre-harvest barley grass weed seed set (seeds/m^2)**	**Pre seeding barley grass numbers (plants/m^2) 27 April**	**Crop establishment (plants/m^2) 16 June**	**Early barley grass numbers (plants/m^2) 16 June**	**Late barley grass (plants /m^2) 1 Sept**	**Late barley grass (heads /m^2) 1 Sept**
District Practice Self-regenerating medic pasture	377	9.3	45.5	34.8	1.6	3.3
IMI system Sultan (SU tolerant) sown medic pasture	0	3.7	88.3	26	1.3	4.7
Cultural Control Self-regenerating medic pasture	360	42.4	46.3	39.3	2.8	5.7
Higher cost herbicide Scepter wheat	88	20	124.7	0.1	1.3	11.3
Two Year Break Trident TT canola	216	45.9	38.5	18	0.1	0.1
LSD (P=0.05)	*84.3*	*ns*	*9.2*	*22.6*	*1.2*	*4.8*

The Trident TT canola was harvested on the 19 October and yielded 0.59 t/ha with 30% oil, 26.8% protein and 6.2% moisture. The Scepter wheat was harvested on the 3 November and yielded 1.39 t/ha. The grain quality achieved the required delivery standards with 11.9% protein, 4.2% screenings, 10% moisture, test weight 82.9 gm and 38.2 gm/1000 grain weight.

What does this mean?

The 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. The germination patterns of this barley grass population was assessed at Roseworthy and showed it was a late germinating population with a requirement for cold (vernalisation), and Group A resistance to quizalofop.

In 2019 the desiccated Compass barley hay cut at a higher seeding rate of 95 kg/ha reduced the overall barley grass weed seed set to 88 seeds/m^2 compared to the other Compass barley systems, reducing the weed seed set by 75%. Despite the 2019 Two Year Break self-regenerating pasture system having higher barley grass numbers during the season the late hay freeze with paraquat sprayed at 1.2 L/ha, 500 mls LI700/100L at water rate 100L/ha in early September sprayed in the morning in cooler overcast conditions (approximately 19 degrees with a Delta T around 3.5) in the pasture phase prevented weed seed set. Using a hay cut and following up with a hay freeze may be an important management option to manage barley grass populations.

With confirmed Group A resistance levels at Minnipa Agricultural Centre in barley grass populations to FOPS, moving to clethodim could be effective for the short term. Generally higher rate of clethodim (500 mL/ha) appears to be effective on most populations where 250 mL/ha rate does not work effectively at present. However, resistance to the higher rate is likely to evolve over the next few years. The broadleaf spray at MAC is done separately several days after the grass weed control, not in the same tank mix. The environmental conditions can also affect the spray efficacy, especially cold weather/frost either 2-3 days before or after spraying, so avoid these events if possible. Dry conditions, plant stress and soil constraints may also affect spray efficacy, but more research is needed in this area.

While the IMI herbicide system is working well at MAC it tends to be quite prone to evolution of resistance in weeds. The 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 chemical applications applied in the break crop systems of the canola and medic crops reduced the late barley grass plant numbers, with the TT Canola system giving the best later barley grass weed management. All systems had some level of barley grass escapes and weed seed carry over, and the number and size of barley grass seed heads will impact on the size of the seed bank in the following season.

The Group A 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 ensure that 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 and ensure the best use of chemicals to maximise the herbicide efficacy. This paddock scale MAC research is ongoing for the 2021 season to assess the barley grass weed management strategies.

Acknowledgements

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Harvest at Minnipa Agricultural Centre, 2020.

Herbicide resistance in barley grass populations from the low rainfall zones in South Australia

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Key messages

- Thirty two barley grass populations were collected from grower paddocks from Eyre Peninsula and Upper North regions in 2019 and screened for resistance to major herbicide groups in 2020. This was not a random survey because most of these populations were considered difficult to control with herbicides.
- All of these barley grass populations collected in 2019 from Eyre Peninsula and Upper North regions were completely killed by glyphosate and paraquat and were rated as herbicide susceptible.
- Resistance to the FOP herbicide quizalofop was confirmed in 50% (n=16) of these targeted populations tested in 2020. In addition to this, 19% of the populations (n=6) were classified as developing resistance.

Ten barley grass populations were confirmed resistant to clethodim at 250 ml/ ha. At the higher clethodim dose (500 ml/ha), only three populations were rated as resistant. This result is consistent with research results for annual ryegrass where higher rates of clethodim can improve weed control. Growers could improve barley grass control by increasing clethodim dose but this is unlikely to be a long-term solution to the problem.

Out of 1O clethodim resistant populations only 3 showed resistance to butroxydim at 90 g/ha and only 1 was resistant at 180 g/ha. These results are consistent with the findings from the previous year, which showed susceptibility of many clethodim resistant populations to butroxydim.

Resistance to the IMI herbicides still appears to be very low in barley grass. Only one barley grass populations from Eyre Peninsula was found to be highly resistant to Intercept® and showed no reduction in plant survival or biomass.

Why do the trial?

Barley grass possesses several biological traits that make it difficult for growers to manage in the low rainfall zone, so it is not surprising that it is becoming more prevalent in field crops in SA. 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. In this survey, barley grass was ranked as the 7th most costly weed to control by the growers in SA and VIC Mallee and Mid-North, Lower Yorke and Eyre Peninsula. In a previous random survey in SA in 2012, Shergill *et al.* (2015) identified resistance to quizalofop in 15% of barley grass populations from Upper North and Eyre Peninsula . Additional herbicide resistant populations have been identified since the previous survey.

Growers in these regions have observed many control failures and have been collaborating with this GRDC funded project to confirm resistance status of their barley grass populations.

How was it done?

Thirty two barley grass populations were collected from Eyre Peninsula (n=22) and Mid North and Upper North regions (n= 10) at maturity in 2019. Most of these populations were collected from fields where growers had observed ineffective weed control. Therefore, this was not a random survey and a higher level of herbicide resistance than in a random survey was expected. Herbicide susceptible barley grass populations collected from Yaninee in 2006 was used as the control. This population has been used in several previous studies of herbicide resistance at the University of Adelaide.

Barley grass seeds of all populations were sown into potting mix (cocoa peat) in seedling trays in April (1st run) and June (2nd run) 2020. When barley grass seedlings reached 1 leaf stage, they were transplanted into pots (1O plant s/pot). Populations were grouped by herbicide treatment and randomised at the time of spraying. Seedlings were sprayed with the label rates of group A, B, L and M herbicides (Table 1). Adjuvants recommended by the manufacturers were added to the spray solution of all herbicides. A research track sprayer (De Vries Manufacturing, Hollandale, United States of America) was used to apply the herbicide treatments, which was calibrated to deliver 100 L/ha through a single TeeJet® 8002E (TeeJet Technologies, Illinois, United States of America) flat-fan nozzle at a speed of 3.6 km/h. Plants were assessed for survival 4 weeks after the herbicide treatment and individuals with new growth were counted as survivors.

Only populations classified as resistant or developing resistance were included in the 2nd run to confirm their resistance status prior to sending reports to the growers. Populations with <5% plant survival were rated as susceptible whereas those with 6-19 were rated developing resistance. Populations with >20% survival were rated to be resistant. This herbicide rating system is currently used by herbicide resistance testing labs in Australia . Populations were only screened for resistance to glyphosate and paraquat in round 1.

What happened?

Barley grass populations sprayed with glyphosate (Weedmaster® DST® 470 g/L @ 760 ml /ha) or paraquat (Para-Ken® 250 g/L @ 1200 mLJha) were completely killed and showed no resistance to these herbicides. On a cautious note it is worth mentioning that resistance to glyphosate was recently identified by our research team in three barley grass populations from a farm on the Yorke Peninsula. Resistance to paraquat was reported previously in barley grass populations from lucerne paddocks in SA. Even though the risk of resistance to these herbicides is low, growers still need to carefully investigate any cases of unexpected survival of weeds sprayed with all herbicides.

Table 1. Details of herbicides and the timing of their application.

Active ingredient (group)	Trade name, manufacturer	Dose (round 1)	Dose (round 2)
Untreated control	N/A		
Quizalofop 100 g/L (group A)	Leopard® , Adama	250 ml/ha	250 and 500 ml/ha
Clethodim 240 g/L (group A)	Grasidim® 240EC, Sipcam	250 ml/ha	250 and 500 ml /ha
Imazamox 33 g/L + imazapyr 15 g/L (group B)	Intercept®, Nufarm	600 ml/ha	375 and 750 ml/ha
Glyphosate 470 g/L (M)	Weedmaster® DST®, Nufarm	760 ml/ha	
Paraquat 250 g/L (L)	Para-Ken 250®, Kenso Agcare	1.2 L/ha	

Table 2. Herbicide resistance status of barley grass populations collected from Eyre Peninsula (n=22) and Mid-Upper North of SA in 2019.

Herbicide	Herbicide resistance frequency (%)"		
	Resistant (>20% survival)	Developing resistance (6-20% survival)	Susceptible (<5% survival)
Glyphosate (Weedmaster DST @ 760 ml/ha)	0 (0)	0 (0)	100 (32)
Paraquat (Para-Ken 250 @ 1.2 L/ha)	0 (0)	0 (0)	100 (32)
Quizalofop (Leopard @ 250 ml/ha)	50 (16)	19 (6)	31 (10)
Clethodim (Grasidim 240 EC @ 250 ml/ha)	38 (12)	6 (2)	56 (18)
Intercept @ 750 ml/ha	3 (1)	3 (1)	94 (30)

[a] *Figures in brackets are the number of populations in each class.*

Table 3. Cross-resistance pattern of a sub-set of barley grass populations screened for herbicide resistance.

Sample number	Survival (%)							
	Leopard 250 (ml/ha)	**Leopard 500 (ml/ha)**	**Clethodim 250 (ml/ha)**	**Clethodim 500 (ml/ha)**	**Factor 90 (g/ha)**	**Factor 180 (g/ha)**	**Intercept 375 (ml/ha)**	**Intercept 750 (ml/ha)**
2	100	100	0	0	0	0	0	0
3	100	100	10	0	0	0	0	0
4	100	100	100	0	0	0	0	0
7	100	100	33	0	0	0	0	0
17	50	0	61	0	0	0	0	0
19	0	0	0	0	0	0	**100**	**100**
23	100	100	100	33	61	67	0	0
25	100	100	100	28	0	0	0	0
26	100	100	100	22	11	0	0	0
Yaninee	0	0	0	0	0	0	0	0

There was a high level of resistance detected to the FOP herbicide quizalofop (Leopard®). Out of 32 barley grass populations investigated, 50% were classified as resistant and 19% were developing resistance (Table 2). All resistant populations were retested in the 2nd run and resistance was confirmed. It was encouraging to see the consistency in the results of quizalofop resistance between the two rounds of testing. The frequency of resistance detected to clethodim (44%) was slightly lower than to quizalofop (69%) but still a cause for concern. Resistance to the IMI herbicide Intercept was very low with only 1 population classified as resistant and 1 developing resistance. This low frequency of IMI resistance is consistent with the results from the resistance screening of barley grass undertaken on samples collected in 2018.

Generally plant survival of FOP resistant barley grass populations was 100% at both rates of Leopard (Table 3). However, there was one exception to this trend. Sample 17 showed high plant survival (50%) at the lower dose of quizalofop but was completely killed at the higher rate of this herbicide. Some barley grass populations were highly resistant to quizalofop but were completely controlled by clethodim even at the lower rate (e.g. sample 2). Sample 17 also survived (61%) the lower rate of clethodim but was killed at 500 ml/ha. There were 3 populations from the Mid-North that showed complete survival at the lower rate of clethodim and moderate survival (22-33%) even at the higher rate. Consistent with the results from last year, butroxydim provided effective control of most of the clethodim resistant barley grass populations (Table 3). However, Sample 23 from near Tarlee was even resistant to the higher rate of butroxydim. Presence of different patterns of cross-resistance to group A herbicides indicates presence of different resistance mechanisms within this weed species.

Based on resistance screening of barley grass populations in 2019, resistance to the IMI herbicide tends to be less prevalent than to group A herbicides. In the previous survey, only one population with a high level of IMI resistance was identified. That IMI resistant population was collected from a farm on Eyre Peninsula. Resistance screening in 2020 identified another IMI resistant population from a different farm on the EP (Table 3). It is worth noting that this population (Sample 19) is not resistant to the FOP or DIM herbicides, which indicates direct selection through the use of ALS inhibiting herbicides. This barley grass population is highly resistant to the IMI herbicides and showed no reduction in survival and biomass even at the higher rate of Intercept.

What does this mean?

Herbicide resistance screening of barley grass populations collected at the end of 2019 growing season provided some valuable information. The results clearly show that resistance to group A herbicides in difficult to control barley grass is quite common. Therefore, growers facing poor weed control with this herbicide group should undertake herbicide resistance testing to identify alternative herbicide options. Many of the FOP resistant populations were also resistant to clethodim at the lower rate (250 ml/ha) but complete control was achieved at the higher rate of 500 ml/ha. It would be tempting to increase clethodim rate to improve weed control but resistance to the higher rate is likely to evolve rapidly. This can be seen in three populations from the Mid North to Upper North that showed resistance even at clethodim rate of 500 ml/ha.

As seen last year, butroxydim (Factor®) was highly effective against most of FOP and clethodim resistant populations of barley grass. At the higher rate of butroxydim , only one barley grass population survived as compared to three populations that were resistant to the higher rate of clethodim. This study also showed that some barley grass populations on local farms are already resistant to butroxydim even at the higher rate.

The frequency of resistance to the IMI herbicide Intercept ® was much lower than to the FOP and DIM herbicides. Only one barley grass population from Eyre Peninsula showed resistance to the IMIs. This population was highly resistant to this herbicide group and showed no mortality or suppression in growth. Even though IMIs are considered high risk from resistance viewpoint, current frequency of resistance on local farms appears to be very low. Therefore, growers planning to use Clearfield® crops should go ahead but efforts should be made to diversify crop rotations and herbicide use as well as integration of non-chemical control tactics.

Acknowledgements

We thank GRDC for funding this research through project 9176981 and the growers for submitting samples.

***Collecting barley grass seed on upper EP for resistance screening, October* 2020.**

Establishing Barley on Salt Scald Trial

Author(s): Stefan Schmitt
Funded By: UNFS & Nelshaby Agricultural Bureau
Project Title: Establishing Barley on Salt Scald
Project Duration*:* 1 year
Project Delivery Organisations: Agricultural Consulting and Research

Key Points:

- No significant differences in establishment or yield were observed in any of the treatments in this season.
- 90mm of rainfall was received soon after sowing, therefore most plots achieved full establishment.
- Favourable sowing conditions in 2020 did not compliment the aims of this trial.

Background

Saline groundwater tables are increasingly affecting the lower lying flats in the Lower Broughton region. Commonly referred to as 'salt scald patches' these areas often see poor establishment due to surface salts reducing water uptake during germination. Salt scald patches are best suited for cropping in seasons with strong early breaks, when rainfall leaches surface salt. Barley is the preferred crop type on these soil types as it has outstanding salinity tolerance versus other crops.

Climate models are projecting a drying climate in which we are likely to experience less frequent strong breaks reducing the ability to establish crops on saline soils. This trial looks at a way in which establishment can be improved on these soils by reducing the impact of salinity. Treatments in this trial explore impacts of cultivar along with manipulating the seed zone using in-furrow and seed coated water retention agents. Moisture retention agents are known to hold water in the furrow by slowing the movement of water vertically and horizontally in the profile. Water retention agents are most commonly used on non-wetting sand to improve establishment. This trial looks at the ability of these products to improve establishment under saline conditions.

Notes on products

1. Se14 by SACOA is a mix of surfactants and retention agents that has been proven to improve establishment on some non-wetting soils and under dry seeding conditions. By attracting and retaining moistures. **Note in this trial Se14 has been trialled as a seed coat which is an off label application and is therefore not recommended for implementation unless label changes occur.**

2. Rain Drover discontinued is a mix of surfactant and retention agents to aid the establishment of crops on non-wetting soils

Methodology

Sowing Date: 21st April 2020
Soil conditions: Dry

Sowing rate: 150 plants /m2
Seeder Type: Knifepoint press wheel
Liquid Delivery: Friction Flow, liquid treatments applied at 100L/ha liquid stream close to seed.
Chemicals at Sowing: BoxerGold @ 2.5L/ha EPE
Broadleaf Weed Control: MCPA Amine 750 @ 400mls/ha + 180mls/ha Kamba500 + Tilt 250 @ 400mls/ha.

Table 1. Treatment details

Treatment Number	Treatment
1	Fathom Barley (district practice)
2	Buff Barley
3	Fathom Barley + Se14 on seed @ 2L/tonne
4	Buff Barley + Se14 on seed @ 2L/tonne
5	Fathom Barley + Se14 @ 4L/tonne
6	Fathom Barley + Se14 @ 5L/ha in furrow
7	Fathom Barley + Rain Drover @ 5L/ha in furrow

***Seed treatments applied 1 day prior to sowing.**

Results and Discussion

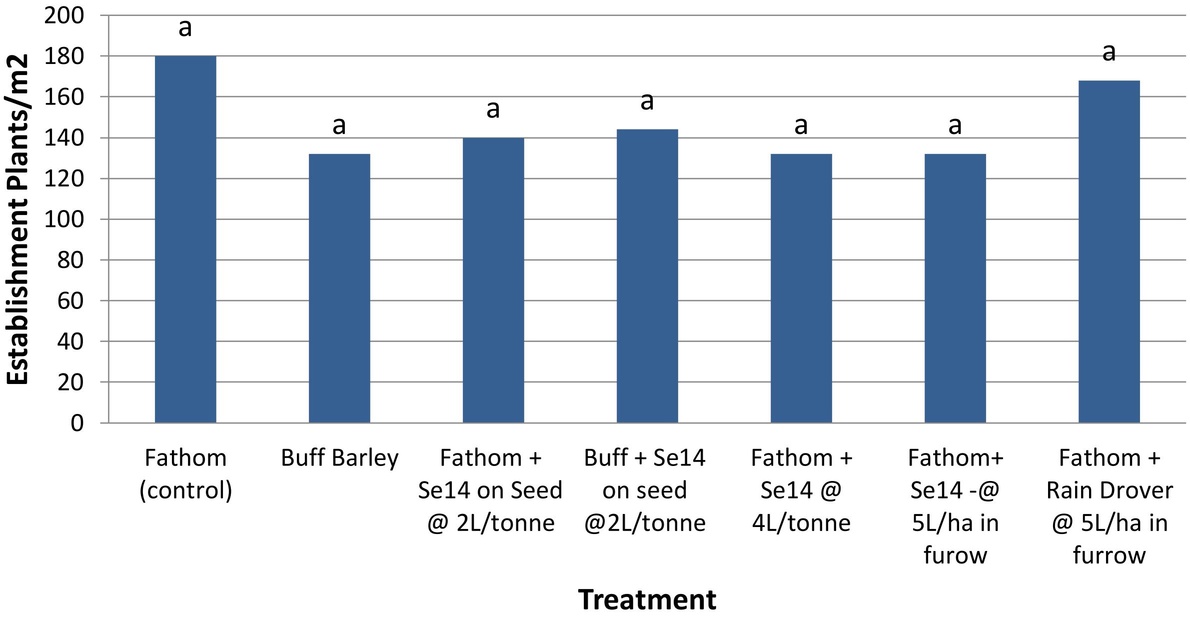

Figure 1. Average plant establishment of trial treatments per square metre. An analysis of variance (ANOVA) was conducted on the data using R statistical software. Treatment means have been grouped using Tukey's HSD at the 95% level of confidence. Treatment means with letters in common do not significantly differ from one another.

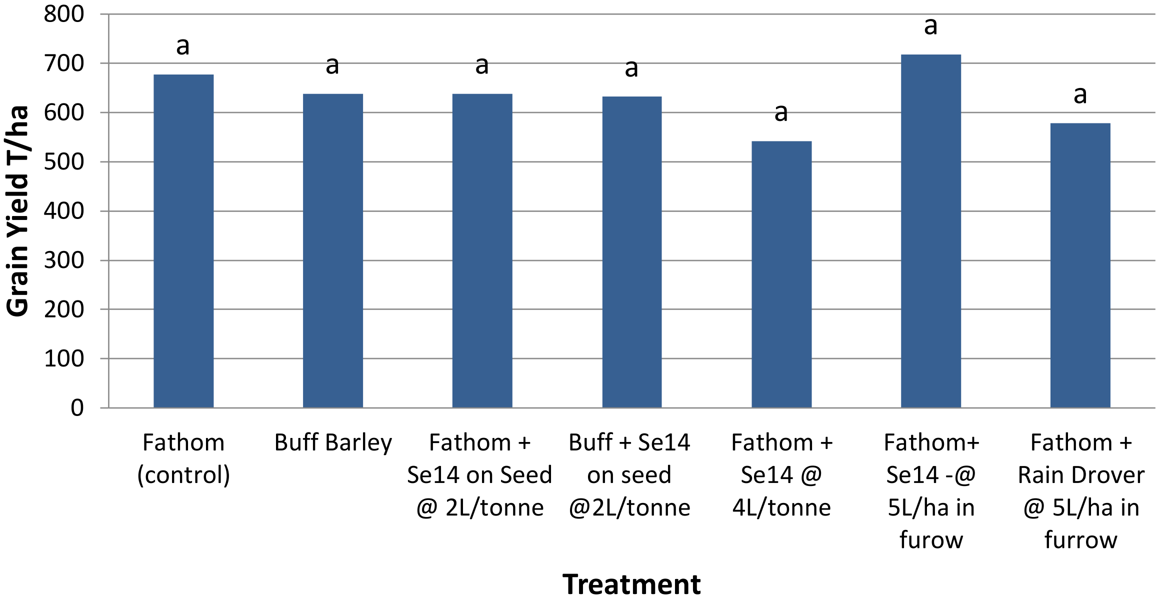

Figure 2. Average plot yield of trial treatments tonnes/ha. An analysis of variance (ANOVA) was conducted on the data using R statistical software. Treatment means have been grouped using Tukey's HSD at the 95% level of confidence. Treatment means with letters in common do not significantly differ from one another.

Discussion

In this season there was no significant difference between the control 'district practice' and applied treatments for both establishment and grain yield. This site experienced a strong break with ~90mm of rainfall over a two day period one week after sowing. This resulted in almost full establishment being achieved across all treatment. The aim of this trial was to assess applied treatments under challenging conditions for germination, which was not experienced this year. This has more than likely masked and treatment effects.

Acknowledgements:

- **A big thankyou to Leighton Johns for providing the trial site**
- Funding support from the Nelshaby Agricultural Bureau
- Funding support from The Upper North Farming Systems Group

Funding and Delivery Partners

GRDC Sandy soils IMPACT trials – Warnertown

Author (s): Sam Trengove, Stuart Sherriff and Jordan Bruce
Funded By: GRDC
Project Title: CSP00203 Increasing production on sandy soils in low and medium rainfall areas of the Southern Region
Project Duration: 2019-21
Project Delivery Organisations: Trengove Consulting

Key Points

- Ripping plus spading was the highest yielding treatment, increasing grain yield by 0.36t/ha (38%) over the control treatment.
- Ripping plus inclusion increased yield by 0.16t/ha (16%). No other treatments produced significant increases.
- There was a poor relationship between late August GreenSeeker NDVI and grain yield (R^2 = 0.18).
- Deep ripping with inclusion plates has produced the greatest cumulative partial gross margin for seasons 2019 and 2020.

Location: Warnertown, -33.2832, 138.0872

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

Methodology – How was it done?

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	11 April 2019
Seeding	12 May 2020
Site rolled	12 June 2020
Harvest	18 November 2020

Variety: 50 kg/ha PBA Hallmark XT lentils
Fertiliser: 60 kg/ha MAP + 1% Zn

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 adjacent 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 2019, 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. The full 50m plots were harvested in two 25m sections.

Establishment counts were conducted on the 12 June prior to rolling the plots on the same day. However, rolling of the plots resulted in a reduction in plant numbers in some plots, such as the Plozza plots, due to burying of some plants. Other in crop measurements included GreenSeeker NDVI recorded on 30 July and 27 August.

Results

Table 1. In crop measurements of plant establishment and GreenSeeker NDVI, and grain yield data.

Treatment	Plants/ m² (June 12)	NDVI 30 July		NDVI 27 August		Grain yield (t/ha)	
Control	112	0.288	a	0.587	a	0.92	c
Shallow Rip	114	0.297	a	0.553	a	0.97	bc
Deep Rip	101	0.310	a	0.613	a	0.99	bc
Deep Rip + Inclusion	112	0.310	a	0.596	a	1.07	b
Rip + Plozza	106	0.180	b	0.400	b	0.95	bc
Rip + Spade	111	0.267	a	0.604	a	1.28	a
P(>F)	*ns*	*0.086*		*0.024*		<0.001	

The plant establishment count did not return any significant differences between treatments. A follow up count a few weeks after rolling may have been appropriate to estimate the loss of plants due to rolling.

The 30 July GreenSeeker NDVI showed that the Plozza treatment was 39% lower than all other treatments (Table 1). This may have been a result of the rolling that occurred in June, which decreased plant numbers and therefore also reduced NDVI.

This lower GreenSeeker NDVI value continued for the Plozza treatment as it was still 32% lower on average on 27 August.

Ripping plus spading was the highest yielding treatment, increasing grain yield by 0.36t/ha (38%) over the control treatment (Table 1). Ripping plus inclusion increased yield by 0.16t/ha (16%) but did not yield significantly higher than any other treatment. No other treatments produced significant increases. Correlation between August NDVI and grain yield is low, another measurement later in September may have proved beneficial in understanding canopy development later into the season and the effect on yield. The two highest yielding treatments would have incorporated the greatest amount of organic matter and mixing of the top part of the soil profile using inclusion plates and spading. Therefore, it appears that the mixing and inclusion are key drivers of the yield response at this site in 2020, more than any effects on reducing compaction. The Plozza treatment yield was similar to the control, indicating good late season recovery given the earlier reductions in NDVI.

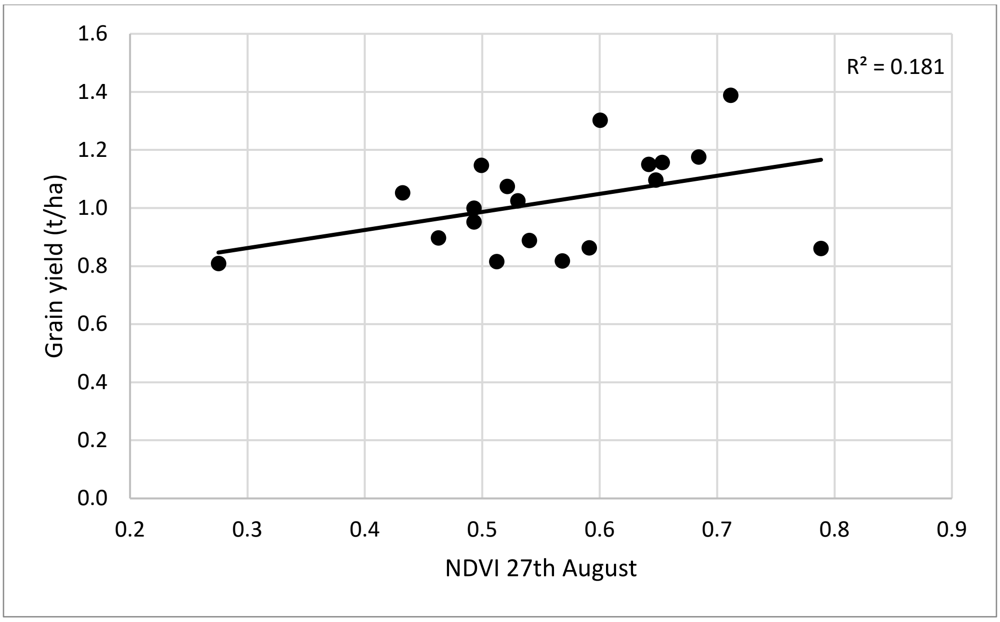

Figure 1. GreenSeeker NDVI (27 August) and grain yield relationship for the Warnertown site.

The relationship for GreenSeeker NDVI and grain yield was not strong (Figure 1). This is contrasting to many other trials of lentils on sandy soils, where increasing biomass results in increased yields.

Table 2. Cumulative partial gross margin (PGM) for seasons 2019 and 2020 for the Warnertown trial. Price assumptions include barley BAR1 (2019) $270/t and lentils (2020) $680/t.

Treatment	Amelioration cost ($/ha)	Cumulative yield (t/ha)	2020 gross income ($/ha)	Cumulative gross income ($/ha)	Cumulative PGM ($/ha)
Control	$0	4.23	$623	$1,517	$1,517
Shallow Rip	$50	4.58	$662	$1,637	$1,587

Deep Rip	$70	4.81	$670	$1,702	$1,632
Deep Rip + Inclusion	$100	5.09	$730	$1,814	$1,714
Rip + Plozza	$150	4.24	$648	$1,534	$1,384
Rip + Spade	$250	5.12	$869	$1,905	$1,655

Rip with spading and deep rip with inclusion plates has produced the highest cumulative yield over two seasons (Table 2). However, deep rip with inclusion plates has generated the highest cumulative partial gross margin over the two trial seasons due to the lower up front cost of amelioration, generating $197/ha increased income over the untreated control. Rip with spade and deep rip treatments were next highest, increasing PGM over control by $138/ha and $115/ha, respectively.

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.

Plozza Plough in action - photo by Glen Fletcher

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Cereal Micronutrients Trial - Zinc, Copper and Molybdenum – Booleroo Centre

Author(s): Andrew Catford & Matt Foulis (Northern Ag)
Funded By: South Australian Grains Industry Trust (UNF117)
Project Title: Increasing the knowledge and understanding of micronutrient deficiency in the Upper North
Project Duration: 2017-2021
Project Delivery Organisations: Upper North Farming Systems, Northern Ag

Key Points

- No yield benefits resulted from the treatment applications of Zinc, Copper or Molybdenum.
- Molybdenum uptake was achieved while all other treatments resulted in no change in leaf tissue or grain composition suggesting other limiting factors to uptake or plant development.

Background

Following on from previous UNFS micronutrient trials (2017-2019), the purpose of this trial aims to assess yield and/or quality benefits from application of these foliar products.

Methodology

At a site located 13km east of Booleroo Centre, Scepter wheat plots were applied with varying rates and formulations of zinc, copper and molybdenum **(Table 1)**. 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 all but one of the zinc treatments were early applications. The one late applied zinc treatment was to help establish any other benefits zinc might have. Molybdenum (Mo) is important in the plants nitrogen pathways. As nitrogen deficiency can develop early in the plants life and is often treated early with an application of urea, it was added to the trial this year as an early applied treatment to identify any potential advantages foliar molybdenum might have in this area.

The trial was a randomised block design with three replicates, 11 treatments and a control. 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. The soil is characterised as a clay loam.

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 1L/ha to try to establish if a more pronounced response would be achievable at a relatively extreme rate. Molybdenum chelate was applied at 300ml/ha rate which is the highest label recommended rate for cereals.

Table 1. Treatment list

Number	Product	Strength (g/L)	Rate (L/ha)	Timing
1	Wilchem Sentinal Zinc Chelate	60	2.5	GS21
2	Wilchem Sentinal Zinc Chelate	60	1	GS21
3	Wilchem Sentinal Copper Chelate	60	2.5	GS21
4	Wilchem Sentinal Copper Chelate	60	1	GS21
5	Icon Zinc Oxide	1500	0.1	GS21
6	Icon Zinc Oxide Early and Late	1500	0.1	GS21 & GS40
7	Icon Zinc Oxide	1500	1	GS21
8	Wilchem Sentinal Copper Chelate Late	60	2.5	GS40
9	Icon Copper Oxide	1070	0.1	GS21
10	Wilchem Sentinal Zinc Chelate & Wilchem Sentinal Copper Chelate	60	2.5	GS21
11	Wilchem Signature Molybdenum Chelate	100	0.3	GS21
12	Untreated Control			

The split application of zinc oxide at 100ml/ha at both GS21 and GS40 aimed to establish if there was benefit to a late growth stage zinc application which is uncommon for the district. Copper chelate was also applied at both GS21 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 GS21 as is common district practice.

Table 2. Relevant timings of pesticides, micronutrient applications and tissue testing at trial site

	Assessment/Application	Date
Grower Pre-Emergent	Trifluralin @1.5L/ha applied using growers boomspray	6/5/20
Grower Sowing	Scepter wheat sown at 65kg/ha with 65kg/ha of DAP (18:20) using growers seeding unit	6/5/20
Grower Post-Emergent	Amicide Advance 700 @0.8L/ha Lontrel Advance 600 @75ml/ha	15/7/20
GS21 Treatments	Hand Boom Application	23/6/2020
GS40 Treatments	Hand Boom Application	28/8/2020
Tissue Test	1 Sample Per Rep	15/9/2020

The micronutrients were applied using a hand boom at a water rate of 100L/ha on the 23rd of June and the late copper and zinc applied on the 28th of August. Tissue tests were conducted on each treatment taking the 10 youngest expanded blades from each plot (30 per treatment) on the 15th of September. The plots were harvested by SARDI at the season's end. Grain was 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: Sampling and data collected through-out the trial.

Tissue Test	Grain Sample Test	Harvest Data
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		

Results and Discussion

The trial showed no significant result in copper, zinc or molybdenum levels in the plant tissue tests. There were also no trends in the zinc or copper levels assessed across all treatments. Tissue tests presented no trends with both zinc and copper analytes resulting in the untreated control treatment having higher levels of zinc and copper compared to many of the treatments which had zinc and copper applied. The late applications of zinc oxide and copper chelate did show an increase in their respective analytes however both sets of data was not significant when analysed.

The trial did show a trend where molybdenum levels increased in the plant tissue test when molybdenum was applied (Figure 1). 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 containing zinc or copper. Molybdenum showed statistically significant results (Figure 2). It is not yet known the benefit of high levels of molybdenum in wheat grain or seed other than decreasing any molybdenum deficiencies in wheat seedlings. There were no other obvious trends to suggest that the zinc and copper treatments would have produced significant differences if replicated out further.

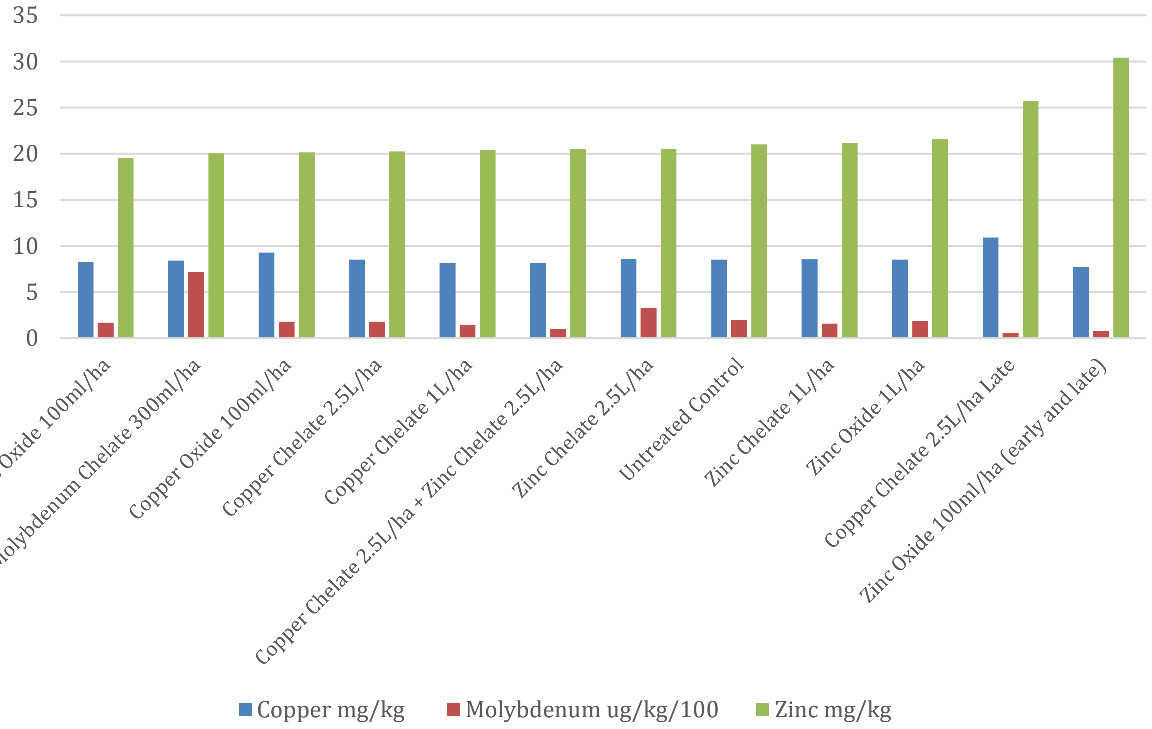


Figure 1. Tissue test results showing zinc and copper levels (mg/kg) for each treatment

All treatments yielded statistically equal or poorer than the control treatment (Fig 3). This may be due to plants not displaying clinical deficiencies due to reduced plant biomass early in the season. Zinc copper and molybdenum are very important in plant development and growth. With average growing conditions early in the season 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.

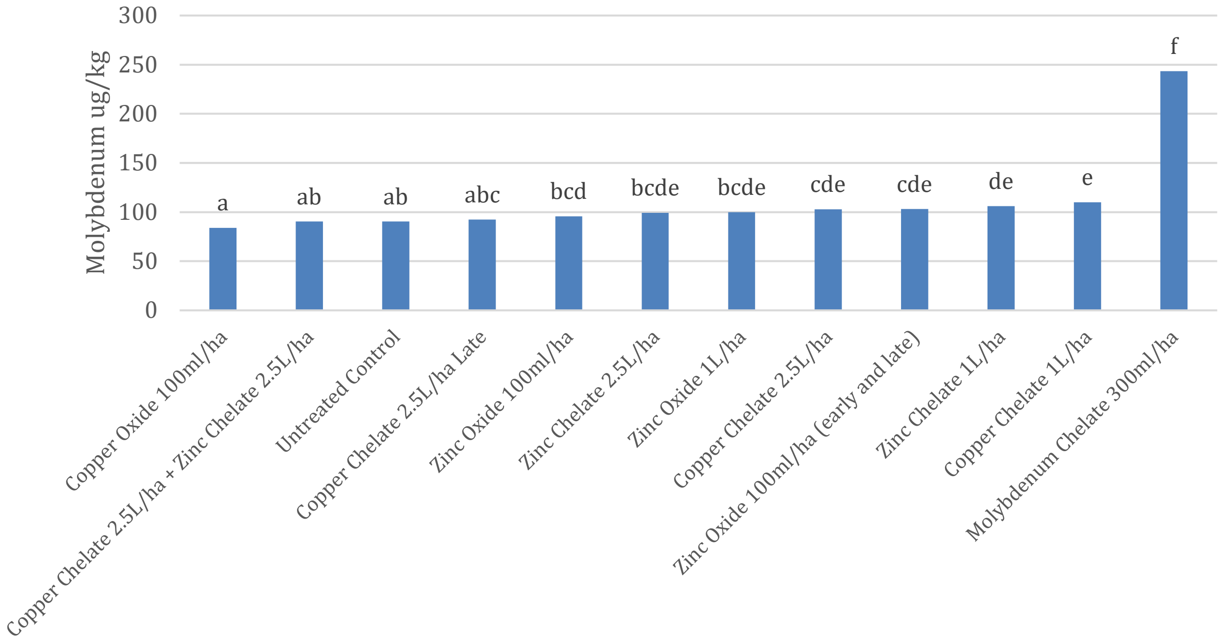


Figure 2. Grain test results showing molybdenum levels (ug/kg) for each treatment.

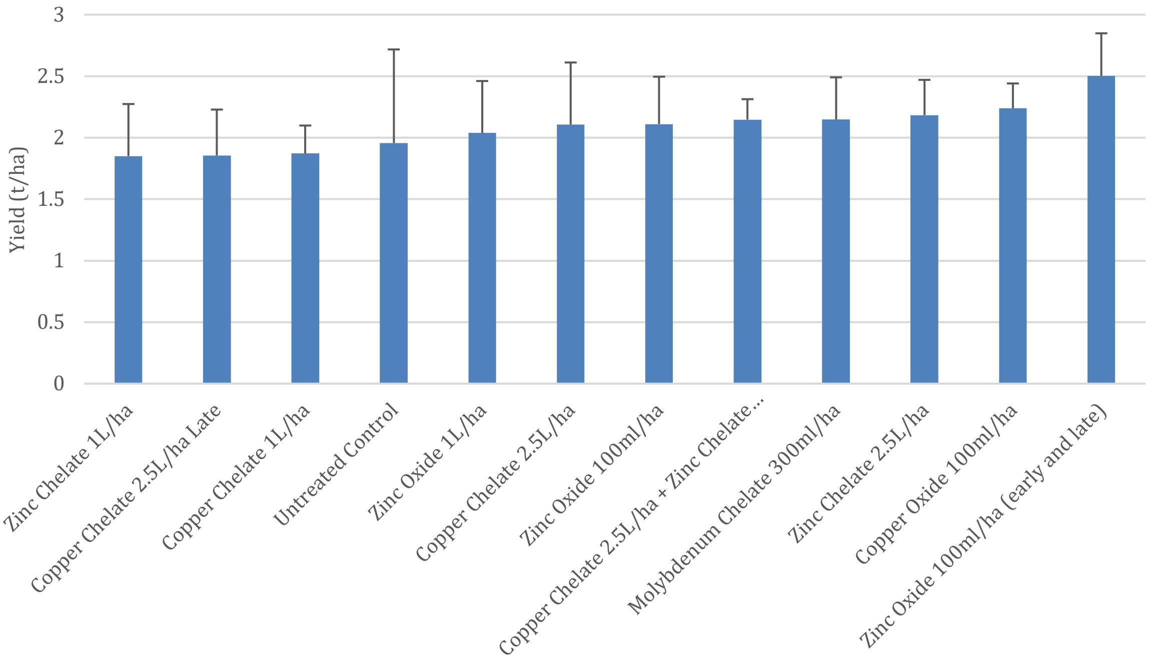


Figure 3. Yield harvest data (t/ha) for each of the treatments. Error bars show standard deviation.

Conclusion

There was no significant response in yield to any applied treatment at this site. This included formulation type, rate of product and timing of the copper chelate and zinc oxide applications. Whilst we had favourable spring conditions, we had a drier than average winter which may have potentially reduced the benefits of the treatments applied as the plant was not actively growing after applications. This season (2020) had a very favourable finish for crop yield however netted similar results to the previous two trials (2018 and 2019) in this region, which both were exposed to terminal springs. However, all three seasons (“18, ”19 and “20) have enduring below average winters, especially June and July. Potential uptake of these micronutrients could be limited due to other factors in the soil type. Further trial work in this space could be worthwhile investigating the same treatments at a higher rainfall site to ensure optimum growing conditions for a full season.

Acknowledgements

- David Hombsch for hosting trial site
- SAGIT for funding the trial work.

Pulse Micronutrients Trial - Molybdenum – Booleroo Centre

Author(s): Andrew Catford & Matt Foulis (Northern Ag)
Funded By: South Australian Grains Industry Trust (UNF117)
Project Title: Increasing the knowledge and understanding of micronutrient deficiency in the Upper North
Project Duration: 2017-2021
Project Delivery Organisations: Upper North Farming Systems, Northern Ag

Key Points

- Significant uptake of molybdenum and zinc in lentil grain and tissue samples
- No significant response in Lentil grain yield from applied treatments

Background

Following on from previous UNFS micronutrient trials (2017-2019), the aim of this trial was to assess yield and/or quality and nutritional benefits from application of these foliar products.

Methodology

The trial was conducted at a site 10km north-west of Booleroo Centre on a crop of Hurricane lentils in which varying rates of Molybdenum and Zinc were applied. This is the second year of running this trial, with the extremely dry conditions in 2019 unfortunately causing a failed crop.

The trial was a randomised block design with three replicates, four treatments and a control (Table 1). The trial was placed over the grower sown crop and marked out in crop post crop emergence so that an even crop establishment site could be achieved. The soil is characterised as a red clay over limestone.

Table 1. The applied treatments of Molybdenum and Zinc on Hurricane lentils, 2020.

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

Zinc oxide was applied at 100ml/ha, molybdenum chelate applied at 150ml/ha and 300ml/ha were to be representative of common field rates used in the district. Zinc oxide at 200ml/ha and molybdenum chelate at 500ml/ha was to try an establish if a more pronounced response would be achievable at a relatively extreme rate.

Molybdenum chelate was applied at 300ml/ha rate which is the highest label recommended rate.

Table 2. Relevant timings at trial site

	Assessment/Application	Date
Grower Pre-Emergent	Simazine at 450g/ha and Trifluralin at 800ml/ha applied using growers boomspray	8/5/19
Grower Sowing	Hurricane lentils sown at 45kg/ha with 30kg/ha of DAP using growers seeding unit	8/5/19
Grower Post-Emergent	Status at 500ml/ha and Kwicken at 1%	2/6/2020
Treatments	Hand Boom Application	28/8/2020
Tissue Test	1 Sample Per Rep	15/9/2020

The micronutrients were applied using a hand boom at a water rate of 100L/ha on the 28th of August. Tissue tests were conducted on each treatment taking the 10 youngest expanded blades from each plot (30 per treatment) on the 15th of September. The plots were harvested by SARDI. Both the harvest data and grain sample data were then analysed for statistical significance using ANOVA at the 5% significance level.

Table 3. Data accrued for tissue test analysis, grain sample analysis and harvest data

Tissue Test	Grain Sample Test	Harvest Data
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		

Results and Discussion

There were clear trends in increased zinc and molybdenum levels assessed across the treatments (Figure 1). All other nutrients analysed in the tissue samples did not show any relevant responses to treatments (see appendix).

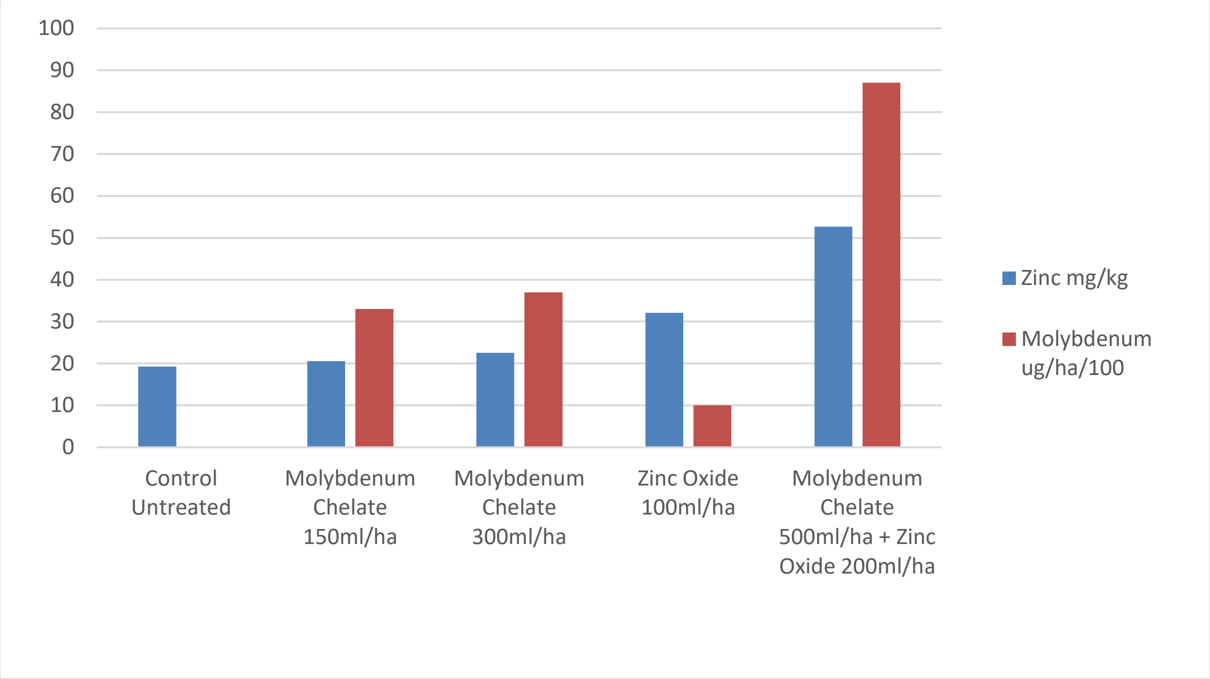


Figure 1. Tissue test results showing Zinc (mg/kg) and Molybdenum (ug/kg/100) against the treatments

Lentil grain tests showed statistically significant increase in molybdenum as a result of increase foliar treatment of molybdenum chelate (Figure 2**)**. This indicates that the foliar applied molybdenum has been successfully taken up by the lentil plants.

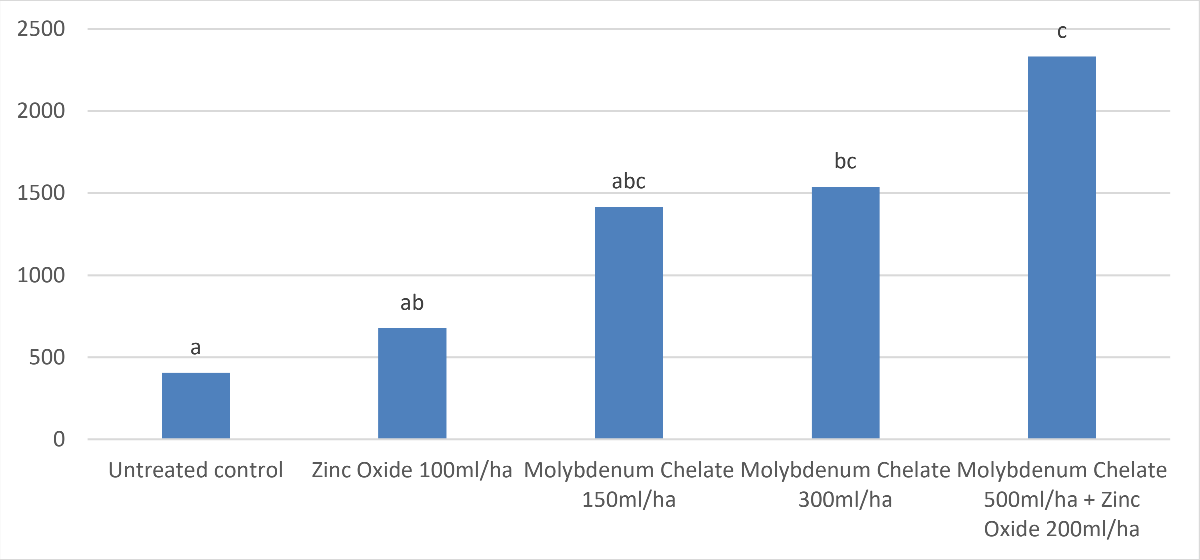


Figure 2. Lentil grain test results showing molybdenum levels (ug/kg) for each treatment.

Other nutrient and grain quality data collected from the trial site did not show any significant differences between the treatments. There were also no obvious trends to suggest that the treatments would have produced significant difference if replicated out further.

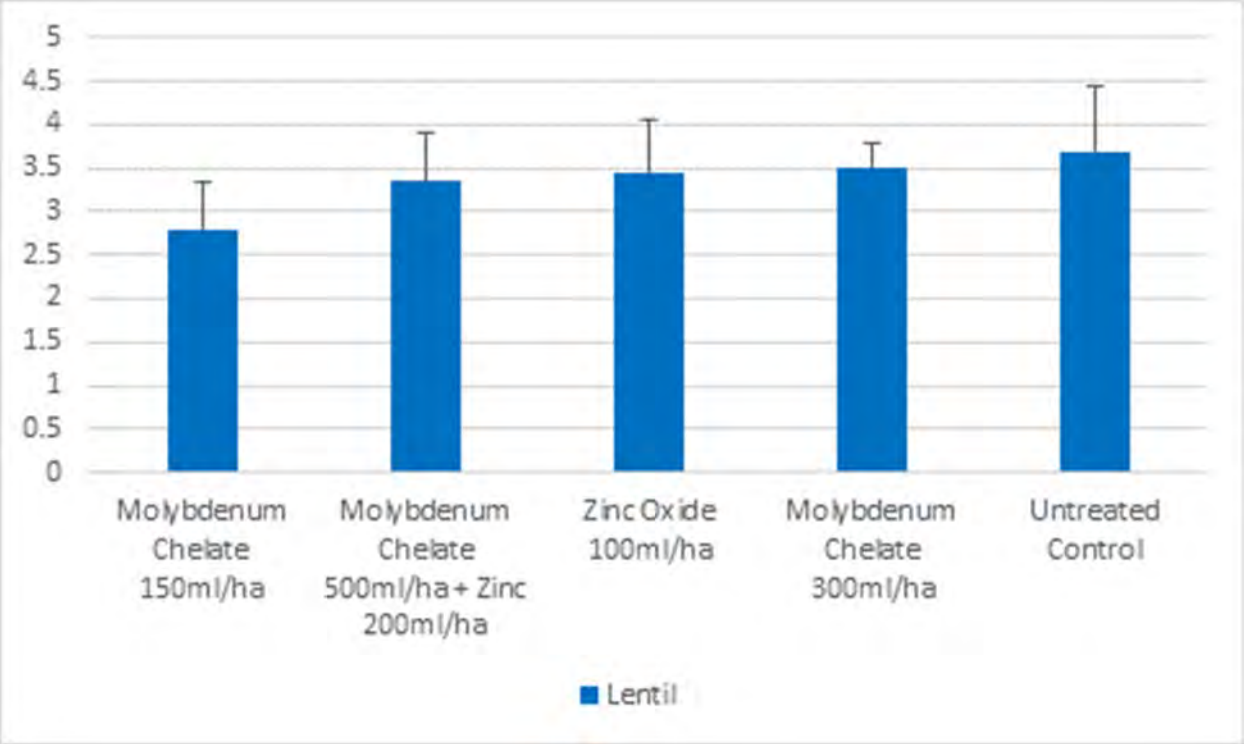


Figure 3. Yield harvest data (t/ha) for each of the treatments. Error bars show standard deviation.

All treatments at the sites yielded statistically equal to the control treatment (Figure 3)**.** The grain quality data collected for both trials showed no significant differences between any of the treatments for any factor tested.

Summary

Although we have identified positive responses to molybdenum and zinc in grain and tissue samples, we have not seen any significant response to grain yield at this site. Molybdenum in pulses is something that needs investigating further in the region, as we have seen visual responses on certain soil types in previous seasons.

Acknowledgements

- Thank you to Walter Farming for hosting trial site
- SAGIT for funding the trials

Appendix: Tissue Sample Analysis

	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	283.06	20.76	1.434	0.341	210	4.54	243.2	0.167	72.69	3300
Molybdenum 300ml/ha	316.84	20.8	1.499	0.312	230	4.5	263.4	0.174	76.41	3700
Zinc Oxide 100ml/ha	321.45	21	1.366	0.384	210	4.18	263.3	0.186	69.9	10
Molybdenum 500ml/ha + Zinc 200ml/ha	274.41	19.06	1.29	0.307	220	4.43	223.6	0.17	68.43	8700
Untreated control	379.67	20.16	1.339	0.323	220	4.23	308.7	0.192	72.94	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	66	2.732	12	1.5	19.4	0.227	1.842	0.0332	0.141	20.59
Molybdenum 300ml/ha	118	2.766	12.7	1.6	19.9	0.218	1.739	0.0326	0.139	22.56
Zinc Oxide 100ml/ha	37	2.548	11	1.4	18.2	0.232	1.763	0.0285	0.14	32.07
Molybdenum 500ml/ha + Zinc 200ml/ha	35	2.583	11.2	1.4	18.6	0.23	1.913	0.0261	0.139	52.63
Untreated control	56	2.513	10.9	1.4	17	0.231	1.859	0.0301	0.148	19.28

Micronutrient Trial – Zinc, Molybdenum and Copper in Cereals at Mambray Creek in the Upper North

Author(s): 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: 2017-2021
Project Delivery Organisations: Upper North Farming Systems, YPAG

Key Points

- All treatments yielded higher than the untreated
- High levels of molybdenum and high rates of zinc chelate resulted in the highest yields
- Further investigation into Zinc applications and its effect on yield would be recommended

Background

Following on from previous UNFS micronutrient trials (2017-2019), the purpose of this study was to assess the benefits of the application of various micronutrients to a wheat crop at different rates and timings, furthermore to identify effects of different formulations for each specific nutrient. The aim of this trial was to:

1. Identify whether micronutrient products can be better utilised to maximise yield potential
2. Identify if micronutrient deficiencies are causing yield penalties

Methodology

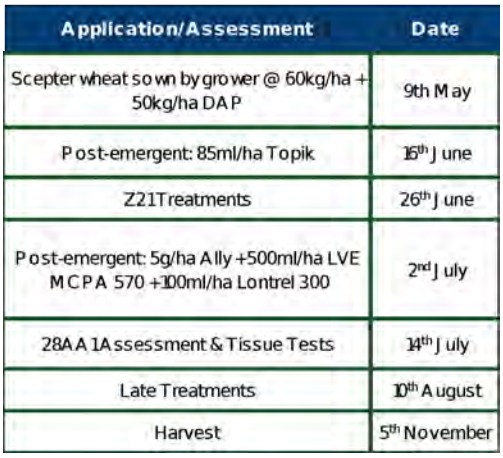
This study was a randomised block design plot trial with 10 treatments on the wheat cultivar Scepter. There were 3 replicates with plots of 10m x 2m. The soil was characterised over the course of the trial (Appendix A and B).

Table 1. Micronutrient treatments, product names, rate and timings applied on pulse trial at Mambray Creek, 2020.

Treatment		Rate	Timing
1	Untreated		
2	Signature Zinc	2L/ha	GS21
3	Signature Zinc	0.75L/ha	GS21
4	Signature Copper	3L/ha	GS21
5	Signature Copper	1.2L/ha	GS21
6	Zinc Oxide	0.1L/ha	GS21
7	Zinc Oxide x 2	0.1L/ha x 2	GS21 + GS37
8	Zinc Oxide	1L/ha	GS21
9	Signature Copper	3L/ha	GS37
10	Copper Oxide	0.12L/ha	GS21
11	Signature Copper + Signature Zinc	3L/ha + 2L/ha	GS21
12	Molybdenum (Mo)	300ml/ha	GS21
13	Ezyflo Trace	1L/ha	GS21
14	ZMC 341	4Lha	GS21
15	Signature Iron	2L/ha	GS21
16	Signature Potassium	3L/ha	GS21

*Refer to Appendix C for more details on formulations included in treatments, Signature is a product name

Table 2. Chronology of events

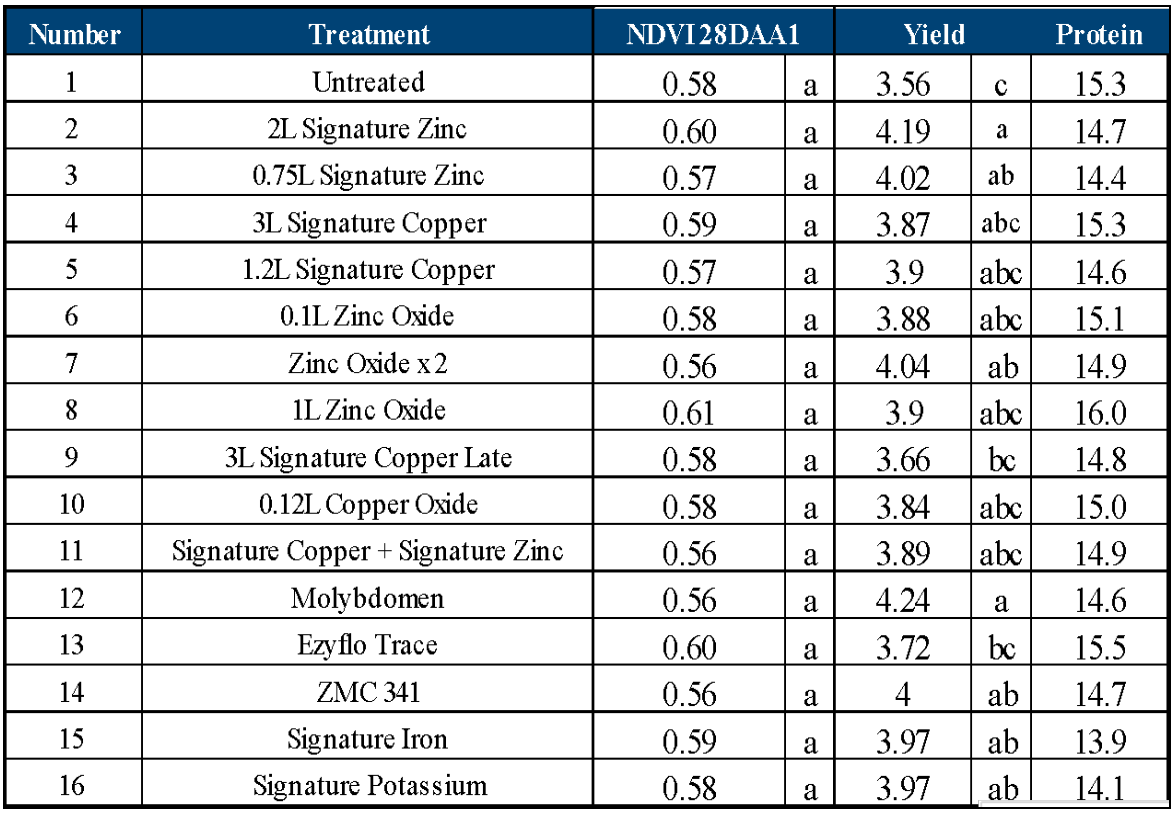


Application/Assessment	Date
Scepter wheat sown by grower @ 60kg/ha + 50kg/ha DAP	9th May
Post-emergent: 85ml/ha Topik	16th June
Z21 Treatments	26th June
Post-emergent: 5g/ha Ally + 500ml/ha LVE MCPA 570 + 100ml/ha Lontrel 300	2nd July
28AA1 Assessment & Tissue Tests	14th July
Late Treatments	10th August
Harvest	5th November

Results and Discussion

As seen in the yield data (Table 3) (Figure 1), there were several significant differences found in this trial. There appeared to be apparent rate response with higher rates or dual applications of Zinc resulting in higher yields. No visual differences in treatments occurred as shown by NDVI data and the lack of significant differences (Table 3). The top five yielding treatments were molybdenum at 300ml/ha which yielded 4.24t/ha. This was followed by Signature Zinc at 2L/ha yielding at 4.19t/ha, Zinc Oxide x 2 yielding at 4.04t/ha, Signature Zinc at 0.75L yielding at 4.02t/ha and ZMC 341 yielding at 4t/ha (Table 3).

Table 3. Full yield and assessment results



Number	Treatment	NDVI28DAA1		Yield		Protein
1	Untreated	0.58	a	3.56	c	15.3
2	2L Signature Zinc	0.60	a	4.19	a	14.7
3	0.75L Signature Zinc	0.57	a	4.02	ab	14.4
4	3L Signature Copper	0.59	a	3.87	abc	15.3
5	1.2L Signature Copper	0.57	a	3.9	abc	14.6
6	0.1L Zinc Oxide	0.58	a	3.88	abc	15.1
7	Zinc Oxide x 2	0.56	a	4.04	ab	14.9
8	1L Zinc Oxide	0.61	a	3.9	abc	16.0
9	3L Signature Copper Late	0.58	a	3.66	bc	14.8
10	0.12L Copper Oxide	0.58	a	3.84	abc	15.0
11	Signature Copper + Signature Zinc	0.56	a	3.89	abc	14.9
12	Molybdomen	0.56	a	4.24	a	14.6
13	Ezyflo Trace	0.60	a	3.72	bc	15.5
14	ZMC 341	0.56	a	4	ab	14.7
15	Signature Iron	0.59	a	3.97	ab	13.9
16	Signature Potassium	0.58	a	3.97	ab	14.1

Further investigation into Chelated Signature Zinc and Zinc Oxide products would be recommended from the yield differences observed (Table 3).

Application of copper did not show the same trends as above. Although yielding higher than the untreated, there was high variance in yield between different formulations and rates of copper showing no statistically significant response to copper. However, yield response to copper appeared greater when applied early rather than late which suggest further work could be investigated here.

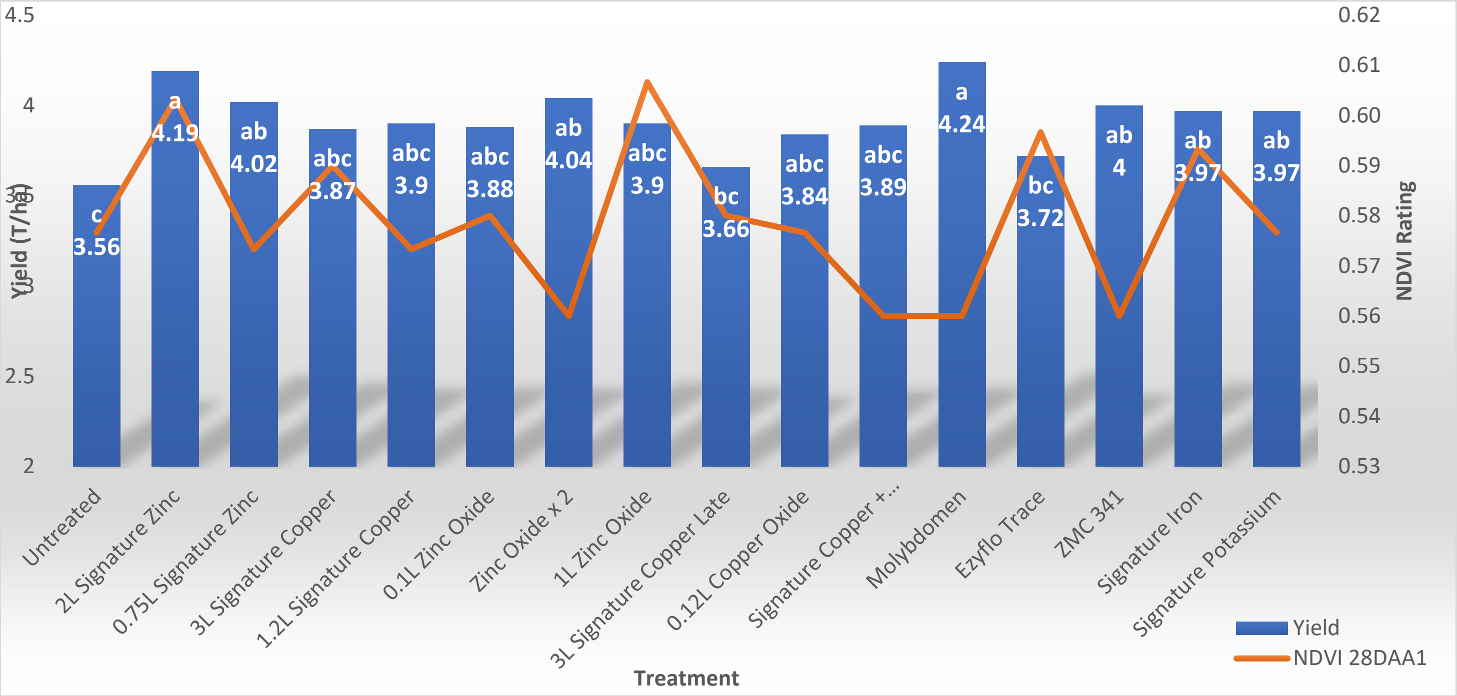


Figure 1. Yield (t/ha) and Normalised Difference Vegetation Index (NDVI)assessment chart for each treatment

There were no significant differences in any of the NDVI or protein data obtained suggesting the micronutrient applications had no effect on these in this trial.

Table 4. Tissue test results (mg/kg)

Treatment	N	S	P	K	Mg	Ca	Na	Cl	Fe	Al	Mn	B	Cu	Zn	Co	Mo
1	4.55	0.31	0.27	3.08	0.1	0.26	0.014	0.87	96	18	45	6.4	6.3	18	0.18	0.71
2	4.67	0.32	0.26	3.14	0.1	0.26	0.006	0.82	83	13	44	6.1	6.5	18	<0.16	1
3	4.67	0.32	0.28	3.1	0.1	0.25	0.006	0.85	81	<9	45	6.3	6.4	18	<0.16	0.84
4	4.73	0.33	0.28	3.26	0.11	0.3	0.011	0.94	87	12	49	5.7	6.6	19	<0.16	0.63
5	4.71	0.31	0.26	3.08	0.09	0.24	0.005	0.88	69	<9	41	5.4	6.6	18	<0.16	0.71
6	4.67	0.3	0.28	3.08	0.1	0.25	0.01	0.82	77	12	45	4.9	6.4	19	<0.16	0.69
7	4.64	0.31	0.26	3	0.1	0.27	0.007	0.79	86	16	45	5.2	6.3	18	<0.16	0.6
8	4.72	0.33	0.28	3.23	0.1	0.27	0.007	0.89	82	12	46	6.3	6.6	20	<0.16	0.87
9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	4.47	0.3	0.26	3.09	0.09	0.24	0.006	0.78	70	10	44	5.3	6.1	18	<0.16	0.47
11	4.57	0.3	0.28	2.96	0.1	0.24	0.006	0.78	81	15	44	5.4	6.1	18	<0.16	0.73
12	4.7	0.31	0.25	2.96	0.1	0.27	0.006	0.83	76	14	47	6.1	6.3	17	<0.16	1
13	4.8	0.31	0.26	3.09	0.1	0.25	0.007	0.8	100	48	43	5.4	6.3	18	<0.16	0.73
14	4.56	0.3	0.25	2.86	0.09	0.23	0.006	0.75	73	9.4	42	5.4	6.1	17	<0.16	0.66
15	4.62	0.31	0.27	3.02	0.1	0.24	0.007	0.75	77	15	42	5.2	6.4	18	<0.16	0.67
16	4.62	0.32	0.28	3.02	0.1	0.25	0.004	0.81	76	15	45	6.2	6.5	18	<0.16	0.72

The application of molybdenum at 300ml/ha resulted in the highest yield of the trial (4.24t/ha) and a significant yield increase over the untreated. Tissue test results showed the application of Mo correlated with the highest level of molybdenum. This level of Mo in the tissue samples was also found in the high rate of Signature Zinc at 2L/ha, which yielded statistically equal to treatment 12, molybdenum. The increase in yield from applying molybdenum or zinc resulted in a positive return on investment (ROI) from these applications on these soil types with these timings (Table 5).

Table 5. Treatments, rate, costs and ROI of applying micronutrient applications. Price assumptions based on the PIRSA Gross Margin Guide 2021 prices (2020/2021) forecast for a LOW rainfall zone and total variable costs for each cereal type (wheat).

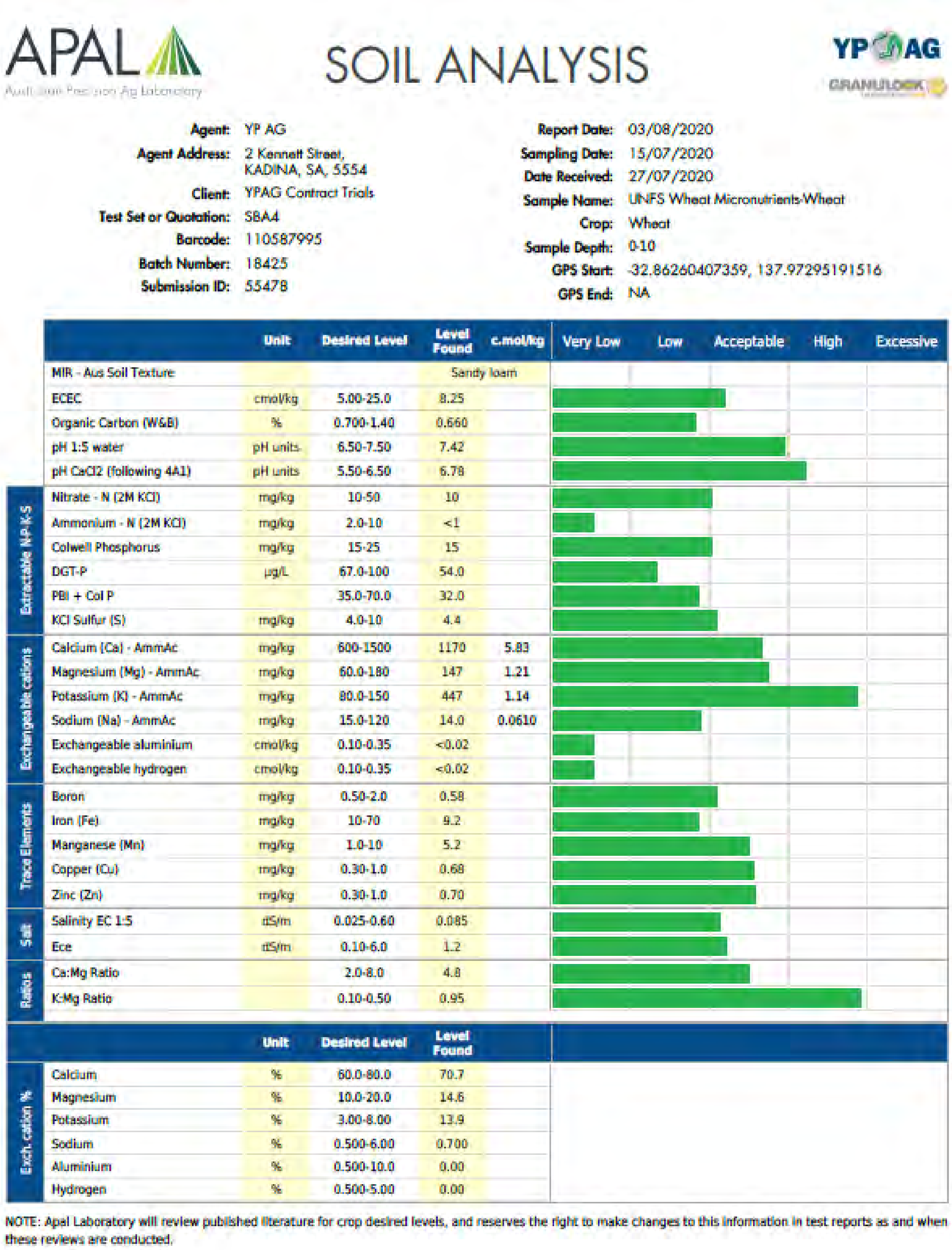
Treatment	Rate (ml/ha)	Total cost ($/ha)	Yield increase (t/ha)	ROI ($/ha)
Molybdenum	300ml	4.80	0.6	185.2
Zinc (Signature)	2L	7.30	0.6	183.1

These results suggest high molybdenum levels in the plant at an early-stage lead to a high yield response and this can be achieved through direct application or addressing other limitations to plant function enabling the plant to access the Mo from the soil. Similar trials undertaken in the same season on different soil types did not have similar results. As such further research into differing soil types and regions would be beneficial.

Acknowledgements

- SAGIT for funding the trial.
- Wilchem – micronutrient product supply
- YPAG – trial spraying, assessment, and harvest equipment under contract.
- Alex Burbury (YPAG) – Statistical analysis via ARM
- APAL – Protein analysis data
- Sandalwood Ag – land use and sowing of trial

Appendix A. APAL soil analysis results for 0-10cm.



APAL
Australian Precision Ag Laboratory

SOIL ANALYSIS

YP AG
GRANULOCK

Agent: YP AG
Agent Address: 2 Kennett Street,
KADINA, SA, 5554
Client: YPAG Contract Trials
Test Set or Quotation: SBA4
Barcode: 110587995
Batch Number: 18425
Submission ID: 55478

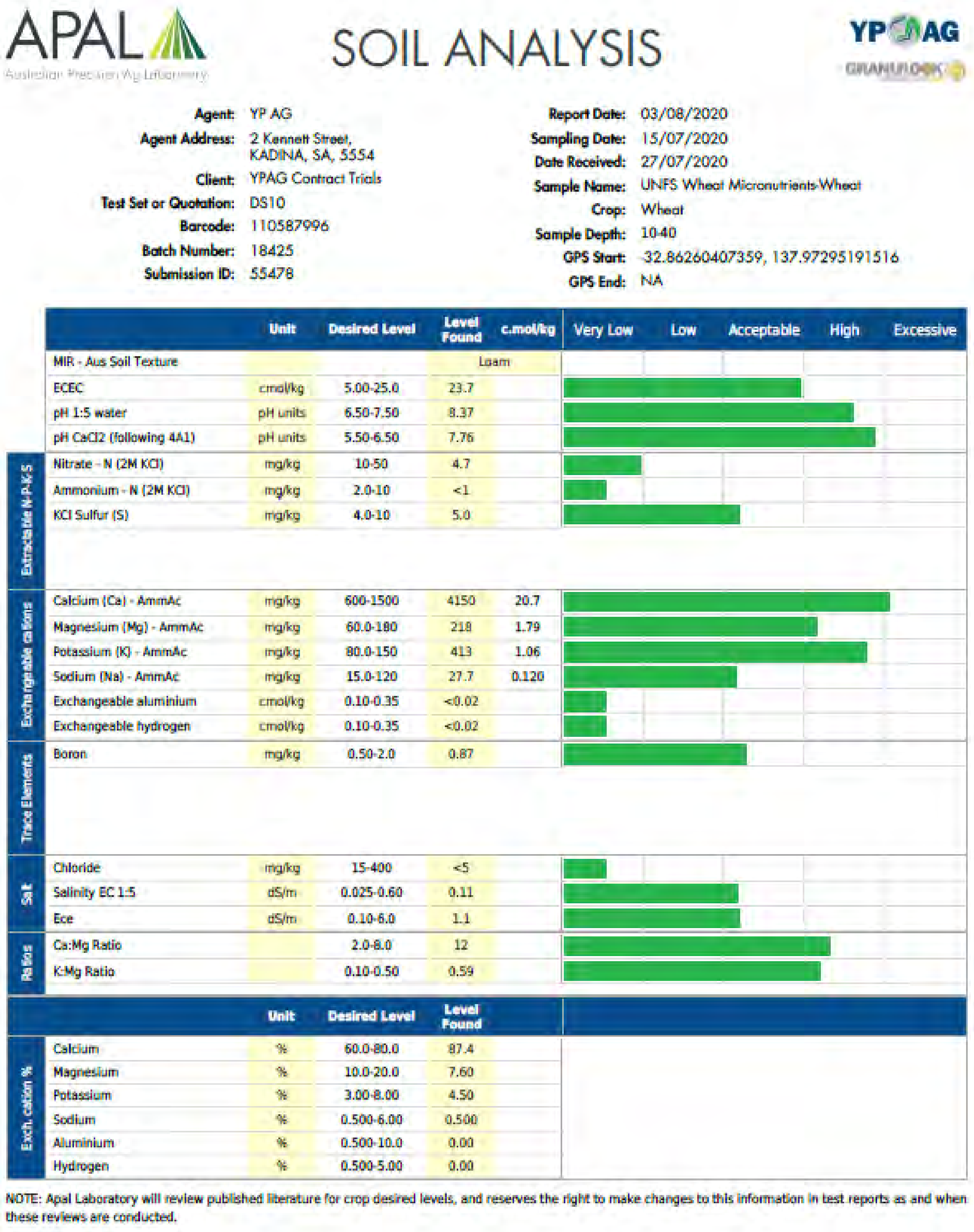
Report Date: 03/08/2020
Sampling Date: 15/07/2020
Date Received: 27/07/2020
Sample Name: UNFS Wheat Micronutrients-Wheat
Crop: Wheat
Sample Depth: 0-10
GPS Start: -32.86260407359, 137.97295191516
GPS End: NA

		Unit	Desired Level	Level Found	c.mol/kg	Very Low	Low	Acceptable	High	Excessive
	MIR - Aus Soil Texture			Sandy loam						
	ECEC	cmol/kg	5.00-25.0	8.25		🟩	🟩	🟩		
	Organic Carbon (W&B)	%	0.700-1.40	0.660		🟩	🟩			
	pH 1:5 water	pH units	6.50-7.50	7.42		🟩	🟩	🟩		
	pH CaCl2 (following 4A1)	pH units	5.50-6.50	6.78		🟩	🟩	🟩	🟩	
Extractable N-P-K-S	Nitrate - N (2M KCl)	mg/kg	10-50	10		🟩	🟩	🟩		
	Ammonium - N (2M KCl)	mg/kg	2.0-10	<1		🟩				
	Colwell Phosphorus	mg/kg	15-25	15		🟩	🟩	🟩		
	DGT-P	µg/L	67.0-100	54.0		🟩	🟩			
	PBI + Col P		35.0-70.0	32.0		🟩	🟩			
	KCl Sulfur (S)	mg/kg	4.0-10	4.4		🟩	🟩	🟩		
Exchangeable cations	Calcium (Ca) - AmmAc	mg/kg	600-1500	1170	5.83	🟩	🟩	🟩		
	Magnesium (Mg) - AmmAc	mg/kg	60.0-180	147	1.21	🟩	🟩	🟩		
	Potassium (K) - AmmAc	mg/kg	80.0-150	447	1.14	🟩	🟩	🟩	🟩	
	Sodium (Na) - AmmAc	mg/kg	15.0-120	14.0	0.0610	🟩	🟩			
	Exchangeable aluminium	cmol/kg	0.10-0.35	<0.02		🟩				
	Exchangeable hydrogen	cmol/kg	0.10-0.35	<0.02		🟩				
Trace Elements	Boron	mg/kg	0.50-2.0	0.58		🟩	🟩	🟩		
	Iron (Fe)	mg/kg	10-70	9.2		🟩	🟩			
	Manganese (Mn)	mg/kg	1.0-10	5.2		🟩	🟩	🟩		
	Copper (Cu)	mg/kg	0.30-1.0	0.68		🟩	🟩	🟩		
	Zinc (Zn)	mg/kg	0.30-1.0	0.70		🟩	🟩	🟩		
Salt	Salinity EC 1:5	dS/m	0.025-0.60	0.085		🟩	🟩	🟩		
	Ece	dS/m	0.10-6.0	1.2		🟩	🟩	🟩		
Ratios	Ca:Mg Ratio		2.0-8.0	4.8		🟩	🟩	🟩		
	K:Mg Ratio		0.10-0.50	0.95		🟩	🟩	🟩	🟩	

		Unit	Desired Level	Level Found
Exch. cation %	Calcium	%	60.0-80.0	70.7
	Magnesium	%	10.0-20.0	14.6
	Potassium	%	3.00-8.00	13.9
	Sodium	%	0.500-6.00	0.700
	Aluminium	%	0.500-10.0	0.00
	Hydrogen	%	0.500-5.00	0.00

NOTE: Apal Laboratory will review published literature for crop desired levels, and reserves the right to make changes to this information in test reports as and when these reviews are conducted.

Appendix B. APAL soil analysis results for 10-40cm



SOIL ANALYSIS

Agent: YP AG
Agent Address: 2 Kennett Street,
KADINA, SA, 5554
Client: YPAG Contract Trials
Test Set or Quotation: DS10
Barcode: 110587996
Batch Number: 18425
Submission ID: 55478

Report Date: 03/08/2020
Sampling Date: 15/07/2020
Date Received: 27/07/2020
Sample Name: UNFS Wheat Micronutrients-Wheat
Crop: Wheat
Sample Depth: 10-40
GPS Start: -32.86260407359, 137.97295191516
GPS End: NA

		Unit	Desired Level	Level Found	c.mol/kg
	MIR - Aus Soil Texture			Loam	
	ECEC	cmol/kg	5.00-25.0	23.7	
	pH 1:5 water	pH units	6.50-7.50	8.37	
	pH CaCl2 (following 4A1)	pH units	5.50-6.50	7.76	
Extractable N-P-K-S	Nitrate - N (2M KCl)	mg/kg	10-50	4.7	
	Ammonium - N (2M KCl)	mg/kg	2.0-10	<1	
	KCl Sulfur (S)	mg/kg	4.0-10	5.0	
Exchangeable cations	Calcium (Ca) - AmmAc	mg/kg	600-1500	4150	20.7
	Magnesium (Mg) - AmmAc	mg/kg	60.0-180	218	1.79
	Potassium (K) - AmmAc	mg/kg	80.0-150	413	1.06
	Sodium (Na) - AmmAc	mg/kg	15.0-120	27.7	0.120
	Exchangeable aluminium	cmol/kg	0.10-0.35	<0.02	
	Exchangeable hydrogen	cmol/kg	0.10-0.35	<0.02	
Trace Elements	Boron	mg/kg	0.50-2.0	0.87	
Salt	Chloride	mg/kg	15-400	<5	
	Salinity EC 1:5	dS/m	0.025-0.60	0.11	
	Ece	dS/m	0.10-6.0	1.1	
Ratios	Ca:Mg Ratio		2.0-8.0	12	
	K:Mg Ratio		0.10-0.50	0.59	

		Unit	Desired Level	Level Found
Exch. cation %	Calcium	%	60.0-80.0	87.4
	Magnesium	%	10.0-20.0	7.60
	Potassium	%	3.00-8.00	4.50
	Sodium	%	0.500-6.00	0.500
	Aluminium	%	0.500-10.0	0.00
	Hydrogen	%	0.500-5.00	0.00

NOTE: Apal Laboratory will review published literature for crop desired levels, and reserves the right to make changes to this information in test reports as and when these reviews are conducted.

Appendix C. Formulations of applied treatments

Number	Treatment	Cost/ha	Rate	Timing	Nutrient applied (gai/ha)					
1	Untreated	0			Zn	Mn	Mo	Mg	Fe	K
2	Signature Zinc	$7.30	2L/ha	GS21	160					
3	Signature Zinc	$2.75	0.75L/ha	GS21	60					
4	Signature Copper	$13.80	3L/ha	GS21						
5	Signature Copper	$5.50	1.2L/ha	GS21						
6	Zinc Oxide	$1.15	0.1L/ha	GS21	65					
7	Zinc Oxide x 2	$2.30	0.1L/ha x 2	GS21 + GS37	130					
8	Zinc Oxide	$11.15	1L/ha	GS21	650					
9	Signature Copper	$13.80	3L/ha	GS37						
10	Copper Oxide	$5.50	0.12L/ha	GS21						
11	Signature Copper + Signature Zinc	$21.10	3L/ha + 2L/ha	GS21	160					
12	Molybdomen	$4.80	300ml/ha	GS21			30			
13	Ezyflo Trace	$15	1L/ha	GS21	200	240	0.1	40	3	
14	ZMC 341	$14.60	4Lha	GS21	120	40				
15	Signature Iron	$7.20	2L/ha	GS21					100	
16	Signature Potassium	$11.10	3L/ha	GS21						540

Micronutrient Trial – Zinc and Molybdenum in Lentils at Baroota in the Upper North

Author: Jonathon Mudge

Funded By: South Australian Grain Industry Trust (UNF117)

Project Title: Increasing the knowledge and understanding of micronutrient deficiency in the Upper North
Project Duration: 2017-2021
Project Delivery Organisations: Upper North Farming Systems, YPAG

Key Points

- Clear visual differences seen throughout the trial following the early applications – particular response to Molybdenum application
- Yield and NDVI showed no significant difference to the untreated control. Trend lines showed correlations between yield and NDVI
- Nodulation and Nitrogen uptake were shown to increase with certain treatments. The nodulation in the split and late applications of Molybdenum and Zinc Oxide were statistically equal and higher than other treatments.
- Further investigation into Molybdenum applications and its correlation with yield would be recommended

Background

Following on from previous UNFS micronutrient trials (2017-2019), the purpose of this study was to assess the benefits of the application of various micronutrients, in particular Molybdenum, to a pulse crop (lentils) at different rates and timings, furthermore, to identify effects of different formulations for each specific nutrient. The aim of this trial was to identify whether Molybdenum and other micronutrient products can be better utilised to maximise potential yield.

Methodology

This study was a randomised block design plot trial with 5 treatments on the lentil cultivar Jumbo 2. There were 3 replicates with plots of 10m x 2m.

Table 1. Treatment list and protocols

Number	Treatment	Rate	Timing
1	Untreated		
2	Molybdomen	300ml/ha	Early
3	Molybdomen	150ml/ha + 150ml/ha	Early + Late
4	Molybdomen	150ml/ha	Late
5	Molybdomen	300ml/ha	Late
6	Zinc Oxide	100ml/ha	Early
7	Zinc Oxide	100ml/ha	Late
8	Zinc Oxide + Molybdomen	200ml/ha + 500ml/ha	Early
9	Zinc Oxide + Molybdomen	200ml/ha + 500ml/ha	Late

Table 2. Chronology of events

Application/Assessment	Date
Jumbo 2 lentils sown by grower @ 50kg/ha + 80kg/ha Granulock SS	7th May
Pre-emergent: 1L/ha Propyzamide	7th May
Early Treatments: GSV4-V5	17th June
Post-emergent: 500ml/ha Select Xtra	20nd June
28AA1 Assessment, Nodule counts & Tissue Tests	14th July
56DAA1 Assessments & Late Treatments (pre-podding)	10th August
Harvest (plot harvester)	5th November

Results and Discussion

Due to large variances in yield and crop growth across reps, there was no significant differences in lentil yield of this trial however there is a clear upwards trend in yield when Molybdenum was applied. Further investigation into Molybdenum application and its effect on yield would be recommended. This investigation would also follow the NDVI data obtained where both the 28DAA and 56DAA assessments both showed the similar upwards trend to the yield. The protein results analysed from grain samples (Table 3) show no trends for Molybdenum or zinc applications to protein content.

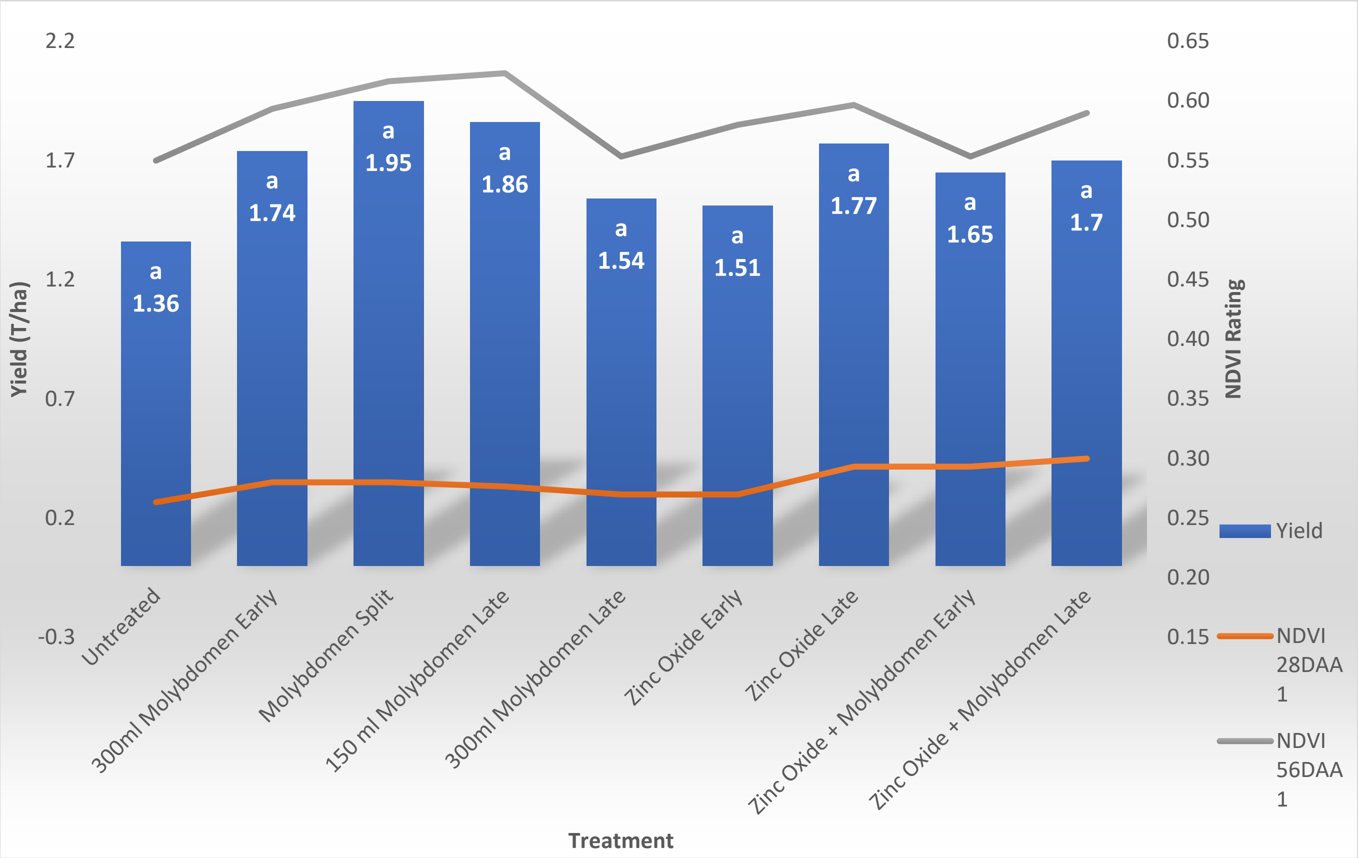


Figure 1. Yield and NDVI assessment chart for each treatment

Table 3. Full yield and assessment results

Number	Treatment	NDVI28DAA1		NDVI56DAA1		Nodule Counts		Protein	Yield	
1	Untreated	0.26	a	0.55	a	10.93	b	23.69	1.36	a
2	300ml Molybdomen Early	0.28	a	0.59	a	9.00	b	22.63	1.74	a
3	Molybdomen Split	0.28	a	0.62	a	17.00	a	22.63	1.95	a
4	150 ml Molybdomen Late	0.28	a	0.62	a	11.07	b	23.00	1.86	a
5	300ml Molybdomen Late	0.27	a	0.55	a	13.87	ab	21.73	1.54	a
6	Zinc Oxide Early	0.27	a	0.58	a	10.73	b	22.47	1.51	a
7	Zinc Oxide Late	0.29	a	0.60	a	14.53	ab	22.63	1.77	a
8	Zinc Oxide + Molybdomen Early	0.29	a	0.55	a	11.00	b	23.06	1.65	a
9	Zinc Oxide + Molybdomen Late	0.30	a	0.59	a	11.00	b	22.95	1.7	a

Nodule counts show variation (Table 3) across treatments, however, there is no difference between Molybdenum rates. There was a significant increase with the late application and split rate suggesting early applications are unable to be utilised by the plants as effectively.

Table 4. Tissue test results of early treatment applications

Number	Treatment	N	S	P	K	Mg	Ca	Na	Cl
1	Untreated	3.84	0.23	0.41	1.97	0.24	0.54	0.018	0.27
2	300ml Molybdomen Early	4.28	0.24	0.42	2.04	0.24	0.53	0.017	0.28
3	Molybdomen Split	4.36	0.23	0.4	1.95	0.24	0.56	0.016	0.25
4	150 ml Molybdomen Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	300ml Molybdomen Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	Zinc Oxide Early	3.76	0.23	0.4	1.93	0.23	0.52	0.018	0.27
7	Zinc Oxide Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Zinc Oxide + Molybdomen Early	4.27	0.24	0.42	1.94	0.23	0.54	0.017	0.24
9	Zinc Oxide + Molybdomen Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Number	Treatment	Fe	Al	Mn	B	Cu	Zn	Co	Mo
1	Untreated	450	450	130	15	5.2	40	0.68	<0.4
2	300ml Molybdomen Early	460	480	130	15	5.9	41	0.67	0.58
3	Molybdomen Split	470	440	120	14	5.4	38	0.72	<0.4
4	150 ml Molybdomen Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	300ml Molybdomen Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	Zinc Oxide Early	540	510	110	14	5.5	42	0.78	<0.4
7	Zinc Oxide Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Zinc Oxide + Molybdomen Early	570	560	130	14	5.8	49	0.78	1.2
9	Zinc Oxide + Molybdomen Late	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

* Late treatments were applied; however late plant tissue tests could not be undertaken due to earlier than expected haying off of the crop.

The tissue test results (Table 4) suggest that there is a definite response of nitrogen uptake by the plant following a Molybdenum application as well as the increased level of Molybdenum itself in these treatments. These results also show an apparent response to various other nutrients when Zinc was applied including Iron, Aluminium and Cobalt.

This research shows the potential of molybdenum in the nitrogen fixation process in pulses and to these fertiliser applications. Further research into the effect of molybdenum applications at differing rates (and product types) would be recommended.

Acknowledgements

- Project Funded by SAGIT
- Wilchem – micronutrient product supply
- YPAG – trial spraying, assessment, and harvest equipment
- Alex Burbury (YPAG) – Statistical analysis via ARM
- APAL – Protein analysis data
- Sandalwood Ag – land use and sowing of trial

Final Technical Report

Surveys and associated diagnostics of the incidence and severity of diseases of cereals and pulses in the Southern Region (South Australia).

Project code: UOA2007-006RTX

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22/03/2021

Location

The locations of the 39 bread wheat, 23 barley, 11 chickpea, nine faba bean, ten field pea and ten lentil paddocks surveyed for foliar disease in South Australia in 2020 are shown in Figure 1. The details of these paddocks are stored at SARDI on a network drive as specified in the project IP Register.

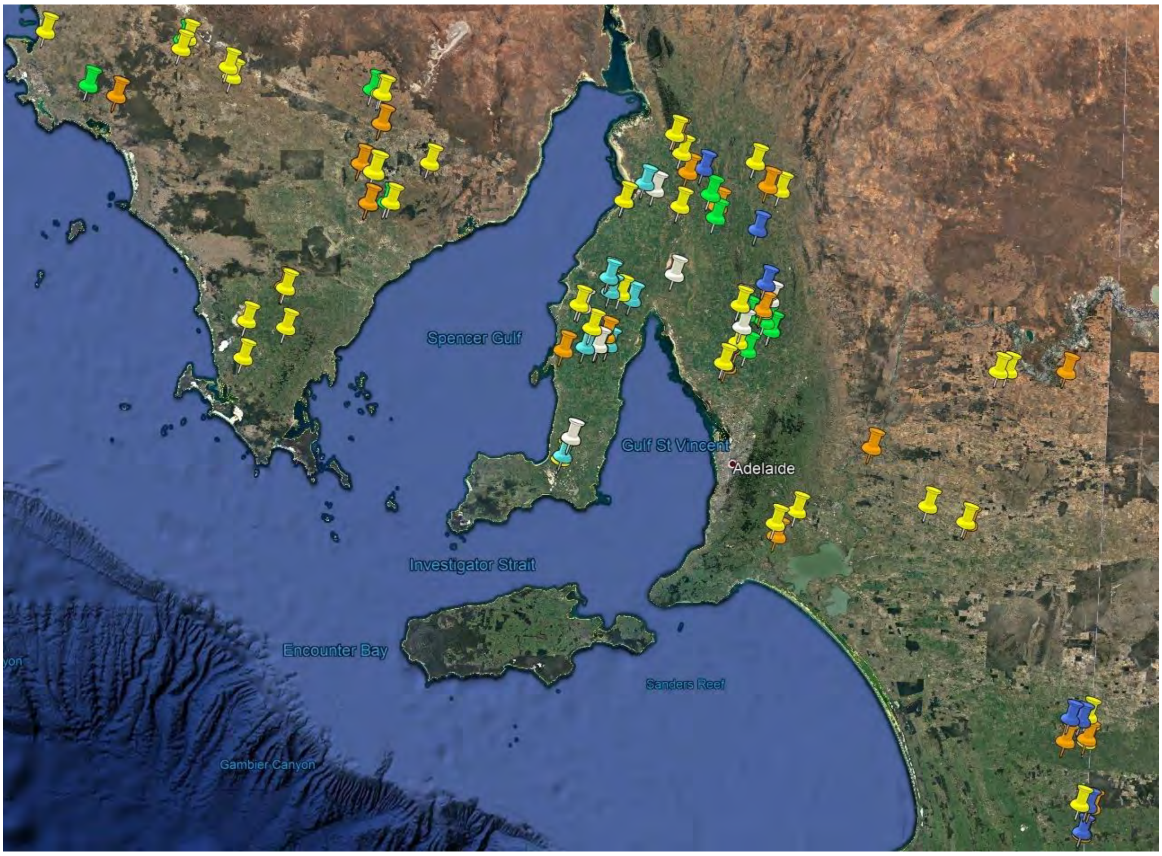

Figure 1. Location of bread wheat (yellow pins), barley (orange pins), chickpea (white pins), faba bean (dark blue pins), field pea (green pins) and lentil (pale blue pins) crops inspected for selected endemic and exotic leaf diseases in South Australia in 2020.

Executive Summary

The objectives of this project were to conduct a structured survey of cereal and pulse crops in South Australia (SA) to quantify disease prevalence and distribution of endemic leaf diseases and to detect and record notifiable exotic diseases of high priority. This project permitted the monitoring of disease epidemics including the distribution of pathogens and severity of disease expression. This information will guide priorities for continued research and to ensure that breeding efforts are targeted at priority and/or changing pathogen populations. Integrated disease management decisions can also be enhanced by gathering associated farming systems information to help determine the success of current recommended strategies. Importantly, the project also supports claims to export markets that SA cereal and pulse grain is free from notifiable high priority exotic plant pests.

A survey of 100 crops of cereals (n=60) and pulses (n=40) was conducted in spring 2020 across the five main growing regions in SA: Eyre Peninsula (EP), Yorke Peninsula (YP), lower-mid-upper North (L-M-U N), Mallee, and upper-lower South East (U-L SE). Crop numbers per region were based on the area sown in 2019 of each crop type per region. To select paddocks, a comprehensive list of agronomists and independent consultants was compiled then a stratified random sampling approach was applied. Additional data were collected including GPS coordinates of paddock, sowing date, crop type and variety for the 2020 season, as well as three-year paddock history of crop and cultivar. Fungicide application products and timing for the 2020 season was also sought to assist in interpreting the disease data.

100 plants were sampled per paddock and transferred to the laboratory for disease rating. Biosecurity protocols for both person and vehicle were followed to ensure no transfer of pests, weeds or diseases from one paddock to the next. Each sample (100 plants per crop) was assessed for disease incidence (presence/absence) of the major endemic diseases per crop type and of five selected high priority exotic plant diseases. Disease severity of each of the leaf diseases was assessed using either percent leaf area diseased for the upper two leaves in cereals, or percent whole plant area diseased for pulse crops.

Overall, the level of visual foliar disease identified was generally low in both cereal and pulse crops with disease expression at levels unlikely to cause significant yield loss. This low level of disease was likely due to the contribution of fungicide applications, where most crops received at least one or two foliar fungicide applications, along with the dry climatic conditions in June and July. For cereal samples, 90 percent of samples examined had visual symptoms of one to five fungal pathogens on upper leaves and/or heads. For pulses, at least one foliar disease was observed in 73 per cent of the samples. None of the targeted high priority notifiable exotic diseases were detected.

In wheat, Septoria tritici blotch was found in 53 per cent of samples. Yellow leaf spot, powdery mildew, stripe rust and leaf rust were present in 15 per cent or fewer samples. Stripe rust was at levels likely to cause significant yield loss in two paddocks surveyed from the South East, where the disease was difficult to manage in the 2020 season. In barley, the widespread incidence of net form net blotch (43 per cent) is a concern given the potential for severe damage and increasing fungicide resistance. Spot form net blotch was found in 74 per cent of samples and sowing susceptible varieties should be avoided in future seasons.

For pulses, ascochyta blight in the chickpea, faba bean and lentil paddocks surveyed was very low, including some completely free of disease. However in field pea, all plants in all paddocks showed ascochyta blight (syn. blackspot) symptoms varying from low to high level of disease. Low levels of downy mildew were also detected in some paddocks however reports of this disease were widespread earlier in the season. No bacterial blight on field pea was found during the survey although reports of this disease were received during the season. Chocolate spot was found only in the four faba bean paddocks in the South East, with moderately high levels of disease in two paddocks associated with mistimed fungicide sprays. Disease levels in these two paddocks would have affected grain yield and or quality. Further research on timing of fungicide application for chocolate spot control would be of great benefit the industry.

Industry benefits from this project through the disease management priorities and guidelines that will be informed by the recently collected information. This will assist growers and researchers to stay

abreast of developing issues and guide the year-to-year tactical response as well as longer term strategic needs of industry. Additionally, the surveys provided the opportunity to improve survey protocols and upskill staff in disease identification, with a particular emphasis on the identification of exotic diseases. Importantly, the high priority pest (absence of exotic disease) data collected in this survey will be delivered to BiosecuritySA as a record of exotic disease monitoring showing that none of the five exotic diseases targeted in this project were found in SA.

As this information is of great benefit to industry and for Australian grain trade, it is recommended that structured surveys of broadacre grain disease in future seasons continue especially as the 2020 season for most regions was characterised by a drier winter period and low levels of disease. Due to the intensive nature of sampling (particularly travel time), surveying for root diseases using molecular techniques would add great value to the survey data set as plant samples are already collected and scored back at the laboratory. A more strategic approach targeting more paddocks of fewer crop types in any one survey year would ensure a more comprehensive data set is collected; one that is more representative of each region and state. A suggested approach is increased sampling conducted on the crops with the high priority plant pest of most concern or interest to South Australia and Australia more broadly. Furthermore, it is recommended that future surveys are not constrained to just the spring period where some diseases may not be expressed; for example, cercospora leaf spot of faba bean typically initiates in early-mid winter but may not be observable by spring. Whilst state biosecurity restrictions and trespass laws prevent ad-hoc surveys of growers paddocks without permission, the flexibility to survey additional paddocks en route to other paddocks or field trials would greatly increase the data set available to contribute to area freedom and understanding of regional disease epidemics.

The full technical report can be found at: https://unfs.com.au/other-resources/

Sheep Technology Group – UNFS Project 237

Author: Rachel Trengove, Project Officer, UNFS
Funded By: SA Red Meat and Wool Growth Program, PIRSA
Project Title: Producer Technology Group
Project Duration: *July 2020 - March 2022*
Project Delivery Organisation: *UNFS*

Background

Upper North Farming Systems (UNFS) was successful in acquiring funding to run a Producer Technology Group through the SA Red Meat and Wool Growth Program. The group will meet four times over an 18 month period, with the format, content and delivery of the group's activities tailored to suit group members' knowledge and skills.

Producer Technology Groups aim to:

- Explore and share experiences and knowledge on ways that precision livestock management technologies can be used in red meat and wool production.
- Learn from experts on how technologies could assist you to improve productivity, efficiency and profitability in your business.
- Support sheep producer members to implement and apply technology to improve productivity and profitability.

The project started in July 2020. The UNFS Sheep Technology Group is led by facilitator Rachel Trengove and started with a core group of ten who designed a delivery plan of four workshops with four themes. The plan for the group was then circulated to all UNFS members and has attracted 28 members committed to the group. The first workshop was held on Tuesday 29th September 2020 at the Blacksmith Chatter, Orroroo, 18 attended, details of Workshop 1 are below.

Workshop 1. Paddock to Plate – Sheep Meat Quality

Daniel Schuppan, Livestock consultant, Nutrien Ag Solutions Jamestown, facilitated the morning and introduced livestock management technologies available and how we can use them to make commercial decisions to better our bottom line.

We discussed what group members would like to achieve from the four sessions and identified areas of interest and knowledge gaps, some goals were set and the idea of making a brief technology plan for members' livestock enterprise was introduced.

Presenters for the day:

1. Presentation (virtual) from the **NSW DPI Red Meat and Sheep Development team at Cowra, Dr Ben Holman and Steph Fowler**: Development of technologies to measure meat and carcass qualities and sheep meat quality from paddock to plate.
2. Presentation (virtual) from **Elke Hocking, Elke Hocking Consulting**: Genetics and ram selection for meat quality, use of ASBVs, technology to enable sheep carcass feedback, MSA, flock profiling.
3. Presentation from **Dayna Grey, Thomas Foods International**: Maintaining meat quality through the meat supply chain to better satisfy consumer demand, auditing and quality assurance programs in the future.

The delivery plan for the remaining three workshops is below.

Workshop 2. EID and its Applications

a. How to implement an individual animal data collection system.
b. Tools and Technologies available for implementation
c. Return on Investment for technology
d. Pitfalls of application – a farmer panel
e. Decision making across the animal traits for improved overall long-term enterprise profitability – Balancing genetics, weight gains, meat and fleece production.
    I. Genetics and trait identification and management – Michelle Cousins, Cousin Merino Services – Using the data to drive your productivity gains
    II. Elise Bowen (Wagga Wagga – specializes in sheep data management
    III. Visit to farmers already using technologies eg Andrew Kitto, Mark Noonan
    IV. Demonstrations of technologies on farm

Workshop 3. Yards, Shearing sheds and Water Infrastructure – Improving Efficiency in your Sheep Enterprise

a) Yard design, auto drafters, set-ups for pregnancy and condition scanning, animal welfare
b) Shearing shed design, smart sheds, fleece sampling and data recording
c) Water Infrastructure efficiency improvements, bore equipment, flow meters, remote monitoring etc. Tim Stockman Electronics.
d) Rick Llewelyn – virtual fencing – CSIRO researcher in farming systems
e) Visits on farm and demonstrations of technologies

Workshop 4. Feed and Pasture Management, Confinement Feeding Tools and Technology.

a) Improving the precision of your pasture paddock management – Satellite imagery for condition and seasonal variation, in paddock sensors, soil sampling and management, soil moisture probes for decision support. – Tom Moten, Nutrien Jamestown, Jess Koch, Breazy Hill and Ed Scott.
b) Confinement Feeding – mob management to maximise conversion – Deb Scammell, Talking Livestock.

c) Confinement and Feedlot Tools and Technology to ensure efficiency and effective weight gains – Princess Royal Feedlot, Technology demonstrations on regular automatic feed delivery systems, water monitoring, feed quality sampling and ration development.

Workshops will be reassessed and tailored to the group on an ongoing basis, any feedback or suggestions are welcomed, as are new members. There has been interest from the group in running a couple of smaller focus groups additional to the four workshops if funding is sufficient. Firstly, a small group are interested in genome testing and flock profiling and are keen to have support from an expert in interpreting results. Secondly, there is interest in learning more about data management in excel and managing bucket files in a practical, hand-on session with a data management expert for those already using EID's.

More information on the Red Meat and Wool Growth Program can be found at https://www.pir.sa.gov.au/major_programs/growing_sa_livestock_industry

Government of South Australia

Department of Primary Industries and Regions

Regenerating Goyder’s Line Project

Author: Denni Agnew, Engagement Officer, UNFS
Funded By: National Landcare Program – Smart Farms Funding and Northern & Yorke Landscape Board
Project Title: Regenerating Goyders Line – Re-establishing productive and profitable grasslands and shrublands in the degraded, once cropped, landscapes of Goyders Line.
Project Duration: *July 2020 – June 2022*
Project Delivery Organisations: UNFS with support from Greening Australia

Background

The region 100kms in the vicinity of Goyder's Line has long been known as a low rainfall zone with the opportunity for cropping and pastoral operations to be highly profitable in better rainfall years and marginal in low rainfall periods. Significant areas of this region have been cropped in history but are no longer cropped and have been left fallow too long under current native vegetation legislation to be cropped again. The target areas for this project have become scalded, bare, or low-quality grasslands and shrublands with limited biodiversity or ecological function, and marginal production capacity.

Farmers along Goyder's Line are looking for ways to return ecological function, develop productive pastures, maintain soil cover, and increase water infiltration within a production enterprise. They are looking to improve the resilience of their landscape and ensure the long-term viability of their farming enterprise.

Recent drought conditions have increased the awareness of the farming community on the value of increased resilience in the landscape through supporting perennial vegetation and maintenance of soil cover. There is a focus on developing production systems that rehabilitate the landscape, rehydrate the soil profile, and facilitate vegetation succession. Healthy landscapes for healthy communities.

This project aims to:

- Re-establish functional pastures & improve ecological function across the soil profile, water cycle & biological system.
- Trial alternative seeding operations into paddocks which are impacted by the Native Vegetation Legislation (ACT 1991 and Regulations 2017) through demonstrating appropriate approval processes and effective low-cost and low-risk seeding practices.
- Share knowledge and lessons learnt with farmers through extension events and activities.

Activities being undertaken as part of this project include:

- Extensive soil testing – determining appropriate species mix, seeder set-up and ameolioration required to effectively re-establish cover and biomass in the landscape.
- Seed purchase & spreading – to assist with native re-establishment due to degraded local seedbank.
- Application for approval to undertake management actions on land covered by the Native Vegetation Legislation in SA.
- Trial seeding of 5 strips at each site to demonstrate effective management actions.
- Land management plans to assist farmers to ensure seeding outcomes result in long-term pasture, groundcover and soil function to regenerate.

Three project demonstration sites have been established at Mount Bryan East and two near Quorn. Each site is subject to the Native vegetation Act and Regulations as they have not been sown for over 5 years and each site is considered low landscape function with extremely low groundcover levels, high weed plant percentages and compacted and eroded soils. This project is seeking an exemption under the regulations of the Native Vegetation Act. More information on this process can be found here: https://www.environment.sa.gov.au/topics/native-vegetation/legislation-administration

Anne Brown, Greening Australia is undertaking the site vegetation assessments, developing vegetation management plans and the clearance exemption applications for all sites. Once an exemption is granted the sites will be sown at wide spacings with a mix of commercially available seed and a demonstration strip incorporating native plant seed, with advice from UniSA researcher Jack Desbolis. The aim of this planting is to re-establish landscape function and generate biomass, reduce erosion and allow native seed to be trapped with the aim to assisting in its establishment. Longer term site management will create a micro-climate that promotes landscape regeneration through the effective management of biomass and diversity of feed base to maintain year-round feed availability and soil protection.

Extension events at the sites will begin in early 2021 with each site being visited through-out the project.

This project is made possible through the Department of Agriculture, Water and the Environment's National Landcare Program: Smart Farms. It is also supported through extension support from the Northern and Yorke Landscape Board.

Australian Government

National Landcare Programme

LANDSCAPE
SOUTH AUSTRALIA
NORTHERN AND YORKE

Southern Pulse Extension Project
UNFS Project 226

Author: Rachel Trengove, Southern Pulse Extension Project Officer, UNFS
Funded By: Grains Research and Development Corporation
Project Title: GRDC Southern Pulse Extension Project - 9175825
Project Duration: 2017-March 2021
Project Delivery Organisations: Birchip Cropping Group, UNFS

Background

Grain growers have been supported to diversify into pulse crops in non-traditional production areas of Victoria and South Australia through a Grains Research and Development Corporation (GRDC) initiative. The Southern Pulse Extension project is a GRDC investment that aimed 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 was the establishment of twelve “Pulse Check” discussion groups across Victoria and South Australia. The Pulse Check groups have met at least three times a year over the three-year life of the project to discuss issues relating to pulse crop production, management and marketing. Each group has consisted of growers and advisers with varying experience in production of pulses. Those with no or limited experience were particularly encouraged to take advantage of a unique opportunity to learn from more experienced growers in their region and experts in the industry.

Since the commencement of the project, UNFS has hosted three to four pulse check group workshops every year, each attended by 15 - 45 people. Given the diversity of the Upper North region, the meetings have been alternated between the western and eastern sides of the Flinders Ranges. It has provided a great opportunity to access agronomic trials and researchers in the region. The meetings have covered a range of topics, including a post-harvest review for the previous season, paddock selection and other sowing considerations, different types of pulse crops and different varieties, pests, weeds, diseases, and pulse storage and markets.

Pulse Check Group Extension Activities for 2020

Pulse Check meetings for 2020 are listed below including topics covered and attendance:

27th February 2020 – Napperby Tennis Club (25 attendees)

Penny Roberts and Sarah Day from SARDI presented results and findings from the 2019 trials at Warnertown and Willowie including new varieties and recent releases, pulse yield performances, intercropping trials, NVT yield performances, break crop benefits trials and trials in lentil herbicide management and nutrition to promote pulse early vigour. An outline was provided for the proposed 2020 trials for Warnertown and Booleroo Centre trial sites and an opportunity to provide feedback on these plans.

Sam Trengove presented results from his GRDC Sandy Soils impact trials near Warnertown and had some interesting results in grain yield increases in response to deep ripping.
Stefan Schmidt talked us through his trials in the Lower Broughton region – Vetch variety performance on challenging soils & response to grazing and Alternative herbicide options in vetch.
Richard Saunders from Rural Directions ran through the @RISK model using a local Upper North famer’s data to assess and show the risks and net profit associated with multiple rotational sequences over 3 to 6 years. Rotations were tested for sequence, duration and crop type including pulses.
The meeting was followed by the Nelshaby Ag Bureau “sticky beak day”.

28th August 2020 – SARDI trial site – Warnertown (42 attendees)
SARDI researchers Penny Roberts, Navneet Aggarwal and Dylan Bruce led a crop walk through the Warnertown trial site discussing intercropping and early sown pulses, as well as showcasing a range of pulse research and validation trials.
A videographer recorded the presentations and discussion from the crop walk for those who could not attend as part of COVID management. Videos were posted on YouTube on UNFS website.

24th September 2020 (16 attendees)
Matt Foulis, Northern Ag and Daniel Hillebrand, YP Ag led a crop walk through the SARDI trials at Fullerville. Trials included intercropping with oilseeds, Gibberellic Acid in vetch, lentil and vetch seeding for alternative end uses, faba bean canopy management, low rainfall disease validation.
Larn McMurray, Global Grain Genetics, presented on future opportunities for pulse varieties in low rainfall areas and pulse herbicide tolerance.
A videographer recorded the presentations and discussion from the crop walk for those who could not attend as part of COVID management. Videos were posted on YouTube on UNFS website.

Conclusion

The Southern Pulse Extension Project finished at the end of March 2021. We will have two meetings before this date. One will be a wrap up of trial results with SARDI researchers presenting as well as a private consultant with significant pulse growing experience and expertise. The final meeting will be an overnight bus tour to the Lower North – ideas for this include AGT plant breeding, Dublin Clean Grain, Adelaide University, Roseworthy campus and onto Waite for a tour of the plant breeding and research centre. This bus tour was planned for springtime 2020 but did not go ahead due to COVID restrictions at the time. A full wrap up of the project outcomes will be include in the 2021 Annual Compendium.

Dryland Legume Pasture Systems: evaluation of spineless burr medics

Fiona Tomney[1], David Peck[2], Jeff Hill[2], Neil King[1], Ian Richter[1] and Ross Ballard[2]
[1]SARDI Minnipa Agricultural Centre, [2]SARDI, Waite

Location
Minnipa Agricultural Centre
paddock N7
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2020 Total: 367 mm
2020 GSR: 255 mm
Paddock history
2019: Spartacus CL barley
2018: Scepter wheat
2917: Canola
Soil type
Red sandy loam
Plot size
5 m x 1.7 m x 4 reps x 25.5 cm row spacing

Key messages

- **Several boron tolerant lines showed promise as future cultivars.**
- **Some of the RLEM tolerant lines also showed promise as a future cultivar.**
- **Although included as a control, the performance of PM-250 strand medic was outstanding in 2020.**

Why do the trial?

Annual medics provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens, improve fertility through nitrogen (N) fixation, and mixed farms have reduced economic risk compared to continuous cropping or livestock farming systems. The most widely grown species of medics are barrel, strand and spineless burr medics. High levels of boron (B) in the subsoil is a constraint to plant production. Boron tolerant barrel and strand medic cultivars exist but current spineless burr medic cultivars are susceptible to high levels of B (see EPFSS 2019, p 219). A cohort of B tolerant spineless burr medics have been developed at Minnipa (Peck *et al*. p 189). Red legged earth mite (RLEM) is a common pest of germinating annual pastures and current cultivars are susceptible. This trial reports on the performance of breeders' lines of spineless burr medics relative to current cultivars; some lines of barrel, strand and disc medics were also included as controls.

How was it done?

The trial at Minnipa Agricultural Centre in paddock N7 was arranged in a fully randomised block design with four replications.

Forty medic entries were sown comprising breeding lines of spineless burr medic, the B-parent, current spineless burr medic cultivars Cavalier and Scimitar, Sultan-SU barrel medic, PM-250 strand medic and Toreador disc medic.

The trial was sown on 18 May 2020 into moist soil. Plant emergence counts were completed on 6 July. GreenSeeker measurements were taken on 26 August, 4 September and 19 October. Plots were scored for vigour on 4 September. Twenty four of the forty lines were selected for seed yield assessment. Seed was vacuum harvested from two x 0.10 m^2 quadrats per plot to measure seed yield.

What happened?

The season opened in late April with 25 mm of rainfall, enabling the trial to be sown into moist soil on 18 May 2020. Unfortunately, the rainfall for May, June and July was more than 50% below average, resulting in slow pasture establishment and growth (Table 1). August then received above average rainfall with October receiving more than double its average rainfall. This spring rainfall provided a significant boost in the growth of most of the medic species and enabled them to stay greener for longer than would be expected in a typical season, despite them already having flowered and set seed pods.

The boron tolerant parent line, and the cultivars Cavalier and Scimitar all established and grew well throughout the season, setting levels of seed that are considered adequate for regeneration. The boron tolerant parent had similar agronomic performance to the burr medic cultivars, with seed production equivalent to Scimitar. This suggests that the boron tolerant gene is not linked to negative agronomic traits that would need to be overcome with further breeding.

DL18 was the most promising of the boron tolerant lines, with growth throughout the season as good as the both the B parent and the cultivars. It also had a high pod yield (1462 kg/ha). DL17 also showed promise with good growth and a high pod yield (1234 kg/ha).

DL67 was the most promising of the RLEM lines with growth and seed set similar to the current burr cultivars.

Table 1. Plant density, green seeker scores, vigour scores and seed pod yields at Minnipa, 2020.

Pasture Legume Species		Plant density (plants/m^2) 6 July	Green seeker (NDVI) 26 Aug	Green seeker (NDVI) 4 Sept	Vigour score (0-10) 4 Sept	Green seeker (NDVI) 19 Oct	Seed pod yield (kg/ha)
Boron parent burr medic	Boron tolerant line	60	0.23 c	0.29 bc	7.3	0.31 bc	1132 cd
Cavalier burr medic	Boron susceptible cultivar	69	0.26 bc	0.31 bc	7.6	0.30 bc	782 d
Scimitar burr medic	Boron susceptible cultivar	77	0.33 bc	0.40 ab	7.8	0.32 bc	1135 cd
DL03 burr medic	Boron line	86	0.23 bc	0.26 bc	7.4	0.25 c	855 cd
DL04 burr medic	Boron line	75	0.20 d	0.26 bc	6.8	0.25 c	859 cd
DL06 burr medic	Boron line	73	0.25 bc	0.29 bc	7.5	0.30 bc	882 cd
DL07 burr medic	Boron line	70	0.21 d	0.25 bc	7.3	0.33 bc	1102 cd
DL08 burr medic	Boron line	80	0.25 bc	0.30 bc	7.6	0.28 bc	922 cd
DL10 burr medic	Boron line	63	0.31 bc	0.35 b	7.5	0.32 bc	1048 cd
DL11 burr medic	Boron line	61	0.29 bc	0.34 bc	7.0	0.34 bc	1162 c
DL12 burr medic	Boron line	68	0.24 bc	0.31 bc	7.4	0.34 b	883 cd
DL14 burr medic	Boron line	65	0.28 bc	0.28 bc	7.4	0.28 bc	957 cd
DL15 burr medic	Boron line	90	0.32 bc	0.36 ab	7.9	0.30 bc	907 cd
DL17 burr medic	Boron line	57	0.24 bc	0.24 c	7.0	0.31 bc	1234 bc
DL18 burr medic	Boron line	71	0.34 b	0.37 ab	7.4	0.34 b	1462 bc
DL19 burr medic	Boron line	72	0.21 d	0.28 bc	7.3	0.28 c	862 cd
DL67 burr medic	RLEM line	74	0.27 bc	0.33 bc	7.4	0.33 bc	1038 cd
DL73 burr medic	RLEM line	69	0.30 bc	0.36 ab	7.6	0.31 bc	734 d
DL76 burr medic	RLEM line	51	0.25 bc	0.25 bc	7.4	0.27 c	573 de
DL78 burr medic	RLEM line	73	0.29 bc	0.33 bc	7.6	0.23 c	793 cd
DL79 burr medic	RLEM line	51	0.25 bc	0.27 bc	7.5	0.27 c	931 cd
Sultan-SU barrel medic	Control	67	0.29 bc	0.30 bc	7.6	0.25 c	1560 ab
PM-250 strand medic	Control	91	0.45 a	0.47 a	9.0	0.41 a	1937 a
Tornafield disc medic	Control	74	0.29 bc	0.33 bc	7.5	0.23 c	298 e
LSD (P=0.05)		-	*0.11*	*0.10*	-	*0.06*	*0.38*

Sultan-SU barrel medic grew well and despite senescing earlier in the season than the spineless burr medics, had a high pod yield of 1560 kg/ha.

PM-250 strand medic had the highest GreenSeeker readings and vigour score and a seed pod yield of 1937 kg/ha. Although there were no quantitative measurements of biomass, the growth of PM-250 was visibly greater than that of the other medics and it could be easily recognised in each of the four replications of forty plots throughout the season, even after it had fully senesced.

Tornafield disc medic grew reasonably well throughout the season but set the lowest amount of seed with only 298 kg/ha of seed pods. Disc medics are specifically adapted to grow in sandy soils, rather than the red sandy loam in this trial, which may explain the low seed pod yield.

Table 1 reports pod yields collected through vacuum harvesting. Seed yields are yet to be measured, however typically seed yields are 50% of the pod yield for burr medics, 30% for strands, 25% for barrels and 40% for disc medics.

What does this mean?

The overall aim of this trial is to develop new spineless burr medic cultivar(s). There are promising lines in both the boron tolerant and RLEM resistant cohorts. The results of this trial will be reviewed along with the performance of the lines in trials at Roseworthy, WA and NSW. This evaluation is not complete and further trials are planned for 2021.

In 2021 the regeneration of the breeding lines will be assessed.

Acknowledgements

This project is supported by funding from the Australian Government Department of Agriculture Water and Environment 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: Minnipa grazing trial

Morgan McCallum[1], Jessica Gunn[1], Ross Ballard[2], David Peck[2]

[1]SARDI Minnipa Agricultural Centre, [2]SARDI Waite

Location
Minnipa Agricultural Centre
paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2020 Total: 367 mm
2020 GSR: 255 mm
Paddock history
2019: Various legume species or Scepter wheat
2018: Various legume species or Scepter wheat
2017: Scepter wheat
2016: Medic pasture
Soil type
Red sandy loam
Soil test
$\text{pH}_{(H20)}$ (0-10 cm) 8.4
Plot size
2 ha x 3 reps

Key messages

- **Wheat grown on previous medic and alternative legume plots showed good grain protein results.**
- **Grain yield was not significantly different following various pastures but there were significant differences in grain protein.**

Why do the trial?

In southern Australian low to medium rainfall 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 crops in the rotation. Included are widely grown legumes (strand medics and vetch) and legumes with reasonable prospects of commercialisation (trigonella).

A five-year grazing and cropping system trial were established at the Minnipa Agricultural Centre (MAC) in 2018 (EPFS Summary 2019, p 222). 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, measuring pasture production, legume seed bank dynamics and animal and crop benefits from different pasture species was established in paddock South 8 at MAC in 2018. The trial consists of six treatments arranged in a randomised block design with three replications. The treatments are: Scepter wheat (Control 1); Volga vetch (Control 2), locally sourced Harbinger strand medic; PM-250 strand medic with powdery mildew resistance and tolerance to SU herbicide and intervix residues; SARDI rose clover; and Trigonella balansae, a new aerial-seeded legume closely related to medic. Each ‘plot’ is two hectares in size and was established to allow grazing during pasture phases and on stubbles after harvest in cropping years.

The planned rotational sequence for the five-year large-scale grazing trial aims to replicate current low to medium rainfall mixed farming practices, but also give novel pasture legumes the opportunity to successfully establish into the current system. Pastures were established in 2018 with the aim of maximising seed set, followed by pasture regeneration in 2019, a wheat crop in 2020, with a pasture regenerative phase in 2021.

In 2020 sowing occurred on the 13 May with the whole trial sown to Razor CL wheat at a sowing rate of 70 kg/ha and 50 kg/ha Granuloc Z. Soil sampling for nutrition, nitrogen and soil borne disease testing was completed on 30 March. The total rainfall for Minnipa this year was 367 mm with 255 mm falling within the growing season. The total rainfall for May was 20 mm which gave the trial a good start to the season. Plant emergence was measured on 6 June with all treatments showing good emergence. Ground cover (NDVI) was estimated using GreenSeeker commencing on 14 July (Figure 1, T1) and was repeated fortnightly until the crop started to ripen, with the last measurement on 9 September (Figure 1, T5). Grain was harvested with a small plot header on 18 November. Stubble cuts were collected after harvest and prior to grazing on 18 December and the sheep were put onto the trial to graze the wheat stubbles on 7 January 2021. Results for both of these measurements are yet to be analysed.

What happened?

Prior to sowing the wheat crop in 2020, the wheat treatment had the highest rhizoctonia level and the available soil N was at the lowest end of the treatment range (Table 1). There was no effect of treatment on wheat establishment density. Whilst there were treatment effects on wheat root health, they did not correspond to earlier differences in rhizoctonia level in the soil.

Table 1. Pre-sowing measures of soil N (0-60 cm) and Rhizoctonia AG8 levels, wheat establishment and wheat root health (0 = no damage).

2019 treatment	Available soil N (kg/ha)	AG8 Rhizoctonia (pg DNA/g)	Wheat establishment (plants/m^2)	Wheat root health (0 - 5)*
Control (Scepter wheat)	124	107	78	2.2
Volga vetch	200	1	75	2.2
Harbinger strand medic	190	49	75	2.8
PM-250 strand medic	164	94	74	2.6
Trigonella balansae	210	49	72	2.8
SARDI rose clover	175	7	75	2.5
LSD (P=0.05)	*ns*	*21*	*ns*	*0.5*

** 0=healthy root, 5=severely damaged roots.*

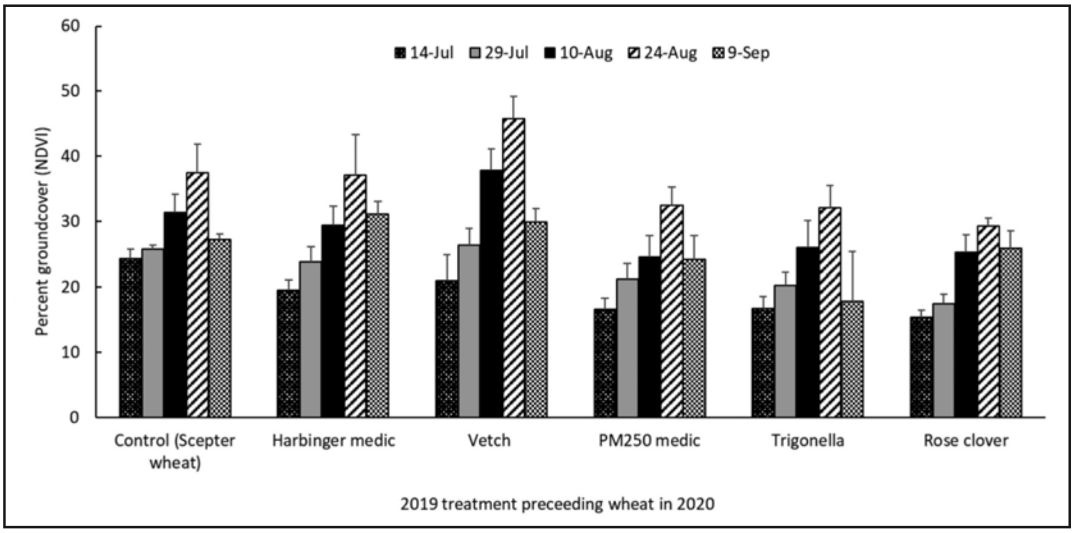

Figure 1. Percentage groundcover (NDVI Greenseeker) results for Razor CL wheat in 2020.

Ground cover (NDVI) when first measured on 14 July ranged from 24% for continuous wheat to 15% for the rose clover treatment (ns *P=0.12*). By the fourth assessment, NDVI of the pasture and continuous wheat treatments ranged from 29 to 37%, but had increased to 46% in the vetch treatment (*ns P=0.13*) (Figure 1).

There were significant differences across all six treatments for protein, test weight and screenings. The control continuous wheat showed results that were expected from a continuous cereal copping cycle (Table 2). The wheat grown following pastures generally had higher protein percentage and test weight and lower percentage screenings.

What does this mean?

In 2018, Harbinger strand medic and Volga vetch had the highest ground cover and highest early vigour (data not shown). They also had less weeds throughout the plots, which would have influenced the high yields observed this year due to less crop competition for moisture in the first year of the trial and less weeds also in 2019 and 2020. Harbinger strand medic also had a high plant density in 2019, resulting in a more productive plot for the cereal phase of the trial. In 2020 it was observed that wheat grown on the previous Volga vetch treatment emerged first, which correlates back to the ground cover and plant density results from 2018 and 2019 as this would establish good soil health for the wheat crop 2020. In 2019 trigonella, Harbinger strand medic and PM-250 fixed the highest percentage of nitrogen contributing to all three treatments producing high protein levels for wheat in 2020.

Ewes born in 2018 grazed the stubbles in early January and they grazed all treatments except the control treatment which is continuous wheat throughout the trial. The main aim of the grazing period is to record sheep weights. The results are yet to be analysed.

In 2021, the pasture treatments will be allowed to regenerate, with the continuous wheat and Volga vetch plots being re-sown. This will allow the legumes sown in 2018 a chance to show their ability to regenerate following a cereal phase. Sheep will graze the plots throughout the growing season and weights will be recorded on and off the trial. The continuous wheat plot will not be grazed.

Wheat yields are presented in Table 3, no significant differences were observed.

Table 2. Grain quality results. The treatments listed are those that were sown in 2018 and regenerated in 2019, with the grain quality results from the 2020 wheat.

Treatments	Protein (%)	Test weight (kg/HL)	Screenings (%)
Control (Scepter wheat)	10.20	77.03	4.46
Harbinger strand medic	11.95	79.71	3.08
Volga vetch	11.63	78.09	3.39
PM-250 strand medic	12.18	78.37	3.05
Trigonella balansae	12.20	79.19	3.55
SARDI rose clover	11.78	77.90	3.65
LSD (P=0.05)	*0.21*	*1.57*	*0.91*

Table 3. Grain yield for Razor CL wheat for each treatment of the Grazing trial in 2020.

2019 Treatment	Yield (t/ha)
Volga vetch	2.95
Control (Scepter wheat)	2.91
Harbinger strand medic	2.64
PM-250 strand medic	2.38
Trigonella balansae	2.18
SARDI rose clover	2.11
LSD (P=0.05)	*ns*

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. We gratefully acknowledge the help of Jake Hull, Wade Shepperd and John Kelsh for site set-up and management and the assistance of Steve Jeffs, Neil King and Katrina Brands for data collection, and the Waite team and Murdoch University team for data processing.

Dryland Legume Pasture Systems: pasture demonstration sites

Morgan McCallum[1], Jessica Gunn[1], David Peck[2] and Ross Ballard[2]
[1]SARDI Minnipa Agricultural Centre, [2]SARDI Waite

Location
Lock
Rainfall
Av. Annual: 340 mm
2020 Total: 322 mm
2020 GSR: 277 mm
Paddock history
2019: Medic
2018: Wheat
Soil type
Sandy loam
Plot size
2 m x 25 m x 2 reps

Location
Wirrulla
Rainfall
Av. Annual: 375 mm
2020 Total: 315 mm
2020 GSR: 293 mm
Paddock history
2019: Medic
2018: Wheat
Soil type
Calcareous grey sandy loam
Plot size
2 m x 25 m x 2 reps

Key messages

- **Grain protein, but not grain yield was significantly affected by the type of pasture legume previously grown.**
- **The findings will be used to prioritise further research and development of novel pasture species on sandy soils.**

Why do the trial?

Over the past three decades there has been a shift from integrated crop-livestock production to intensive cropping in dry areas, which has significantly reduced the resilience of farms in low to medium rainfall areas. Intensive cropping is prone to herbicide resistant weeds, large nitrogen fertiliser requirements, and major financial shocks due to frost, drought or low grain prices.

A pilot project with MLA and AWI in WA and southern NSW has demonstrated how novel pasture legumes such as serradella, biserrula and bladder clover can improve livestock production while reducing nitrogen requirements, weeds and diseases for following crops. The extent to which these new legumes establish, grow and persist on South Australia's alkaline sandy soils requires clarification.

The demonstration sites are primarily an extension tool, unlike research trials requiring detailed data collection. The purpose of these sites is to gather information on regional legume performance, including benefits to the crops that follow.

How was it done?

The demonstration trials were designed after discussions with local farmers at the Minnipa Agricultural Centre 2018/19 harvest meetings in several locations across upper Eyre Peninsula. It was decided that the two sites chosen should target challenging soil types (particularly sandy soil) for establishing and successfully growing legume pastures in the mixed farming environment. Cultivars were chosen based on recommendations from low to medium rainfall pasture experts, site locality and soil profile information, including recent soil tests undertaken.

<u>Site 1</u>

Lock, SA, (Kerran 'Gus' Glover)
Treatments established in 2019: Best bet variety demonstration - 2 reps x 10 treatments, 2 m x 25 m plots. The pastures were managed for maximum seed set, fenced off from grazing over summer and sown to Spartacus barley in 2020. Pasture treatments were:

- Casbah biserrula sown @ 5 kg/ha
- Toreador disc medic sown @ 7.5 kg/ha
- PM-250 strand medic sown @ 7.5 kg/ha
- Sultan-SU barrel medic 2.5 sown @ 2.5 kg/ha
- Sultan-SU barrel medic 10 sown @ 10 kg/ha
- Scimitar spineless burr medic sown @ 7.5 kg/ha
- Volga vetch sown @ 40 kg/ha
- SARDI rose clover & Bartolo bladder clover mix sown @ 3.75 kg/ha
- Volga (40 kg/ha) & Sultan-SU (10 kg/ha) mix
- Margurita French serradella sown @ 7.5 kg/ha

In 2020 on 8 May, the site was sown to Spartacus barley @ 60 kg/ha, with DAP @ 70 kg/ha and 1.8 L/ha glyphosate, 100 ml/ha oxyfluorfen, 2 L/ha trifluralin applied pre-sowing. Soil sampling for soil nitrogen and soil borne diseases occurred on 4 April. GreenSeeker and weed assessments were conducted on 18 August. The site was harvested on 17 November. Lock received a total of 322 mm rainfall for the year with 277 mm falling within the growing season.

Site 2

Wirrulla, SA, (Dion Trezona)

Treatments applied in 2019: Best bet variety demonstration - 2 reps x 10 treatments, 2 m x 25 m plots. The pastures were managed for maximum seed set, were fenced off from grazing over summer and sown to Scepter wheat in 2020. Pasture treatments were:

- Casbah biserrula sown @ 5 kg/ha
- Toreador disc medic sown @ 7.5 kg/ha
- Scimitar spineless burr medic sown @ 7.5 kg/ha
- SARDI rose clover & Bartolo bladder clover mix sown @ 3.75 kg/ha
- Margurita French serradella sown @ 7.5 kg/ha
- Boron tolerant DL11 sown @ 7.5 kg/ha
- PM-250 strand medic sown @ 7.5 kg/ha
- Sultan-SU barrel medic 2.5 sown @ 2.5k g/ha
- Volga (40 kg/ha) & Sultan-SU (10 kg/ha) sown @ 10 kg/ha
- Sultan-SU barrel medic 10 sown @ 10 kg/ha
- Volga vetch sown @ 40 kg/ha

On 21 May 2020, the site was sown to Scepter wheat with Granuloc Zinc DAP applied @ 60 kg/ha. Soil sampling for soil nitrogen and soil borne diseases occurred on 4 April. GreenSeeker, Canopeo (determines % area green) and weed assessments were conducted on 17 August. The site was harvested on 9 November. Wirrulla received a good amount of rainfall with an annual total of 315 mm and 293 mm of that falling within the growing season.

What happened?

In 2019, Volga vetch produced the greatest biomass on both soil types (calcareous grey sandy loam at Wirrulla and sandy loam at Lock). Pasture production at Wirrulla in general was low in 2019, with the biomass ranging from 0.80 t/ha Margurita French serradella to 3.23 t/ha Volga vetch. Seed pod set was noticeably low at the Wirrulla site due to a dry finish compared to the Lock site, where the PM-250 strand medic, Scimitar spineless burr medic and Casbah biserrula set the most pods. Overall, the majority of species at both sites produced adequate seed set for regeneration in 2021, following a cereal crop. At both sites in 2020 measurements including soil nitrogen, soil disease assessment and GreenSeeker analysis conducted throughout the growing season showed no differences between the treatments (data not shown).

The wheat and barley at Wirrulla and Lock showed consistent emergence (mean plants/m^2) across all pasture treatments, with no significant treatment differences observed. Cereal grain yields in 2020 ranged from 1.7 to 1.9 t/ha at Lock and from 1.0 to 1.2 t/ha at Wirrulla but there were no statistically significant differences between treatments.

Grain quality analysis was conducted for both sites and grain protein levels following the pasture treatments showed significant differences between treatments at both sites. At the Lock site, the average protein percentage ranged from 11.5% in the Volga vetch treatment to 10.5% for Scimitar medic (Table 2). At Wirrulla grain protein ranged from 11.6% in the PM-250 strand medic treatment to 10.8% in the Toreador disc medic.

Table 1. Grain yield of Spartacus barley (t/ha) at Lock and Scepter wheat (t/ha) at Wirrulla in 2020.

Lock		**Wirrulla**	
2019 Treatment	**Average yield (t/ha)**	**2019 Treatment**	**Average yield (t/ha)**
Casbah biserrula	1.88	Casbah biserrula	1.19
Toreador disc medic	1.85	Toreador disc medic	1.13
PM-250 strand medic	1.80	Scimitar spineless burr medic	1.12
Sultan-SU barrel medic 2.5	1.78	SARDI rose clover & Bartolo bladder clover mix	1.12
Scimitar spineless burr medic	1.78	Margurita French serradella	1.10
Volga vetch	1.78	Boron tolerant medic DL11	1.08
SARDI rose clover & Bartolo bladder clover mix	1.75	PM-250 strand medic	1.07
Sultan-SU barrel medic 10	1.73	Sultan-SU barrel medic 2.5	1.06
Volga & Sultan Mix	1.69	Volga & Sultan	1.06
Margurita French serradella	1.69	Sultan-SU barrel medic 10	1.06
		Volga vetch	1.04
LSD (P=0.05)	*ns*		*ns*

Table 2. Grain protein quality in 2020 from the Lock and Wirrulla sites.

Lock		Wirrulla	
2020 Treatment	**Grain protein (%)**	**2020 Treatment**	**Grain protein (%)**
Volga vetch	11.45 a	PM-250 strand medic	11.60 a
Sultan-SU barrel medic 10	11.20 ab	Volga Vetch	11.40 a
PM-250 strand medic	11.15 a	Boron tolerant medic DL11	11.35 a
Volga & Sultan Mix	11.15 a	Margurita French serradella	11.25 ab
Casbah biserrula	11.05 a	Sultan-SU barrel medic 2.5	11.20 ab
Margurita French serradella	11.0 a	Casbah biserrula	11.15 ab
SARDI rose clover & Bartolo bladder clover mix	10.95 ab	Sultan-SU barrel medic 10	11.15 ab
Toreador disc medic	10.75 ab	SARDI rose clover & Bartolo bladder clover mix	11.10 ab
Sultan-SU barrel medic 2.5	10.5 b	Scimitar spineless burr medic	11.10 ab
Scimitar spineless burr medic	10.5 b	Volga & Sultan Mix	10.95 ab
		Toreador disc medic	10.80 b
LSD (P=0.05)	*0.76*		*0.65*

What does this mean?

Grain protein content, but not grain yield was affected by the pasture treatment that proceeded the wheat crop. Wheat yield was not improved by biserrula, which produced inferior levels of dry matter production in 2019 (data not shown). Factors such as water availability, rather than pasture performance, were likely to have determined grain yield in this instance. Grain protein differences of about 1% were measured at both sites. At Lock, grain protein was highest following Volga vetch, which was the most productive species at that site, but otherwise grain protein was not obviously linked to previous legume production at either site. Whilst the trials indicate scope to improve grain protein by using pasture species aligned with the soil types, further work is needed to understand the transfer of N between the legume and crop phase.

In 2021 both sites will be left to regenerate back to their pasture species. This will provide critical information on the persistence of the sown legumes through a cereal crop and help select the best pasture prospects for future studies.

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 grower groups: Mingenew Irwin Group, Corrigin Farm Improvement Group, Asheep Esperance, Eyre Peninsula Agricultural Research Foundation, Upper North Farming Systems, Mallee Sustainable Farming, Lower Eyre Ag Development Association, Birchip Cropping Group, Farmlink, Central West Farming Systems. We would like to thank Kerran Glover and Dion Trezona for the use of their land for the demonstration sites and for assistance in broadacre management. We gratefully acknowledge the help of Ian Richter for site management, Neil King and Fiona Tomney for data collection, and the Waite team for data processing.

Sultan-SU barrel medic - Photo by BARENBRUG Australia

Dryland Legume Pasture Systems (DLPS): alternative species adaptation trial

Fiona Tomney[1], Neil King[1] and Ian Richter[1]; David Peck[2], Jeff Hill[2] and Ross Ballard[2]

[1]SARDI Minnipa Agricultural Centre, [2]SARDI Waite

Location
Minnipa Agricultural Centre
paddock N7
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2020 Total: 367 mm
2020 GSR: 255 mm
Paddock history
2019: Spartacus CL barley
2018: Scepter wheat
2017: Canola
Soil type
Red sandy loam
Plot size
5 m 1.7 m x 4 reps x 25.5 cm row spacing

Key messages

- **The largest amount of early pasture growth was produced by Sultan-SU barrel medic (1.5 t/ha dry matter (DM)) and Trigonella DL60 (1.2 t/ha DM).**
- **Margurita French serradella produced large amounts of late pasture growth with 2.4 t/ha DM, however it failed to set adequate levels of seed.**
- **In the 2020 growing season the Trigonella lines DL59, DL60 and WA1 were consistently productive pasture legume species in terms of both early and late growth, and seed production.**

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 that are available or being developed offer improved seed harvestability and are better suited to establishment when dry sown and/or provide better nutrition for livestock. Regional evaluation is being undertaken in this project 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 in Minnipa paddock N7 (loam soil) was arranged in a fully randomised block design with four replications.

Sixteen legume genotypes were sown: Casbah biserrula; five lines of trigonella; French serradella cultivars Frano (new earlier season cultivar) and Margurita; Ioman astragalus (+/- inoculation); Bartolo bladder clover and an earlier bladder clover line; SARDI rose clover; and Cefalu arrowleaf clover. The spineless burr medic cultivar Scimitar and barrel medic cultivar Sultan-SU were included as controls.

The trial was sown on 18 May 2020 into moist soil. Plant emergence counts were completed on 30 June. Green Seeker measurements were taken on 27 August, 9 September and 20 October. Plots were scored for vigour on 8 September. Plots were sprayed for Cowpea aphid on 9 September. Early dry matter (DM) cuts were completed on 14 September and late DM cuts taken on 5 November. Plots were sampled to estimate seed production on 24 November 2020.

Results were analysed using Analysis of Variance with Genstat 64, version 20.

Table1: Average dry matter production and seed yield for pasture legume species at Minnipa in 2020.

Legume Species	Early DM 14/9/20 (t/ha)	Late DM 5/11/20 (t/ha)	Seed Yield (kg/ha)
Bartolo bladder clover	0.39 de	1.81 b	726
Bladder clover WA4	0.36 de	1.33 bc	1027
SARDI rose clover	0.80 cd	1.97 ab	1158
Cefalu arrowleaf clover	0.19 e	1.92 ab	833
Ioman astragalus nil Rhizobia	0.84 cd	1.74 bc	819
Ioman astragalus inoculated	0.77 cd	1.97 ab	766
Casbah biserrula	0.25 e	2.03 ab	325
Trigonella 5045	0.58 d	1.28 c	190
Trigonella DL59	1.13 bc	1.51 bc	355
Trigonella DL60	1.19 ab	1.90 ab	476
Trigonella WA1	1.08 bc	2.14 ab	179
Trigonella WA2	0.80 cd	1.17 c	220
Margurita French serradella	0.33 de	2.37 a	28
Frano French serradella	0.25 e	1.40 bc	8
Sultan-SU barrel medic	1.47 a	1.25 c	256
Scimitar spineless burr medic	0.90 c	0.78 c	356
LSD (P=0.05)	*0.28*	*0.54*	

What happened?

The season opened in late April with 25 mm of rainfall, enabling the trial to be sown into moist soil. However, rainfall for May, June and July was more than 50% below average, resulting in slow pasture establishment and growth (Table 1). Above average spring rainfall (August to October) increased the growth of biserrula, Margurita French serradella and Cefalu arrowleaf clover, but was too late in the growing season for the medics.

The trial suffered an attack from cowpea aphids in early September. There was evidence of aphids present on all plots, but only the astragalus appeared to be badly damaged. The aphids were quickly controlled, with all lines continuing to grow, flower and set seed; however the astragalus looked less vigorous post attack.

Sultan-SU barrel medic and Trigonella DL60 had the highest DM in early spring (14 September) with 1.47 t/ha and 1.19 t/ha DM (Table 1). Other genotypes with reasonable DM (>0.8 t/ha) included Scimitar burr medic, trigonella (other than APG5045), Ioman astragalus (nil Rhizobia) and SARDI Rose clover. The other entries had low DM (<0.4 t/ha).

By late spring (5 November) Margurita French serradella, trigonella lines WA1 and DL60, biserrula, SARDI rose clover, astragalus (inoculated) and Cefalu arrowleaf clover all produced more than 1.8 t/ha. With the exception of the trigonellas and SARDI rose clover, these lines all had low DM in early spring. The annual medics did not produce any more DM than was present in early spring.

All lines flowered and set seed (Table 1). The two French serradella cultivars had very low (28 and 8 kg/ha) seed set despite producing a large amount of spring growth.

What does this mean?

Despite a challenging early growing season with below average rainfall, all pasture legume lines established, flowered and set seed, although the amount set by the serradellas is expected to be insufficient for adequate regeneration. Sultan-SU barrel medic and Trigonella DL60 produced the greatest amount of early DM. Trigonella lines DL59, DL60 and WA1 performed consistently well in terms of both early and late DM, and seed set; these recent selections appearing to perform better than 5045. SARDI rose clover also performed consistently well throughout the 2020 growing season.

The above average rainfall in spring allowed Margurita French serradella, Cefalu Arrowleaf clover and Casbah biserrula, which are later flowering than the medics included in the trial, to produce very large amounts of feed when the medics had already set seed and begun to senesce. However these later producing legumes were slow to establish and grew poorly during winter, with low biomass and ground cover. Margurita and Frano serradella also set inadequate amounts of seed. Trigonella lines DL59, DL60 and WA1 were more consistent performers in terms of both early and late biomass, and seed set.

The large differences in the seasonal production of the different legume species may be able to be exploited to provide a more consistent feed resource for livestock, where sensible combinations of the legumes are used and able to be managed for persistence and weed control.

The three growing seasons of the DLPS Project have all had above average spring rainfall, hence the performance of alternative lines has not yet been assessed in a season with average or below average spring rainfall.

In the 2018 and 2019 Dryland Legume Pasture Systems Legume Adaptation trials, astragalus was the best adapted alternative legume species. Although Astragalus did not reach its full potential in 2020 due to an aphid attack, its overall performance was still good and merits further investigation in the Minnipa environment. Seed is still not commercially available.

In 2021 species regeneration will be assessed prior to the trial being sown to wheat.

Acknowledgements

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Identifying suitable legume species for dryland, low rainfall farming land – Canowie Belt

Author(s): Bethany Sleep, Ross Ballard

Funded By: Australian Government Rural R&D for Profit Program.

Project Title: Dryland Legume Pasture Pasture Systems. UNFS Project 229. Australian Government Rural R&D for Profit project #9175959 – 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 Duration: 2019 - 2022
Project Delivery Organisations: UNFS subcontracted by Mallee Sustainable Farming to delivery in the Upper North of SA, Elders Jamestown project managing Canowie Belt trial site.

Key Points:

- Year one of the project looking at different pasture legumes suitability for the low rainfall, medium clays and frosty growing conditions of the Upper North. Site located at Canowie Belt, 20 km's North, East of Jamestown, toward Yongala.
- Species success was highly dependant on the plant's adaptation to the growing conditions present. This was made apparent by the subtle change in pH of the trial site when moving from rep 1 to rep 3.
- Good opening rains combined with a soft finish to the 2020 growing season allowed for good plant establishment and seed set across all species and replications
- Vetch species provided the earliest and largest amount of biomass across all species, however, were affected most by insects (particularly cow pea aphid) and disease (particularly grey mould). This suggests vetch varieties may require increased inputs in contrast to clover and medic species.
- Sultan was found to be the best suited small seeded legume species in this environment, however, ability to regenerate from the seed bank is yet to be assessed. Hard seededness and seed viability will be important considerations in this, which will be assessed in 2021 and 2022.

Background

This study aims to investigate the suitability of various legume species in a dryland, marginal rainfall environment, where typical break crops such as faba beans, field peas or canola are not economically viable. The project will highlight the ability of various pasture legumes to regenerate from a seed bank, following a rotation of an alternate self-regenerating legume crop followed by a cereal cash crop. This is in an attempt to achieve the well-known benefits of a break crop, such as nitrogen fixation, herbicide mode of action rotation and cereal disease break. Additionally, species will be assessed for feed quality and timing of feed on offer throughout the season, ensuring species are suited to our modern mixed farming systems across the Upper North, where focus has shifted toward continuous cropping, meaning viability of established perennial pasture no longer fits the system.

This site will run over three growing seasons with several different factors assessed throughout the trial predominantly including 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

This trial is located in the Canowie Belt region, approximately 20 km's North-East of Jamestown and 10 km's South of Yongala. Long term annual rainfall is ~350 mm with soil and atmospheric temperatures typically declining quickly at the beginning of the season due to frost events. This presents a challenge for early growth, resulting in a feed gap at the beginning of the season which a self-regenerating pasture may be able to address.

The trial was sown into a moist seed bed on the 5th of May with 40 kg/ha starting fertilizer (MAP), after species were inoculated using a slurry coating. Pasture cultivar and species, seeding depth and rates are shown in table 3. The trial utilised a randomised trail design, with 3 replications. Plots run North, South with the trial site locate on a slight incline. Soil type across the trail site is a red, brown earth with clay content increasing down the profile. No major soil constraints were identified in the initial soil sampling (Appendix A). The site pH increases as you move up the slope, meaning the third replication has alkaline conditions, whilst replication one is closer to neutral.

The trial runs over three years (2020 – 2022), with each phase highlighted in table 4. In year one establishment counts, peak biomass, nodulation, feed quality and N fixation are evaluated. Year two assessments include weed pressure, NDVI, grain protein and cereal yield, with year three considering pasture regeneration and DSE for grazing.

Table 3. Cultivar and species used in this trial, which employed a randomised trial design across 3 replications, using plots of 1.75 m by 15 m. Sowing rate and depth used in the trial is also shown below.

Cultivar	Species	Sowing Rate (kg/ha)	Sowing Depth (cm)
*Casbah	Biserrula	5	1
PM250	Strand Medic	7.5	1
*Scimitar	Burr Medic	10	1
SARDI Rose	Rose Clover	7.5	1
SARDI Rose + Bartolp	Rose Clover Bladder Clover	3.7 3.7	1
Margarita	Serradella	7.5	1
Saltan	Barrel Medic	7.5	1
Studencia	Vetch	40	2
*Volga + Saltan	Vetch Barrel Medic	15 7.5	2
*Volga	Vetch	40	2
Lanza	Tedera	10	2
*Mawson	Sub Clover	10	1

* Identifies cultivars where we used old seed. Germination tests were undertaken, with the Casbah (Biserrula) seed being identified as not viable seed and therefore is disregarded in this trial.

Table 4. Trial timeline at Canowie Belt Site.

Year 1 - 2020	Pasture legumes sown and let to set seed
Year 2 - 2021	Wheat sown and pasture legumes sprayed out
Year 3 - 2022	Re-generation of pasture legumes

Results and Discussion

Accurate seed placement and species selection resulted in good establishment across all pasture species (Figure 1), with the exception of Casbah and Lanza, despite marginal rainfall for the first half of the growing season (Appendix B). Casbah was discounted from the trial due to the use of unviable seed as determined after a germination test, whilst the poorer germination of Lanza was subject to the hard seededness of the species. Variation was observed when moving from rep 1 to rep 3 of the trial. This was due to increased pH of the site when moving from low slope to mid slope, highlighting the importance of species adaptation to site conditions in relation to species success.

Species development was also monitored throughout the season, which can be correlated back to species ability to re-generate from the seed bank in following seasons. PM-250, Sultan Su and all vetch varieties entered the reproductive phase much earlier than other species in the trial, suggesting the grazing window is smaller for these varieties. In contrast, Mawson, SARDI Rose, Margurita, Scimitar and Bartolo were all still flowering at the time of sampling (11th September), consequently suggesting the ability to achieve a grater seed set than the earlier varieties, with a longer grazing window.

Biomass measurements were collected at peak biomass timing, on the 11th of September and is shown in figure 2. An 8-fold difference was identified between the best and worst performing species, with the highest biomass averaged across the three replicates attributed to the Volga / Sultan mixed species plot, followed closely by Volga and Studenicia. Sultan SU produced the most biomass compared to all other small seeded legumes, showing a significant difference. All remaining species showed no significant difference, producing between 450 kg/ha to 1040 kg/ha dry matter.

No relationship was found when comparing plants/m^2 (figure 1) to plant biomass/m^2 (figure 2). This trial was therefore able to conclude that species success was strongly related to adaptation of pasture species to growing conditions. Typically, medic varieties are more suited to alkaline growing conditions as seen at this site, providing an explanation for the success of Sultan SU in this trial. PM-250 is generally more suited to sandy soil conditions, potentially limiting its success at this trial site which is medium clay in texture. The scimitar plots utilised two-year-old seed, with reduced vigour commonly associated with old seed.

In season observations found vetch varieties more susceptible to pests, particularly cow pea aphid and grey mould (*Botrytis sp.)* suggesting increased inputs are required when growing vetch in contrast to small seeded legume species.

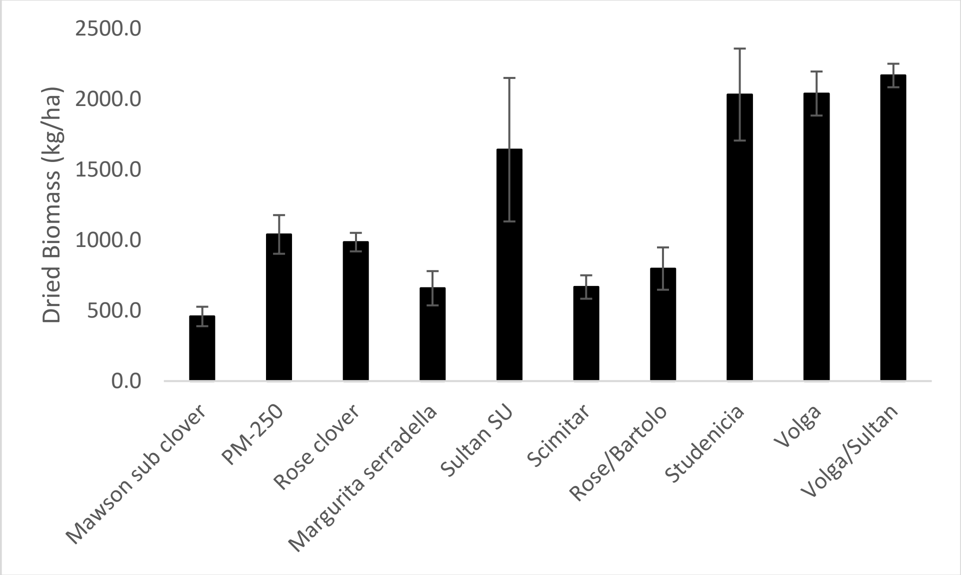

Figure 2. Averaged shoot biomass from replicated trial as recorded from plant biomass collected on the 11th of September, capturing peak biomass. Results show averaged weights from the replicated trial. Error bars highlight variation between the three replicates for each species. Casbah (Biserrula) and Lanza (Tedera) were not included due to low plant populations present at the time of collection.

In general, the levels of nodulation (Figure 3) are in line with what we would expect for the different species. Typically, medics have fewer nodules, with sub-clover showing increased nodulation. Therefore, we conclude that poor nodulation was not the cause of poor production throughout the clover species in this trial. Similarly, all the serradella plants had a reasonable number of nodules, so again it was unlikely to have restricted its production.

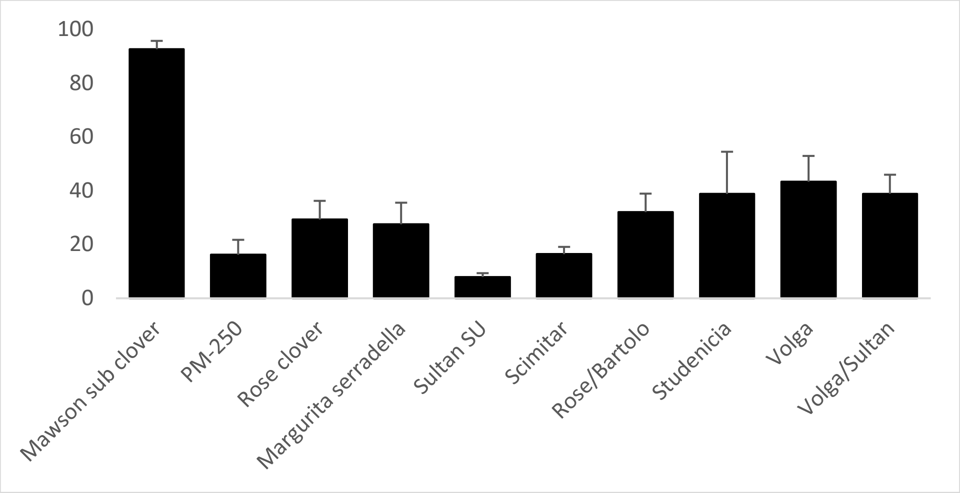

Figure 3. Averaged nodule number per plant, with 10 plants collected per plot collected on the 2nd of October.

Acknowledgements

- Craig, Lyn and Damon Humphris, for providing the site and contributing to project management throughout the year
- SARDI for providing their cone seeder and staff to sow the trial
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Mallee Sustainable Farming

Government of South Australia
Primary Industries and Regions SA

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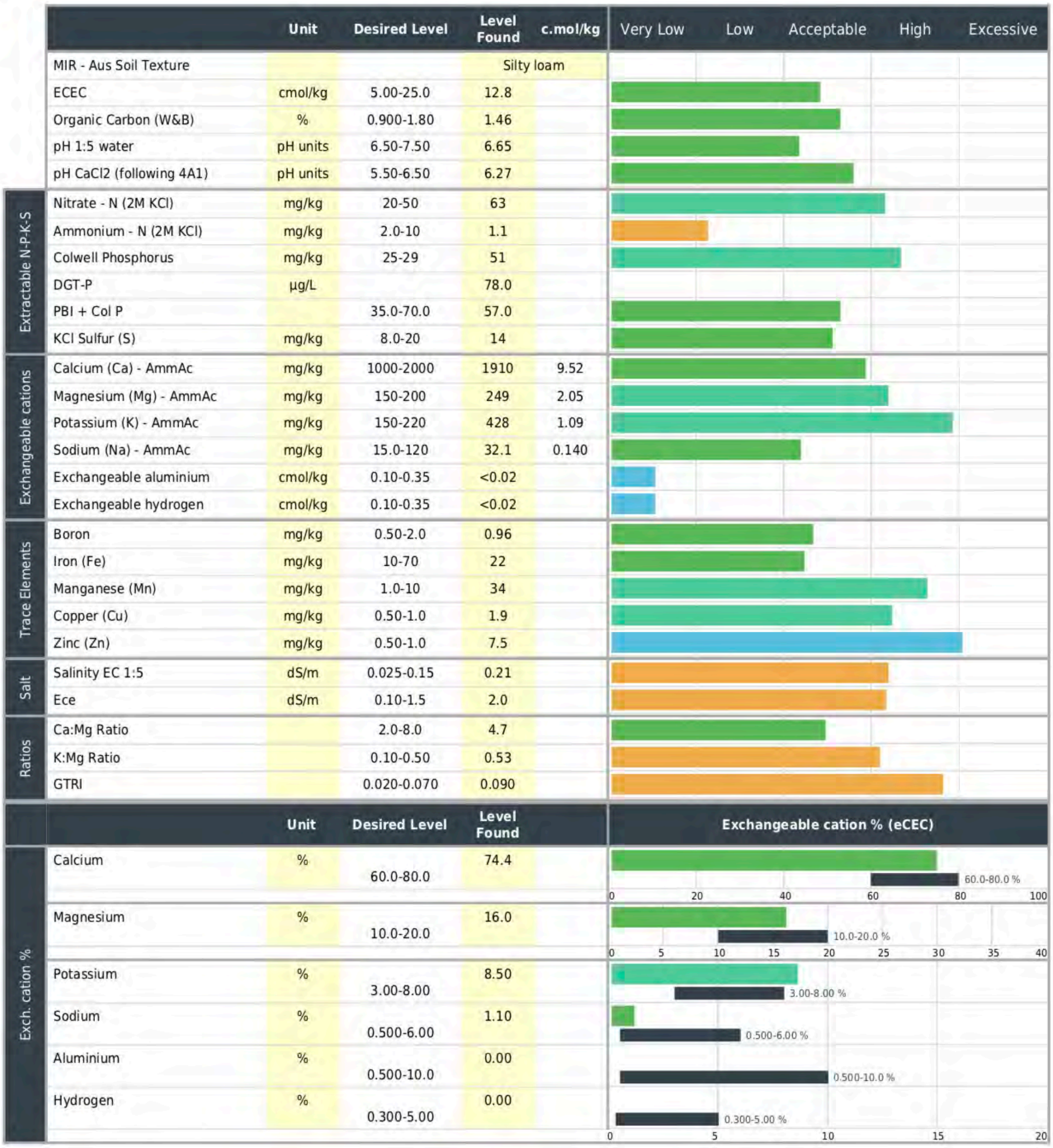
S&W SEED COMPANY

BARENBRUG

Appendix A. Soil sample data, taken on the 10th of April to a depth of 10 cm's.



		Unit	Desired Level	Level Found	c.mol/kg
	MIR - Aus Soil Texture			Silty loam	
	ECEC	cmol/kg	5.00-25.0	12.8	
	Organic Carbon (W&B)	%	0.900-1.80	1.46	
	pH 1:5 water	pH units	6.50-7.50	6.65	
	pH CaCl2 (following 4A1)	pH units	5.50-6.50	6.27	
Extractable N-P-K-S	Nitrate - N (2M KCl)	mg/kg	20-50	63	
	Ammonium - N (2M KCl)	mg/kg	2.0-10	1.1	
	Colwell Phosphorus	mg/kg	25-29	51	
	DGT-P	µg/L		78.0	
	PBI + Col P		35.0-70.0	57.0	
	KCl Sulfur (S)	mg/kg	8.0-20	14	
Exchangeable cations	Calcium (Ca) - AmmAc	mg/kg	1000-2000	1910	9.52
	Magnesium (Mg) - AmmAc	mg/kg	150-200	249	2.05
	Potassium (K) - AmmAc	mg/kg	150-220	428	1.09
	Sodium (Na) - AmmAc	mg/kg	15.0-120	32.1	0.140
	Exchangeable aluminium	cmol/kg	0.10-0.35	<0.02	
	Exchangeable hydrogen	cmol/kg	0.10-0.35	<0.02	
Trace Elements	Boron	mg/kg	0.50-2.0	0.96	
	Iron (Fe)	mg/kg	10-70	22	
	Manganese (Mn)	mg/kg	1.0-10	34	
	Copper (Cu)	mg/kg	0.50-1.0	1.9	
	Zinc (Zn)	mg/kg	0.50-1.0	7.5	
Salt	Salinity EC 1:5	dS/m	0.025-0.15	0.21	
	Ece	dS/m	0.10-1.5	2.0	
Ratios	Ca:Mg Ratio		2.0-8.0	4.7	
	K:Mg Ratio		0.10-0.50	0.53	
	GTRI		0.020-0.070	0.090	

		Unit	Desired Level	Level Found
Exch. cation %	Calcium	%	60.0-80.0	74.4
	Magnesium	%	10.0-20.0	16.0
	Potassium	%	3.00-8.00	8.50
	Sodium	%	0.500-6.00	1.10
	Aluminium	%	0.500-10.0	0.00
	Hydrogen	%	0.300-5.00	0.00

Appendix B. Rainfall data for the 2020 season recorded 2 km south of the trial site on an adjoining farm.

Month	**Total Rainfall**	**Wet Days**	**Month**	**Total Rainfall**	**Wet Days**
Jan	37.5	2	Jul	9.5	3
Feb	69	3	Aug	61.8	11
Mar	0	0	Sept	59.5	3
Apr	59.5	6	Oct	97.5	6
May	25.3	6	Nov	0	0
Jun	20.5	6	Dec	35.5	4
TOTAL	475.6		**GS Rainfall**	333.6	

Managing foliar disease in pulses in low rainfall environments

Author(s): Sarah Day, Jenny Davidson, Penny Roberts
Funded By: Grains Research and Development Institute (GRDC)
Project Title: Southern Pulse Agronomy (GRDC project DAV00150)
Project Delivery Organisations: *Agriculture Victoria, South Australian Research and Development Institute (SARDI), The University of Adelaide*

Key Points:

- Current recommendations for pulse management are based on medium and high rainfall zones and these strategies are often not economical for growers in low rainfall regions.
- Ability to control foliar disease needs to be carefully considered prior to growing a pulse crop.
- It is important to follow an integrated disease management approach, monitor pulse crops for disease and apply fungicides at the first sign of disease infection prior to rain.

Background

The Australian pulse industry experiences a loss of $74 million per year from disease infection, with the highest disease losses occurring in field pea and chickpea [1]. Fungicide seed dressings and multiple foliar applications are highly recommended for field pea and chickpea as there is currently no varietal resistance to Ascochyta blight (AB). However, the cost of these applications is not economical in low rainfall environments where grain production is low. It is important to keep in mind the cost of fungicide products and ensure label directions for use are followed. Applications of newer fungicide products such as Aviator Xpro® can cost almost double that of Mancozeb (Table 1) and cannot be applied after early flowering unlike the latter product.

Pulse disease management strategies are developed for medium and high rainfall zones and these strategies are often not viable or economical for low rainfall growers. To improve grower confidence in pulse production there is a need for pulse management strategies developed specifically for low rainfall environments. Disease infection risk can be low in pulse crops in low rainfall environments. However, regular crop monitoring and disease management strategies are still important as severe disease infection can occur in higher rainfall seasons if left unmanaged. The best approach to managing disease is integrated disease management, combining the selection of a resistant variety, use of clean seed, paddock hygiene and the application of fungicides. It is important to implement a 3-4 year break between crops of the same type, revise cultivar selections and avoid sowing in paddock(s) in close proximity to previous year’s crops [2]. Crop sowing guides and GRDC Grow Notes provide key and up-to-date information on variety resistance characteristics and disease management approaches. The subsequent sections highlight key findings from 2020 trials located at Booleroo and Warnertown, and the key considerations for disease management in low rainfall environments for the commonly grown pulse crops.

Trial Methodology

Chickpea, field pea, faba bean, vetch and lentil low rainfall disease trials were established at Booleroo and Warnertown in 2020. Trials were not inoculated with disease to ensure natural infection to determine the most appropriate fungicide strategy for foliar disease control in pulses in low rainfall environments. Fungicide strategies and products were chosen to target AB in chickpea, lentil, field pea (blackspot) and vetch, botrytis grey mould (BGM) in lentil, and chocolate spot in faba bean (Table 2). For chickpea, vetch, faba bean and lentil multiple varieties were included to represent those with varying levels of disease resistance. One variety of field pea, PBA Oura, was selected as all field pea varieties are rated as moderately susceptible to Blackspot.

Table 1. Fungicide products, estimated cost per product and application cost ($/ha) calculated with registered label rates for each registered pulse crop. Prices obtained from the Rural Solutions Farm Gross Margin and Enterprise Planning Guide 2020.

Fungicide			Application cost $/ha (per label rates)					
Chemical	**Chemical cost**		**Lentil**	**Chickpea**	**Field pea**	**Faba bean**	**Vetch**	**Lupin**
Tebuconazole	$14.90	/litre	-	-	$2.24	$5.22	-	-
Aviator Xpro®	$54.50	/litre	$32.70	$32.70	$32.70	$32.70	-	-
Chlorothalonil	$12.54	/litre	$25.08	$25.08	$22.57	$25.08	-	-
Carbendazim	$9.85	/kg	$4.93	$4.93	-	$4.93	$4.93	-
Veritas®	$24.90	/litre	$24.90	$24.90	$24.90	$24.90	$24.90	$24.90
Mancozeb	$8.83	/kg	$17.66	$17.66	$17.66	$17.66	$17.66	$17.66
Procymidone	$24.60	/litre	$12.30	-	-	$12.30	-	-

Table 2. Pulse varieties, fungicide treatments and rates applied to control natural disease infection, at Booleroo and Warnertown, 2020.

Varieties	**Fungicide treatments**	**Rate**
Lentil (ascochyta blight management) – Booleroo, Warnertown		
PBA Hurricane XT PBA Hallmark XT PBA Highland XT PBA Bolt PBA Jumbo2 PBA Kelpie XT	1. Nil (untreated)	-
	2. Chlorothalonil applied at podding ahead of rain	2 L/ha
	3. Veritas® applied at podding ahead of rain	1 L/ha
Lentil (botrytis grey mould management) - Warnertown		
PBA Bolt PBA Giant PBA Highland XT PBA Blitz	1. Nil (untreated)	**-**
	2. Carbendazim at canopy closure	500 mL/ha
	3. Carbendazim at canopy closure and additional sprays ahead of rain front if minimum temperatures >12°C	500 mL/ha
Field pea (blackspot management) – Booleroo, Warnertown		
PBA Oura	1. Nil (untreated)	-
	2. Veritas® applied 6-8 weeks post sowing	1 L/ha
	3. P-Pickle-T® seed dressing + Veritas® applied 6-8 weeks post sowing	1 L/ha
	4. P-Pickle-T® seed dressing + Veritas® applied 6-8 weeks post sowing and at early flowering	1L/ha
	5. Aviator® applied 6-8 weeks post sowing	600 mL/ha
	6. P-Pickle-T® seed dressing + Aviator® applied 6-8 weeks post sowing	600mL/ha

Faba bean (chocolate spot management) - Warnertown		
PBA Samira PBA Marne PBA Amberley	1. Nil (untreated)	-
	2. Tebuconazole 6 weeks post sowing	350 mL/ha
	3. Tebuconazole 6 weeks post sowing and at canopy closure	350 mL/ha
Chickpea (ascochyta blight management) - Booleroo		
PBA Monarch Genesis090 PBA Royal	1. Nil (untreated)	-
	2. Strategic* Chlorothalonil	2 L/ha
	3. Strategic* Veritas® pre-rain	1 L/ha
	4. Strategic* Veritas® post-rain	1 L/ha
	5. Strategic* Aviator® pre-rain	600 mL/ha
	6. Strategic* Aviator® post-rain	600 mL/ha
Vetch (ascochyta blight management) - Booleroo		
Volga Morava Studenica	1. Nil (untreated)	-
	2. Strategic* Veritas®	1 L/ha
	3. Strategic* Mancozeb at vegetative + strategic Veritas® at flowering and podding	2kg/ha Mancozeb, 1L/ha Veritas

*Strategic fungicides were applied a maximum of 4 times during the growing season ahead of rain (or post-rain for some chickpea applications) where >5 mm of rain was forecast, at late vegetative, early flowering, early podding and mid podding growth stages.

Results and Discussion

Dry winter conditions combined with a low risk environment prevented natural AB (or blackspot) infection occurring in pulse crops at Booleroo and Warnertown, 2021. Consequently, fungicide applications were not necessary to control infection or to reduce grain yield loss due to disease infection. However, it is important to plan to spray fungicides on pulse crops, particularly lentil and chickpea, during podding if AB is present to protect developing seed. Despite relatively dry winter conditions, early season soil moisture at Booleroo aided rapid early canopy growth in vetch, leaving crops susceptible to BGM infection during the wetter spring months. Lentil canopies at Warnertown were also bulky, although BGM infection was not present at this site. Chocolate spot infection occurred on faba bean at Warnertown in late September/early October, however, this coincided with crop senescence and foliar disease levels were difficult to assess. Some seed staining did occur from chocolate spot infection with up to 7% poor coloured seed.

For field pea, the control of blackspot with fungicides is not economically viable where grain production is less than 1.5 t/ha. Where grain production potential is greater than 1.5 t/ha newer fungicide options have been effective in reducing disease and improving grain yield in early sown crops and high disease situations [3]. Blackspot can be reduced using a fungicide strategy of P-Pickel T® seed dressing combined with two foliar fungicide sprays (four to nine weeks post sowing and again at early flowering). Predictions of blackspot risk and spore release times in each field pea growing district can be obtained through 'Blackspot Manager' online (https://agric.wa.gov.au/n/7658).

Growers need to carefully consider their risk of AB infection in chickpea and their ability to effectively control the disease prior to deciding to grow chickpea in the southern region. It is essential that all chickpea seed is treated with a thiram-based fungicide seed dressing to prevent early infection on seedlings, as the disease will survive on stubble and organic matter for a number of years. It is important to monitor crops for signs of infection and apply fungicides ahead of rain, particularly during reproductive growth stages, to protect developing seeds.

An integrated disease management (IDM) strategy is highly important for pulse production in low rainfall environments, to reduce some costs and inputs associated with disease management. It is of particular importance in vetch, as there are few fungicide products registered for use in this crop and some have long withholding periods. Grazing vetch can be utilised as part of an IDM strategy for BGM control, as grazing will open up the canopy, allowing it to dry out and reduce disease spread.

Some pulse varieties offer high levels of disease resistance (e.g. PBA Jumbo2 lentil, PBA Samira faba bean) and can be utilised to reduce the need for multiple fungicide applications without compromising yield potential. It is also highly important to monitor pulse crops for disease infection and apply fungicides at the first sign of disease prior to rainfall to ensure disease does not spread to new crop growth. It is particularly important to spray lentil and chickpea crops during podding ahead of rainfall to protect developing seed.

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1. Murray, G. and J. Brennan, *The current and potential costs from diseases of pulse crops in Australia*, GRDC, Editor. 2012.
2. Blake, S., et al., *Ascochyta blight in intensive cropping of pulses*, in *GRDC Grains Research Updates*, ORM, Editor. 2019: Adelaide.
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Opportunities for early sown pulses

Author(s): Sarah Day, Dylan Bruce, Penny Roberts
Funded By: Grains Research and Development Institute (GRDC)
Project Title: Southern Pulse Agronomy (GRDC project DAV00150)
Project Delivery Organisations: *Agriculture Victoria, South Australian Research and Development Institute (SARDI), The University of Adelaide*

Key Points:

- Grain yield average increases of 31% were achieved through early sowing of lentil and faba bean.
- Early flowering varieties had a greater yield response to early sowing, in particular PBA Marne faba bean.
- Wheat had a negative yield response to early April sowing.

Background

Australia's gross production value of pulses in 2017-2018 was $2.1b, with the nation producing an average of 2.2 million metric tonnes of pulses from more than 1.8 million hectares annually. Producers in the southern growing region have been sowing crops earlier to adapt to changes in rainfall patterns, weather extremes during spring and increasing farm size. Conventionally, the sowing of most pulse crops is delayed to avoid the occurrence of high disease pressure, flowering and podding during periods of high frost risk, to reduce excessive growth to prevent premature lodging, shading and smothering, and to minimise crop injury from herbicide carryover. However, delayed sowing often results in shorter plants, lower bottom pod height resulting in harvest difficulties, reduced biomass production, less flowering nodes, fewer pods, and flowering and grain fill occurring in periods of heat and moisture stress, ultimately resulting in lower yields.

Unlike cereal crops, where flowering and reproductive growth occurs within a narrow window, pulses are indeterminate in their growth pattern, and vegetative and reproductive growth occurs concurrently. This phenomenon often results in flowering and podding over an extended period, where developing flowers and pods are subjected to a broader range of climatic conditions. Negative conditions during this time can result in flower abortion, however, this can be compensated by the continuation and later development of flowers and pods. It is this indeterminacy and adaptability in the growth habits of pulse species that is of interest for exploitation. There is an opportunity to overcome environmental constraints, to extend the growing season and maximise yield potential, compared to conventional sowing times in lower rainfall environments.

Trial Methodology

A pilot research trial was undertaken at Warnertown in the Mid-North in 2020, to assess the opportunistic early sowing of pulses, compared to a crop like wheat, for low to medium rainfall environments, where previous research in these areas has shown the greatest potential. The aim of this trial was to extend the growing season and boost the yield potential of pulses in these regions, compared to when these varieties are conventionally sown. Replicated trials were also conducted at Tooligie and Wudinna, Eyre Peninsula, and Farrell Flat, Mid-North. Sowing was completed at the beginning of April (31st of March) and beginning of May (5th of May), with 20 mm of supplementary irrigation applied via dripper irrigation in-furrow immediately post-April sowing and, and pre-May sowing within a couple of days to simulate a singular rainfall event. Three varieties of faba bean, lentil and wheat were selected to cover a range of phenology characteristics (Table 1). The trial was sown in a split plot design, with crop type and time of sowing assigned to the main plot and variety assigned to the sub plot to ensure each crop received appropriate agronomic management.

Table 1. Phenology characteristics of lentil, faba bean and wheat varieties sown at Warnertown, 2020.

Crop	**Variety**	**Flowering time**	**Maturity time**
Lentil	PBA Bolt	Early-mid	Early-mid
	PBA Highland XT	Early	Early-mid
	PBA Jumbo2	Mid	Mid
Faba bean	PBA Marne	Early	Early-mid
	PBA Bendoc	Mid	Early-mid
	PBA Samira	Mid	Early-mid
		Maturity Classification	
Wheat	Illabo	Mid-quick winter	
	Scepter	Mid	
	Trojan	Mid-slow	

Source: 2021 South Australian Crop Sowing Guide.

Results and Discussion

Seasonal conditions at Warnertown were above average with growing season rainfall of 344 mm and annual rainfall of 489 mm, compared to long-term annual average of 372 mm. 70 mm of rainfall was received in April, providing excellent conditions for crop establishment and early vigorous growth. Rainfall declined during winter months, with less than 50 mm of rainfall over June and July, reducing the risk of foliar disease developing under dense canopies. During this period, faba bean sown at the beginning of April were flowering, with pod development coinciding with increased rainfall in August (Figure 1). Faba bean sown at the beginning of May were flowering during August, when 54 mm of rain fell at the site. Although varietal phenology characteristics vary for both flowering and maturity time, the observed phenology was less variable, particularly days from establishment to first flower. There was greater variation in days to 50% flowering (data not shown) and days to first pod and the cause of this variation needs to be further explored. PBA Marne was the first variety to set pods of those sown on March 31st, while phenology was consistent between varieties when sown in early May. Lentil showed reduced variability in phenology compared to the faba beans, with PBA Bolt podding eleven days earlier than other lentil varieties when sown in early May.

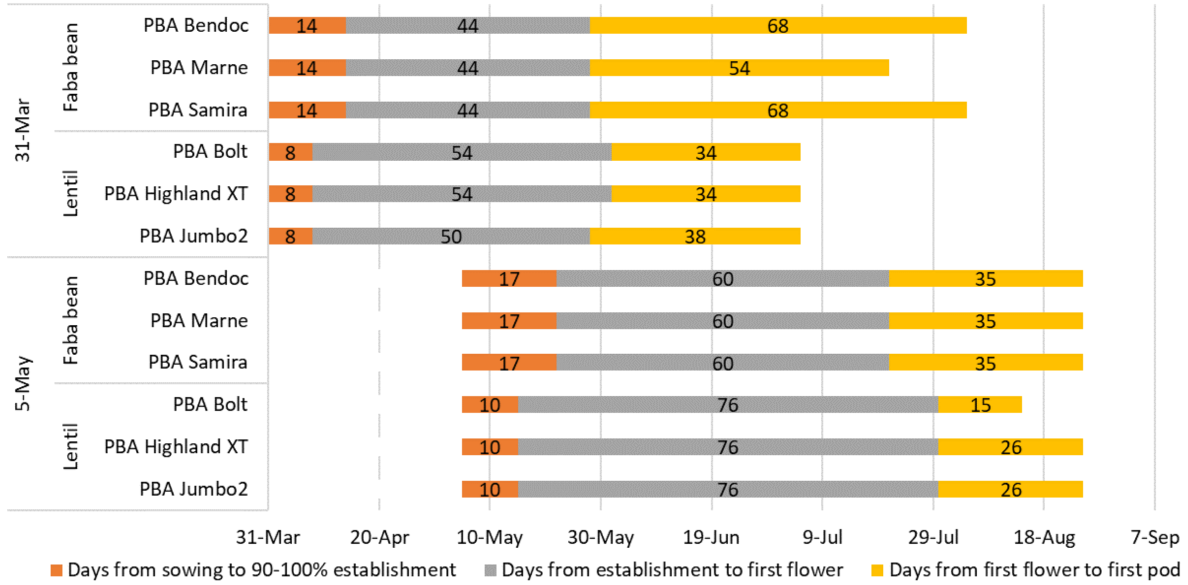

Figure 1. Observed phenology characteristics of faba bean and lentil varieties sown at different times at Warnertown, 2020. Numbers written inside bar graph segments denotes number of calendar days from one observed phenological stage to the next.

Pulses benefitted from early sowing opportunities, with grain yield increases of up to 1.2 t/ha in lentil and 1.6 t/ha in faba bean (Figure 2). Grain yield responses varied between varieties depending on their phenological characteristics, with a greater yield response observed in earlier flowering varieties. PBA Marne faba bean had the greatest yield response of all varieties, with a 1.6 t/ha increase in yield from early sowing. Mid-flowering varieties PBA Bendoc and PBA Samira had more stable grain yield across time of sowing, with no yield difference for PBA Samira and 0.5 t/ha increase in grain yield for PBA Bendoc. This varietal response to time of sowing has previously been observed in research trials conducted at Hart, Mid-North [1].
Early April sown lentil reached physiological maturity in early October, coinciding with spring rainfall and harvest was delayed until late October. This early maturity exposes crops to lodging, shattering and pod drop, and can reduce grain quality, if they cannot be harvested in a timely manner. Similar trends in grain yield response were seen in lentil as for faba bean, where earlier flowering varieties had a greater yield response to early sowing. PBA Bolt and PBA Highland XT had grain yield of 1.2 t/ha and 1.0 t/ha, respectively, from early sowing compared to May sowing. All wheat varieties had a negative response to early sowing, with at least a 0.4 t/ha decrease in grain yield.

This research demonstrated an average grain yield increase of 31% through early sowing of lentil and faba bean at Warnertown. Across this and replicated trials in South Australia the average grain yield increase was 46%. With pulse production currently around 170,000 tonnes annually in the low to medium rainfall zones, this research has the potential to improve returns to the industry of $43,010,000 (at $550 per tonne). Further research is required to identify optimal management and sowing window when an early sowing opportunity presents itself in low to medium rainfall environments. The implications of pushing sowing earlier than what is considered a reasonable pulse sowing time, if sufficient available moisture or an early season break occurs, is yet to be established.

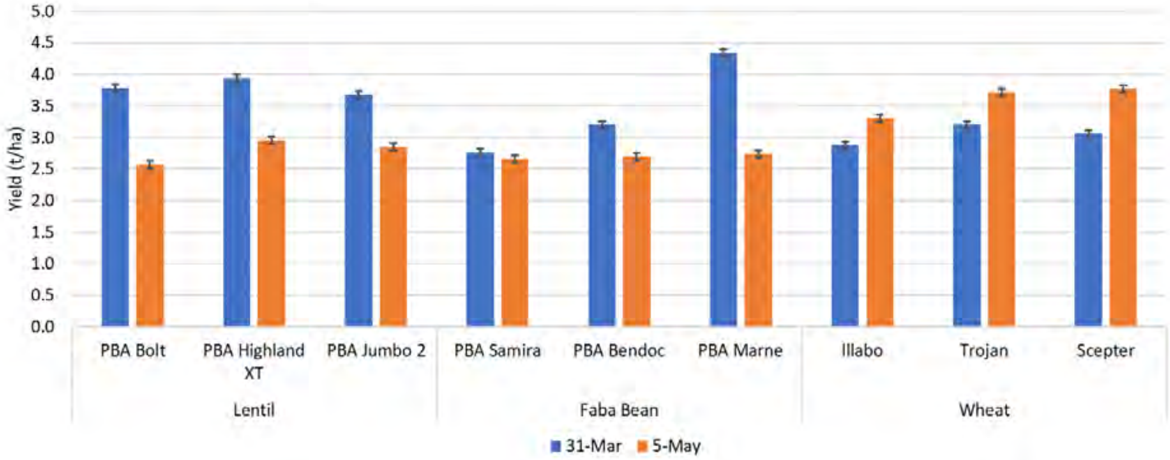

Figure 2. Grain yield (t/ha) of faba and lentil benefited from early sowing opportunities, at Warnertown 2020. Error bars represent standard error (P<0.05).

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC (DAV00150 – Southern Pulse Agronomy), and the authors would like to thank them for their continued support. The continued assistance in trial management from SARDI Agronomy group at Clare is gratefully acknowledged and appreciated.

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1. Roberts, P., et al., *South Australian pulse research update - multi-season results*, in *GRDC Grains Research Update*, ORM, Editor. 2019: Adelaide.

Alternative end use for lentil and novel management strategies for vetch

Author(s): Sarah Day, Penny Roberts
Funded By: Grains Research and Development Corporation (GRDC)
Project Title: Southern Pulse Agronomy (GRDC project DAV00150)
Project Delivery Organisations: *Agriculture Victoria, South Australian Research and Development Institute (SARDI)*

Key Points:

- Gibberellic acid can be utilised to aid plant growth in vetch, however, the effects on biomass production, grain production and phenology need to be investigated further.
- Seeding rate of lentil and vetch can be reduced to three quarters of the recommended seeding rate in some environments without compromising biomass and grain production.
- Lentil provides a favourable alternative to vetch in many low to medium rainfall regions.

Background

Lentil production area has increased over the last decade in the Upper North region of South Australia (Figure 1). This increase in production area has coincided with a reduction in area sown to field pea, as well as recent high grain prices for lentil and developments in breeding, particularly the release of varieties with improved herbicide tolerance characteristics and varieties better adapted to low rainfall environments. The majority of pulse management research is conducted in the medium and high rainfall zones and strategies developed in these environments are often not viable or economical for growers in low rainfall regions. To improve grower confidence in pulse production there is a need for pulse management strategies developed specifically for low rainfall environments. This article highlights and discusses agronomic management trials in vetch and lentil with a focus on novel management approaches, diversifying risk and reducing input costs. The aim of the pulse end use trial was to identify optimal seeding rates and variety selection of vetch and lentil depending on the targeted end use. Where gibberellic acid (GA) was applied to vetch the aim was to quantify the effects of GA at different growth stages on dry matter production.

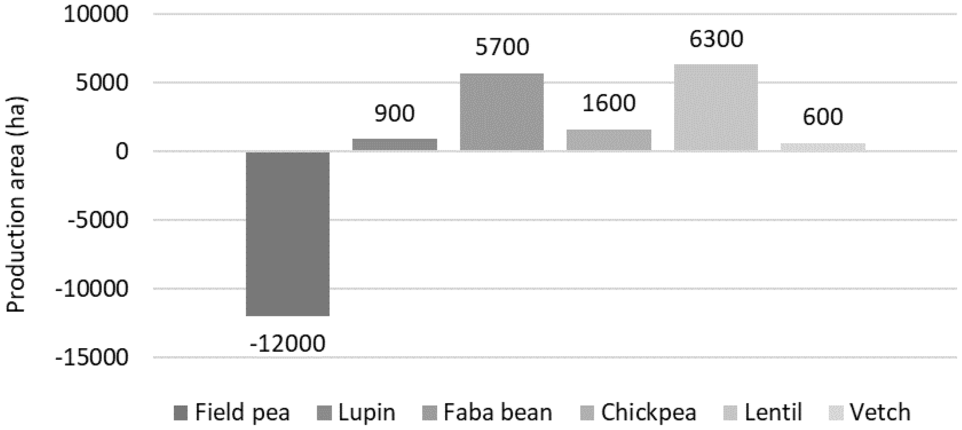

Figure 1. Change in production area (ha) of pulse crops for the Upper North region of South Australia, 2012-2020 [1].

Methodology

All trials were sown using an experimental plot seeder on 23 cm row spacings and harvested with an experimental plot harvester. Booleroo trials were sown on 11 May and harvested on 25 November. Analysis of variance (ANOVA) was conducted for all trial data using Genstat 20th Edition.

Pulse end use trials

Growing lentil for grazing or hay is rising in interest among low rainfall growers, which led to the initiation of these research trials to compare biomass and grain production of vetch and lentil sown at multiple seeding rates, at four trials sites (Table 1). The seeding rates compared the recommended target plant density (120 plants/m^2 for lentil and 60 plants/m^2 for vetch), with a target density of half and three-quarters of the recommended rate to assess whether input costs could be reduced without compromising production potential. Higher than recommended rates were not included, as high plant density crops increase the risk of disease infection and lodging, and reduce resource efficiency due to larger canopies. Three varieties each of vetch (Volgaⓓ, Timokⓓ, Morava) and lentil (PBA Jumbo2 ⓓ, PBA Blitzⓓ, PBA Highland XTⓓ) with varying phenology characteristics were included to refine variety selection depending on target end use. Measurements taken included site soil characteristics, biomass yield, grain yield and crop height. Biomass measurements were taken at late vegetative and early podding growth stages to identify production potential for grazing or hay production. Plots were arranged in a split plot randomised design with three replicates, with crop species randomly assigned in blocks to the whole plot, and variety and plant density randomly assigned to the sub plot. The use of this design ensures that both crop types receive appropriate agronomic management.

Gibberellic acid use in vetch

GA was applied to Volgaⓓ vetch at two growth stages (Table 1) and compared to an untreated Nil to quantify the effects of GA on vetch growth and dry matter production at Kimba and Booleroo, 2020. Measurements included plant height at regular intervals following GA application, biomass dry matter production two weeks post-application, and grain yield. Plot arrangement was in a randomised block design with four replicates.

Table 1. Gibberellic acid treatments applied to Volgaⓓ vetch at Booleroo and Kimba, 2020.

Treatment	Details	Product	Rate
Nil	Untreated	-	-
GA @ 6-8 weeks	Gibberellic acid applied at 6-8 weeks post sowing	GALA Growth Regulator (100 g/L gibberellic acid)	80 mL/ha
GA @ early podding	Gibberellic acid applied at early podding	GALA Growth Regulator (100 g/L gibberellic acid)	80 mL/ha

Results and Discussion

Pulse end use trials

At three of four sites seeding rate was reduced by a quarter without compromising biomass or grain production regardless of variety selection (Table 2). Reducing the seeding rate further to half of the target density did reduce production at some sites. A seeding rate that is too low exposes the crop to aphid infestation, weed establishment and increases harvest difficulty.

There are many unfavourable aspects of vetch production, including limited disease resistance and fungicide options, limited herbicide options, hard seededness of some varieties, poor harvestability and market access. Lentil offers some advantages over vetch and is considered a more favourable break crop option in many regions. In many low rainfall environments lentil biomass and grain production has been equal to or greater than vetch [2]. Optimal variety selection can be complex depending on target crop end use, although there have been some stand out varieties in the low rainfall zone [3]. Similar levels of biomass were produced between lentil and vetch varieties at Booleroo and Eudunda in 2020 (P>0.05, data not shown). Average biomass production was 0.99 t/ha at early flowering and 4.95 t/ha at early podding growth stages at Booleroo, with vetch producing more biomass than lentil at both growth stages that biomass was measured. Although there were no differences in biomass production between varieties, there were differences in crop height at the early podding growth stage (Figure 2 and 3). Varieties with greater crop height, such as Morava vetch, have improved cutting ability for hay production. PBA Jumbo2⦶ lentil had the highest grain yield of all lentil and vetch varieties at Booleroo in 2020 (Figure 4). Differences in grain production were observed between lentil varieties but not vetch varieties, indicating the importance of variety selection in lentil. Additional trials are required in future seasons to further validate this research under different seasonal conditions and on different soil types.

Table 2. Biomass production (t/ha) at early podding and grain production (t/ha) responses to multiple seeding rates of lentil and vetch. LSD = least significant difference. n.s. = not significant.

Seeding rate	**Eudunda**		**Booleroo**		**Kimba**		**Stokes**	
	Biomass yield	**Grain yield**	**Biomass yield**	**Grain yield**	**Biomass yield**	**Grain yield**	**Biomass yield**	**Grain yield**
Recommended	5.2	3.0	5.2	2.6	1.7	0.8	2.6	1.7
Three-quarter	4.8	3.0	4.8	2.7	1.6	0.7	2.2	1.6
Half	4.4	2.8	4.5	2.6	1.5	0.7	2.0	1.5
LSD (P<0.05)	*0.5*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*0.36*	*n.s.*

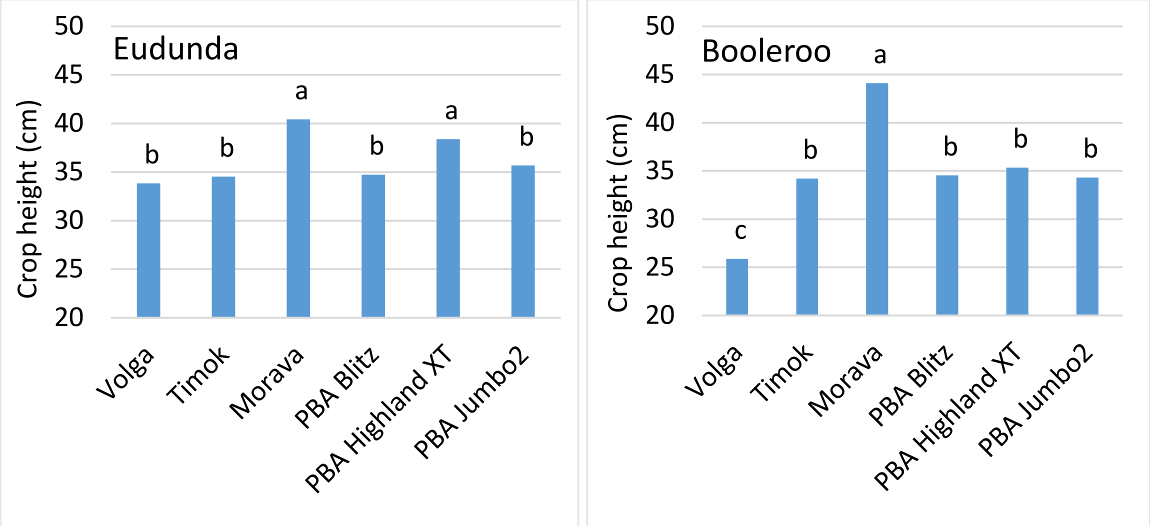

Figure 2 and 3. Crop height (cm) of lentil and vetch varieties during the early podding growth stage, averaged across plant sowing densitities, at Eudunda and Booleroo 2020. Bars labelled with the same letters are not significantly different (P<0.05).

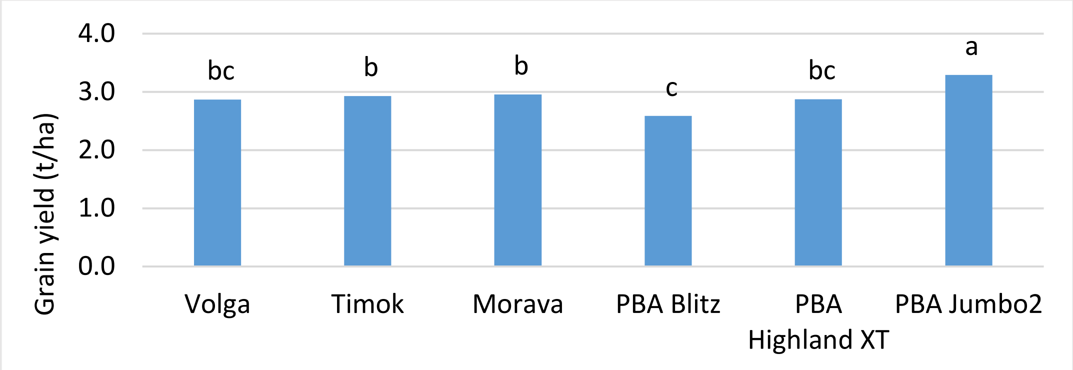

Figure 4. Grain yield (t/ha) response of lentil and vetch varieties averaged across plant sowing densitities, at Eudunda 2020. Bars labelled with the same letters are not significantly different (P<0.05).

Gibberellic acid use in vetch

The application of GA at the late vegetative growth stage increased vetch plant height by 3.8 cm at Kimba and 5.4 cm at Booleroo compared to the Nil plots (Table 3). However, the early podding GA application reduced plant height by 6.8 cm compared to the Nil treatment at Booleroo. It is important that when GA is applied there is adequate soil moisture and nutrition to support and sustain the rapid growth. Following dry seasonal conditions in winter it is likely that soil moisture levels were not adequate to support the late growth of vetch when GA was applied at early podding. Although GA did increase vetch plant height, there was no biomass production response to GA. Vetch biomass production was 0.2 t/ha at late vegetative and 6.7 t/ha at the early podding growth stage at Booleroo. Production potential was much lower at Kimba, with 0.18 t/ha biomass at late vegetative and 2.3 t/ha at early podding. There was no grain yield response to GA application in 2020. However, a negative grain yield response has been observed in previous research trials from the application of GA. Further research is required to quantify the effects of GA on vetch biomass production, grain production and phenology under different environmental conditions.

Table 3. Mean plant height (cm) response to the application of gibberellic acid applied at late vegetative and early podding growth stages at Booleroo and at late vegetative growth stage at Kimba, 2020. LSD = least significant difference. Different letters indicate a significant difference.

Site	**Kimba**		**Booleroo**			
Treatment	**Late vegetative** *Plant height (cm)*		**Late vegetative** *Plant height (cm)*		**Early podding** *Plant height (cm)*	
Nil	8.6	b	11.3	b	82.8	a
GA @ 6-8 weeks	12.4	a	16.7	a	84.4	a
GA @ early podding	9.0	b	11.5	b	76.0	b
LSD (P<0.05)	*1.34*		*0.66*		*5.95*	

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC (DAV00150 – Southern Pulse Agronomy), and the authors would like to thank them for their continued support. The continued assistance in trial management from SARDI Agronomy groups at Clare, Pt Lincoln and Minnipa is gratefully acknowledged and appreciated.

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2. Day, S., P. Roberts, and J. Davidson, *New approach needed for successful pulse management in low rainfall environments*, in *GRDC Grains Research Updates*, ORM, Editor. 2021: Adelaide.
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Vetch Pre-Emergent Herbicide Options

Author(s): Stefan Schmitt
Funded By: UNFS & Nelshaby Agricultural Bureau
Project Title: Vetch Pre-Emergent Herbicide Options
Project Duration: 2019-2020
Project Delivery Organisations: Agricultural Consulting and Research

Key Points:

- There was no impact on the yield of vetch from any of the herbicide treatments used in this season when compared to control plots.
- Reflex herbicide demonstrated improved efficacy on mallow compared to all other treatments.
- Terbyne Xtreme demonstrated improved efficacy on mallow and medic compared to the district standard Diuron.

Background
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 and lack of knockdown opportunities.

This is the second year that this trial has been conducted. In 2019 a similar trial was conducted exploring both pre and post emergent options to control problem weeds such as statice, iceplant, mallow and medic. The trial size in 2020 was reduced and limited to pre-emergent options as at present there are no in crop options for broadleaf weed control in vetch that offer 100% crop safety.

This trial was sown dry on the 21st of April, there was no weed germination at the site at time of sowing. Unfortunately, in this season no statice or iceplant was present at this site so no observations could be made on efficacy of the new pre-emergent Reflex on these target weeds.

Note Reflex 240g/L Fomesafen by Syngenta will be available this year. This product is a group G herbicide that will be registered for the control of a range of weeds in vetch. Reflex will offer a broader weed control spectrum than traditional group C vetch pre-emergent products.

Treatments

1. Diuron 500g/ha IBS
2. Terbyne 875 at 500g/ha IBS
3. Frequency 200mls/ha IBS
4. Reflex 500mls/ha
5. Reflex 1L/ha IBS
6. Reflex split 500mls/ha IBS + 500mls/ha PSPE*
7. Control

* Note the first application of 500mls/ha of Reflex did not go out at the planned rate.

- Frequency is not registered in Vetch
- * IBS (Incorporated by sowing)
- *PSPE (post sowing pre-emergent)

Sowing Details
Sowing date: 21st April
Soil conditions: Dry
Variety: Vetch – Timok at 35kg/ha
Sowing Speed: 4.5km/hr

Application Details
Hand Boom: Treatments applied at 100L/ha with hand boom.
Water Source: Adelaide Mains.

Results
Out of the six products used in this trial (Figure 1) Terbyne and Frequency** provided the best control of medic achieving 70% control. Please note that Frequency is not registered for this use pattern. Diuron at 500g/ha which is considered the 'district practice' treatment provided marginal control at 55%, whilst Reflex at both low and high rates and split applied provided very slight suppression at 10% control.

For mallow control (Figure 2) all products used provided useful suppression. The best treatment was Reflex 1L/ha IBS achieving 85% control of mallow. Terbyne and Frequency** NR were slightly behind but still very useful achieving 78% control of mallow. The 'district practice' treatment of Diuron achieved marginal control at 58%. Reflex at 500mls/ha, which is the lowest label rate, provided slightly less control than the Frequency and Terbyne treatments. The split application treatment of Reflex was only marginally better than Diuron however, this treatment was applied at a reduced rate then stated, the result should therefore be treated with caution.

The grain yield of vetch (Figure 3) was not impacted by the use of any chemical treatments in this season. As there were no significant differences between the mean plot yields of applied treatments.

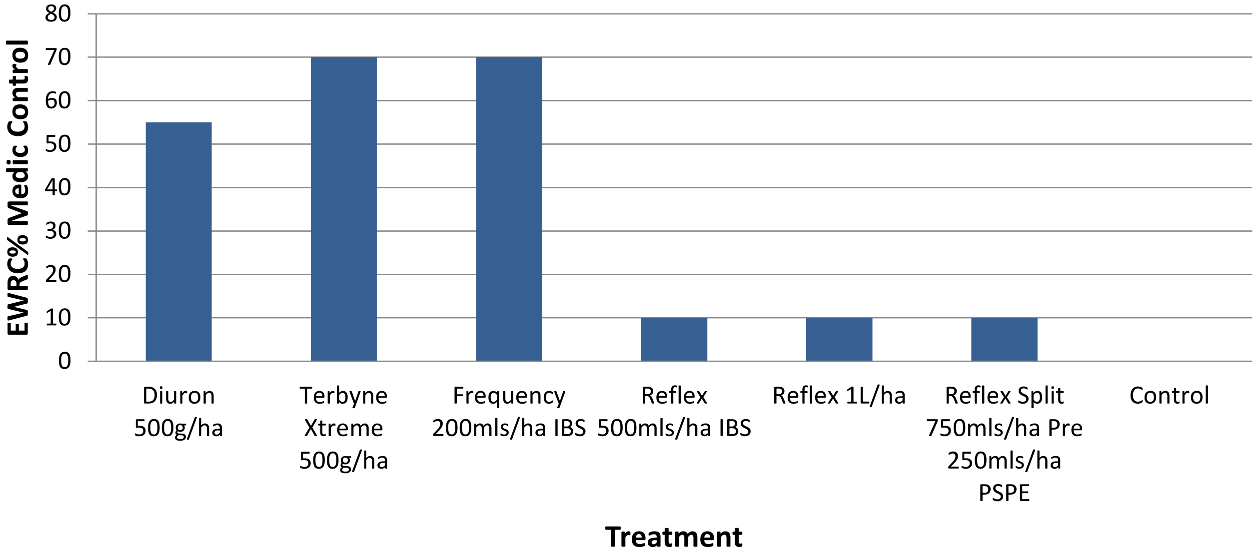


Figure 1. Efficacy of herbicide treatments on controlling burr medic scored using EWRC rating scale.

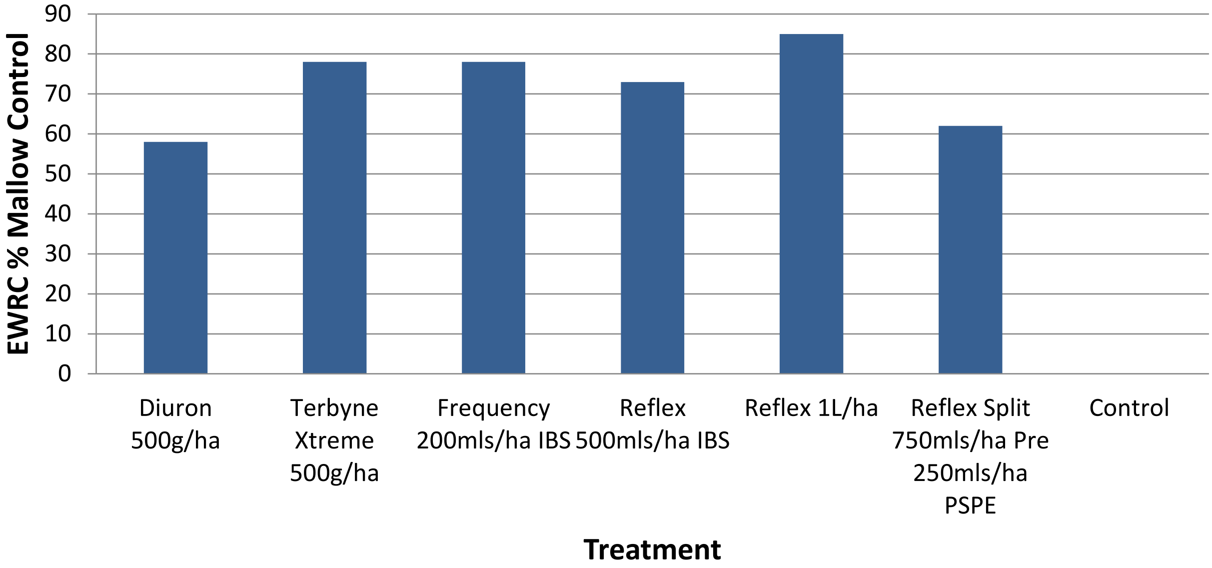


Figure 2. Efficacy of herbicide treatments on controlling marshmallow scored using EWRC rating scale.

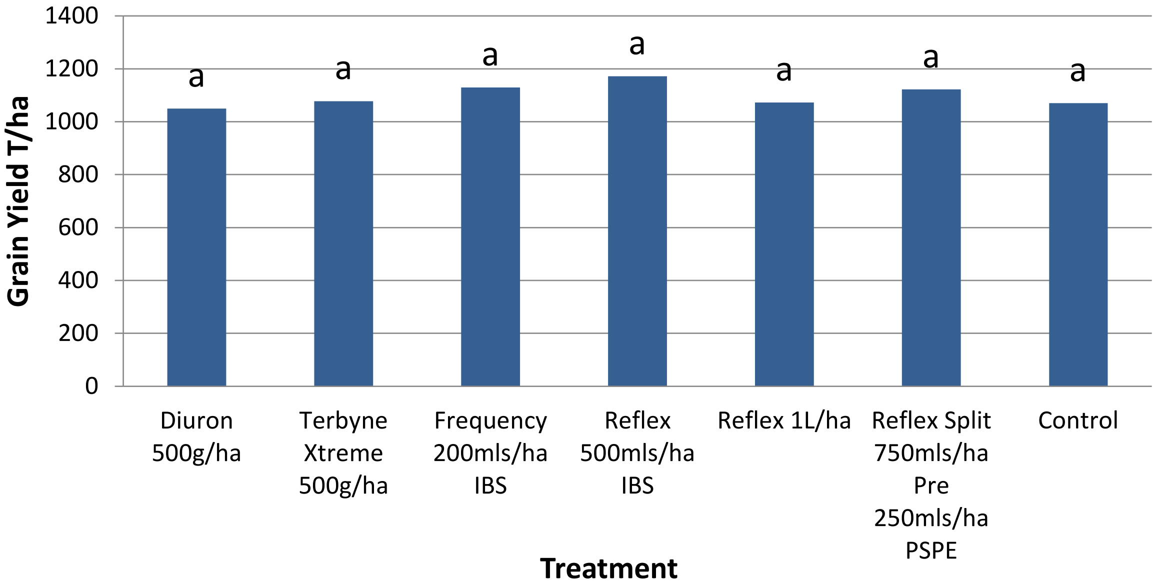


Figure 3. Average yield of herbicide treatment t/ha. An analysis of variance (ANOVA) was conducted on the data using R statistical software. Treatment means have been grouped using Tukey's HSD at the 95% level of confidence. Treatment means with letters in common do not significantly differ from one another.

Discussion

In this season despite large rainfall in the post sowing, all pre and post sowing treatments demonstrated good crop safety. Reflex 1L/ha IBS and Terbyne Xtreme demonstrated improved marshmallow control compared to the district standard of Diuron. Terbyne Xtreme demonstrated improved control of medic and mallow when compared to the district practice treatment of Diuron.

Acknowledgements

- A big thankyou to Leighton John for providing land for the trial site.
- The Nelshaby Agricultural Bureau for providing additional funding support.
- Upper North Farming Systems funding for this project was made possible through the contributions of those involved with the UNFS Commercial Paddock. Thank you to the landholder Northern Ag and to all our volunteers that manage this fundraiser for the UNFS Group.
- Thanks to Syngenta and BASF for providing trial resources.

Vetch pre-emergent herbicide options trial on 24 July 2020

In Season Cover Crop Options for the Upper North: Reducing Soil Borne Disease and Improving Soil Health Summary

Author: Jade Rose
Funded By: National Landcare Program; Smart Farming Partnerships Initiative Round 1, Subcontracted through Ag Ex Alliance
Project Title: Warm and cool season mixed cover cropping for sustainable farming systems in southeastern Australia
Project Duration: 2019 - 2022
Project Delivery Organisations: *Upper North Farming Systems, Elders Jamestown – Darren Pech*

Key Points:

- The crimp roller was ineffective with terminating the medic plots
- Soil testing to assess the effect of the 2020 cover crop occurred in early 2021

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.

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 on the corner of White Cliffs and Miller roads in a paddock that has been underperforming while on a good soil type.

Paddock Trial Plan: 3 years, 3 treatments, 4 replicates, Plot lengths – 60-100m long. Sown with growers' seeder.

Trial Layout: Total Area: 156m x 100m - Rep 1 Rep 2 Rep 3 Rep 4

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

Table 1. Treatments for year 1, 2 and 3 and termination process at the cover crop site, Booleroo

Treatment	Yr 1- 2019	Yr 2 - 2020	Yr 3 - 2021	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

2019 Mix species composition: 5 species:
Smart Radish, Bouncer Brassica Rape, Subzero forage rape, Balance Chicory, Volga vetch

2020 Treatments/Terminations:

Treatment 1 – self-sown/regenerated medic

Treatment 2 – 43Y92 canola @ 2.5kg/ha

Treatment 3 – Mixed species @ 2.5kg/ha (Smart radish, Bouncer Brassica hybrid, Subzero forage rape, Cobra balansa clover, Compass chicory, Volga vetch)

1. Early termination – crimper
2. Early termination – speed tiller
3. Early termination – brown manure
4. Late termination – crimper
5. Late termination – speed tiller
6. Late termination – brown manure

The cover crop species were terminated prior to seed set via the termination list above. The second treatment on the trial incorporated an earlier termination, or green manuring to ascertain whether this improves the rate of soil health changes within the paddock.

Image 1. (L-R) Canola treatment, regenerated clover, cover crop mix with regenerated medic – All taken 30/6/2020 (Darren Pech, Elders)

Results and Discussion

The effects of the cover crop to soil health in the 2020 trial will be determined in 2021, soil testing across the site was undertaken in early 2021 including predicta B results. The 2021 trial was sown to wheat in which yield will be determined at harvest.

Acknowledgements:

- Matt Nottle for the paddock and cooperation
- 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 in this trial.
- Marg Evans – Soil Disease Technical Expertise and sampling.

MIXED COVER CROPS

FOR SUSTAINABLE FARMING

Project Update

March 2021

The project has made significant progress due to improved growing conditions with good rainfall across south eastern Australia in 2020.

A reduction in numbers allowed at gatherings due to COVID restrictions has impacted the way some activities within the project areas have been delivered. In particular cross region restraints (site visit access in Victoria and Tasmania) have prevented project collaborators from meeting up physically to discuss results and reduced the opportunities of providing feedback.

Due to significantly better climatic conditions throughout this project period there has been a considerable improvement in the quality of cover crops. Rainfall Australia wide throughout August was 10% above average and in October was 35% above average across much of the country. October rainfall was the ninth wettest on record for South Australia. The above average start for sowing winter/spring cover crops lead to exceptional results seen in some trials and other summer trials are progressing well.

Project Focus & Activities

The Mixed Cover Crops project started in 2018 and the purpose of the project is to assess the suitability of mixed species cover crops for use in the farming systems of the Southern Region of Australia. The primary focus is the traditional summer fallow, but some cool-season work has also been conducted. There are 20 demonstration trials across the southern region, each evaluating the performance of a mixed cover against a single species or typical summer weed-controlled fallow.

Project structure

The project has three components:

1. Five species evaluation trials to evaluate cover crop species across different soils and climates, established on a small plot basis
2. Nine termination trials testing timing and method of cover trop termination
3. Twenty demonstration trials which span from Streaky Bay in the West to Tasmania, and cover the Upper and Lower Eyre Peninsula, Upper and Mid North, Mallee, Kangaroo Island, South-East, Gippsland, and Tasmania. These are at least one seeder width scale. In the coming months, soil samples will be analysed from these 20 trials.

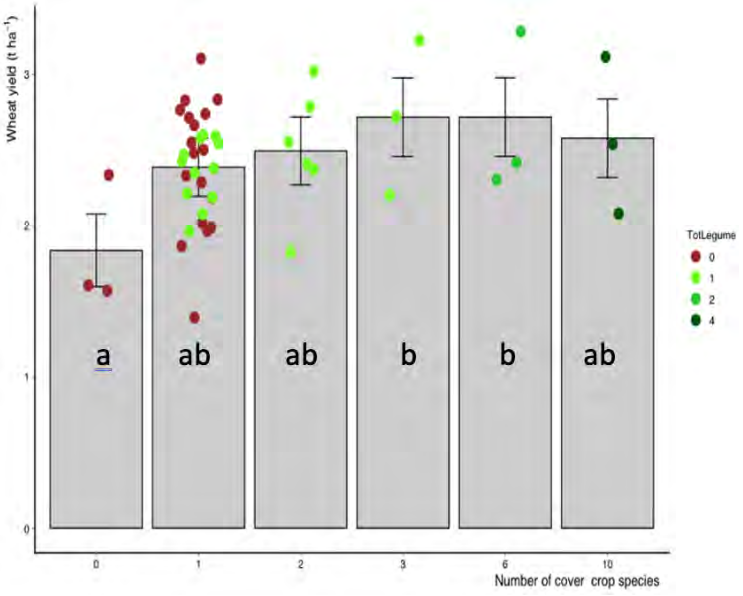
What are we looking for?

To establish where mixed species cover crops can be successfully established without negatively impacting the following cash crop’s yield. Then how the treatments have impacted on soil physical, chemical and biological parameters. Soil testing of all 20 sites is being conducted in autumn 2021, prior to establishment of the final cash crop. Entomology surveys are also being conducted at a number of the demonstration sites over the life of the project.

Soil data

Cover crops have the capacity to alter soil chemical, biological and physical properties. Due to their sensitivity to change, we are placing particular emphasis on factors impacting soil nitrogen cycling and other measures of soil health. We are also investing effort to understand how the cover crop treatments impact the location of water and nutrients within the soil profile.

Early results from the Minnipa winter species selection trial indicate that cover crops may positively impact availability of both water and nitrogen early in crop growth, resulting in significant increases in yield relative to the fallow in some of the mixes. Traditional soil measurements including pH, soil moisture and organic carbon are also being quantified. Along with the physical and biological measurements, the entire dataset, which will be unified across the 20 sites, will enable us to interpret the grain yield and quality results as a function of the cover crop treatments (none, single or multi) and their impact on soil function. They will allow us to understand where and why trends differ across the study area. We expect data to start coming available on the project website early 2022.



Demonstration Trial Sites Progress

AIR EP's demonstration sites being maintained by the farmers, having sown and managed the paddock treatments consistently over the past two years, ensuring all components are documented.

Mixed species trial sites managed by Upper North Farming Systems have performed very well through the whole growing season resulting in the best ground cover and biomass to date. The demonstration paddock was successfully sown on time and with good germination. All treatments have established well in 2020.

Some sites managed by SA No-Till Farmers lacked soil moisture and were not suitable to plant a summer cover crop.

The Lowbank trial site managed by the Murraylands and Riverland Landscape Board is one of the lowest rainfall sites in this project. Aided by a near average rainfall in season 2020 the growth at this trial site has been a vast improvement on previous years. A field day was held at this site with discussion including the visual benefits to the root systems of diversified planting. Highlighting the significant difference in root ball mass where different plant roots were closely intertwined. Discussion also included the role of mixed species over summer and their role in changing the soil rhizosphere through the fostering and proliferation of a wide host of beneficial microorganisms.

There were some challenges surrounding crop rotation and subsequent timing of treatments in the Tasmanian demonstration site. Plans are in place and seed organised for sowing into its cover crop phase following harvest. This paddock demonstration was in its cover crop phase from March through to late August when it was terminated and sown into a spring barley cash crop. Distinct visual differences have been observed in the spring barley crop, with the fallow areas showing up much lighter compared with the cover cropped areas of this trial.

Ashley Amourgis, SFS Research and Extension Officer, has been busy mixing up cover crop blends and inoculating soybeans for a paddock demonstration as a part of the 'Mixed Cover Crops for Sustainable Farming' project.

Paddock demonstration trials have continued through this reporting period at the two Victorian sites. The SW Victoria and Gippsland sites have both been in their cash crop rotation for much of this period. The trial in SW Victoria was in its cash crop of faba beans which was harvested late December. Two days following harvest, the cover crop treatment was sown directly into the bean stubble and these plants have begun to establish. The paddock demo in Gippsland remains in its cash crop of wheat, with harvest planned for Jan-Feb 2021. The final biomass sampling of the cover crop in paddock demonstrations for SW Victoria and Gippsland will be completed in March 2021, along with the soil sampling post-termination, prior to sowing the final cash crop.

Evaluating how summer cover crops impact weeds and dry matter in the following cash crop for Gippsland's farmers.

Cover Crop Species Evaluation Trials Progress

Unfavourable climatic conditions early in the project delayed some of these being sown and germinating. Good conditions in 2020 mean all of these trails have either been completed or are under way.

The first AIR EP species trial sown January 2020 failed to establish evenly due to lack of follow up rain, so a second species trial was sown in November 2020. The site has now established much better this time, with ongoing monitoring for pest species being undertaken.

Termination Trials Progress

Four termination trials were completed during this stage with some data still being collated and will be reported for the next stage. Two other termination trials will occur as demonstration sites are at the appropriate growth stages over the coming months. Following termination trials in Tasmania, Southern Farming Systems conducted another replicated termination trial at the SFS trial site in SW Victoria in early 2021 using the crimp roller as one treatment. A field day and demonstration of the roller in use is planned.

Cover crops species trail at Wangary

Knife rolled plots at the Robinson Terminational trial near Hoyleton In October 2020

Invertebrate Monitoring Update

Ag KI is assisting with sticky traps on the island to assess the flight patterns of diamond back moth and native budworm in mixed species versus single species in canola and faba bean resulted in traps having to be changed twice.

Sticky Trap

Smart traps were deployed at one site to test pest differences between mono and poly cultures in the spring of 2020. However, the lack of telecommunications support in rural areas hindered the use of this technology. Smart traps were ground truthed using delta traps and sweep netting to support local growers adopt IPM. Preliminary analysis from three sites comparing three different pest species suggests no difference in pest numbers between mono and poly cultures. A greater number of beneficial invertebrates was detected in mixed species paddocks, but this result needs to be confirmed with further monitoring next season. Individual reports are being completed.
Once finalised, IPM monitoring data will be incorporated into information regarding invertebrates associated with various cover crop species, which will then be added to the current species review developed by Jenny Stanton.

A pilot study indicated the choice of cover crop termination method may influence ground dwelling invertebrate communities, with spray seed associated with increased Portuguese millipede abundance. This result needs to be repeated.
Winter and spring surveys (pitfall trapping) found lower relative abundance and species numbers of ground dwelling invertebrates in the cover crop paddock in the Mid North. However, a greater number and diversity of ants in the cover crop paddock in spring could provide greater soil porosity.

Smart traps monitoring diamond back moths in mixed species canola.

Increasing plant diversity enhances the natural control of insect herbivory in grasslands. Species-rich plant communities support natural predators and simultaneously provide less valuable ood for herbivores. This was found by a team of researchers led by the German Centre for Integrative Biodiversity Research (iDiv), who conducted two analogous experiments in Germany and the U.S. Their results were published in *Science Advances* and show that increasing plant biodiversity could help reduce pesticide inputs in agricultural systems by enhancing natural biological control. https://phys.org/news/2020-11-diversity-pesticide.html

Checking out the invertebrates in establishing #mixedspecies emerging on abundance of spring moisture

SANTFA Articles
Two new articles relating to the place of mixed species in farming systems can be found on the project web site at https://research.csiro.au/mixedcovercrops/santfa-cover-crop-articles/

Mother Nature Knows Best. The future of agriculture depends on farmers working with natural ecosystems, according US researcher Dr Dwayne Beck, who shares his model for creating profitable and sustainable cropping systems that rebuild the soil and ensure a sustainable supply of food for generations to come.

Drought Tolerance Through Regenerative Farming. Drought conditions in NSW have put Michael Inwood's focus on sustainable and regenerative agriculture to the test but he is seeing promising signs that a combination of plant diversity, pasture cropping and rotational grazing will carry his farm through the dry spells.

Does mixed cover cropping in winter have a place in the low rainfall Mallee?
Mallee Farming Systems have produced a fact sheet addressing the place of mixed cover crops in the region. The fact sheet attempts to answer the following questions:
What is mixed cover cropping?
What are the potential benefits to my farm?
How would mixed cover cropping work in my Mallee farming system?
Find the fact sheet at https://msfp.org.au/wp-content/uploads/Does-mixed-cover-cropping-in-winter-have-a-place-in-the-low-rainfall-Mallee-1.pdf

Project web site
The project web site provides all the relevant background and resources produced in the. Project to date. Go to https://research.csiro.au/mixedcovercrops/

Project Proponents

Ag Excellence Alliance
CSIRO
SANTFA

Project Funders

Australian Government
National Landcare Program
Government of South Australia
Department for Environment and Water
GRDC

Mixed species cropping and intercropping: where, how and why?

Penny Roberts[1,3] **and Amy Gutsche**[2]
[1]SARDI Clare, [2]SARDI Port Lincoln, [3]Affiliate of The University of Adelaide

Location
Tooligie Hill
Bill Long
Rainfall
Av. Annual: 331 mm
Av. GSR: 249 mm
2020 Total: 287 mm
2020 GSR: 252 mm
Paddock history
2019: Barley
2018: Wheat
2017: Field Pea
Soil type
Sandy loam
Soil test
0-10 cm pH = 8.33 (water), Nitrate N 5 mg/kg, Ammonium N 2.2 mg/kg, PBI + Col P 39, Organic Carbon 0.85%
Plot size
2 m x 10 m x 3 reps
Trial design
Experimental: Split plot, whole plot = row arrangement, sub plot = companion variety
Yield limiting factors
Frost, residual herbicide damage

Key messages

- **In 2020, intercropping was more productive than monoculture cropping at the medium rainfall site of Tooligie Hill. The results from this one-year trial are consistent with the outcomes of previous intercropping work in South Australia.**
- **Adoption of an intercropping system needs careful planning including the species mix, variety choice, and the logistics of seeding, weed control and harvest. This planning can lead to productivity gains and ancillary benefits including soil health.**

Why do the trial?

The aim of this work is to increase combined pulse-oilseed productivity and profitability in the medium rainfall zone. Additionally, to increase the knowledge of mixed cropping systems and begin dialog around adapting from a monoculture system to mixed species systems.

There is a need for more robust break crop systems in the low and medium rainfall zones where traditional break crop systems are not yield stable, and risk leaving paddocks susceptible to erosion. Intercropping is a system that has been shown to provide production and sustainability benefits in low rainfall cropping systems. Nine field trials conducted across South Australia from 2016 to 2020 achieved productivity gains of 30 to 80% compared to monoculture, with combinations of canola and either lentil or vetch. Early season ground cover was improved in some intercrop combinations over traditional monoculture systems (Roberts *et al*. 2019 and Roberts, unpublished). This work demonstrated that intercropping has the potential to increase productivity and could lead to ancillary benefits such as increasing groundcover on erosion prone soils.

What happened?

To determine the relative productivity benefit of intercropping, compared to growing crops as monocultures, land equivalent ratio (LER) values were calculated. The LER is expressed as:

$$LER = LA + LB = YA/SA + YB/SB$$

Where LA and LB are the LER for the individual crop yield components, YA and YB are the individual crop yields in the intercrop combinations, and SA and SB are the yields of the monocultures (adapted from Mead and Willey, 1980). An LER value of 1.0 means the productivity of the intercrop components was equivalent to the monocultures. An LER value of <1.0 means the productivity of the intercrop components are less than the monocultures, while an LER value >1.0 means the intercrop components are more productive than the monocultures, which is referred to as 'over-yielding'.

Consistent with the results from previous work the intercropping treatments at Tooligie Hill (Table 1) over-yielded, meaning it was more productive to grow the two crops as a mix compared to growing them as separate monoculture crops (Figure 1). The largest productivity benefit was achieved when growing the pulse crop with a short stature and low yielding canola variety for this environment. Canola-pulse combinations generally performed better than pulse-pulse combinations, however, lentil-faba bean appeared promising from this first year trial. With the exception of the chickpea-faba bean combination, all other intercrop combinations could be harvested, and the two grain types separated with ease.

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Table 1. Trial management details at Tooligie, 2020.

Trial design	**Split plot; whole plot = row arrangement, sub plot = companion variety x 3 replications.**
Treatments	Whole plot 1. Sole faba bean 2. Sole canola 3. Sole lentil 4. Sole chickpea 5. Lentil + faba bean mixed row 6. Lentil + canola mixed row 7. Lentil + faba bean skip row 8. Lentil + canola skip row 9. Chickpea + faba bean mixed row 10. Chickpea + canola mixed row 11. Chickpea + canola skip row 12. Chickpea + faba bean skip row Sub plot 1. Short variety (ATR Bonito/PBA Marne) 2. Tall variety (Nuseed Diamond/PBA Samira) 3. Imi tolerant variety (Pioneer43Y92/PBA Bendoc)
Varieties (sole plots)	Chickpea: CBA Captain Lentil: PBA Hallmark XT Canola and faba bean: as per sub plot treatments
Management	Sowing date: 13 May 2020 Fertiliser applied at sowing: 100 kg/ha MAP Fertiliser applied to monoculture canola: 100 kg/ha MAP In crop fungicides and herbicides: Clethodim @ 800 mL/ha (2 applications), Mancozeb @ 2.2 kg/ha, Carbendazim @ 500 mL/ha, Aviator Xpro @ 600 mL/ha (2 applications), Veritas @ 1 L/ha, Weedmaster DST @ 2 L/ha Harvest date: 20 December 2020
Measurements	Soil nitrogen, Plant numbers, NDVI, Plant height, Biomass at late flowering early podding (hay cut simulation), Lowest pod height, Harvest index, Grain yield, Grain quality
Analysis	A spatial analysis was undertaken on the data using Genstat version 20.1.

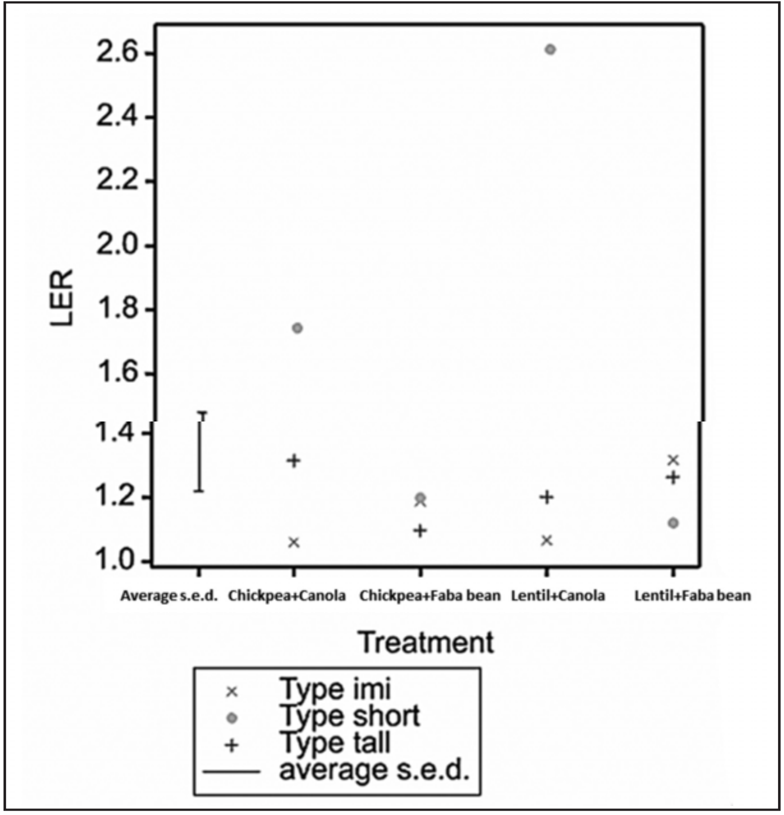

Figure 1. Intercropping demonstrates grain yield benefits for the intercrop combinations with land equivalent ratio (LER) values of greater than one at Tooligie Hill, 2020.

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Whilst, productivity gains from intercropping can be measured using LER, it assumes equal value of the two crops and doesn't account for the relative proportion that each crop contributes to the overall plot yield. The aim of the work at Tooligie Hill was to achieve most of the intercropping yield and economic return from the pulse crop, as such the canola is considered the secondary crop in this system and sown at a reduced seeding rate in intercropping treatments. The lower canola plant numbers in the intercrop, compared to the monoculture canola that was sown at the full seeding rate, is reflected in the grain yields. The canola grain yields were lower in intercrop compared to monoculture canola, ranging between 54% and 90% of the monoculture canola yields (Figure 2a).

The impact of intercropping on the pulse crop varied between the pulse species and was influenced by variety (Figure 2b, 2c, 2d). Intercropping chickpea with canola was largely more successful than intercropping chickpea with faba bean, with the chickpea grain yield when intercropped with faba bean 37% to 40% of that of monoculture chickpea (Figure 2b and 2c). The canola variety was an important factor in the relative yield of the intercropped chickpea and lentil compared to the monoculture crop of each. When intercropped with a low yielding canola there was no yield reduction of the pulse in the intercrop, conversely when intercropped with the higher yielding canola varieties yield was reduced by 36% to 61% for chickpea intercrops, and 36% to 61% for lentil intercrops. Intercropping lentil and faba bean showed relative yield reductions of 28-47% and 41-53% in each crop, respectively (Figure 2c and 2d).

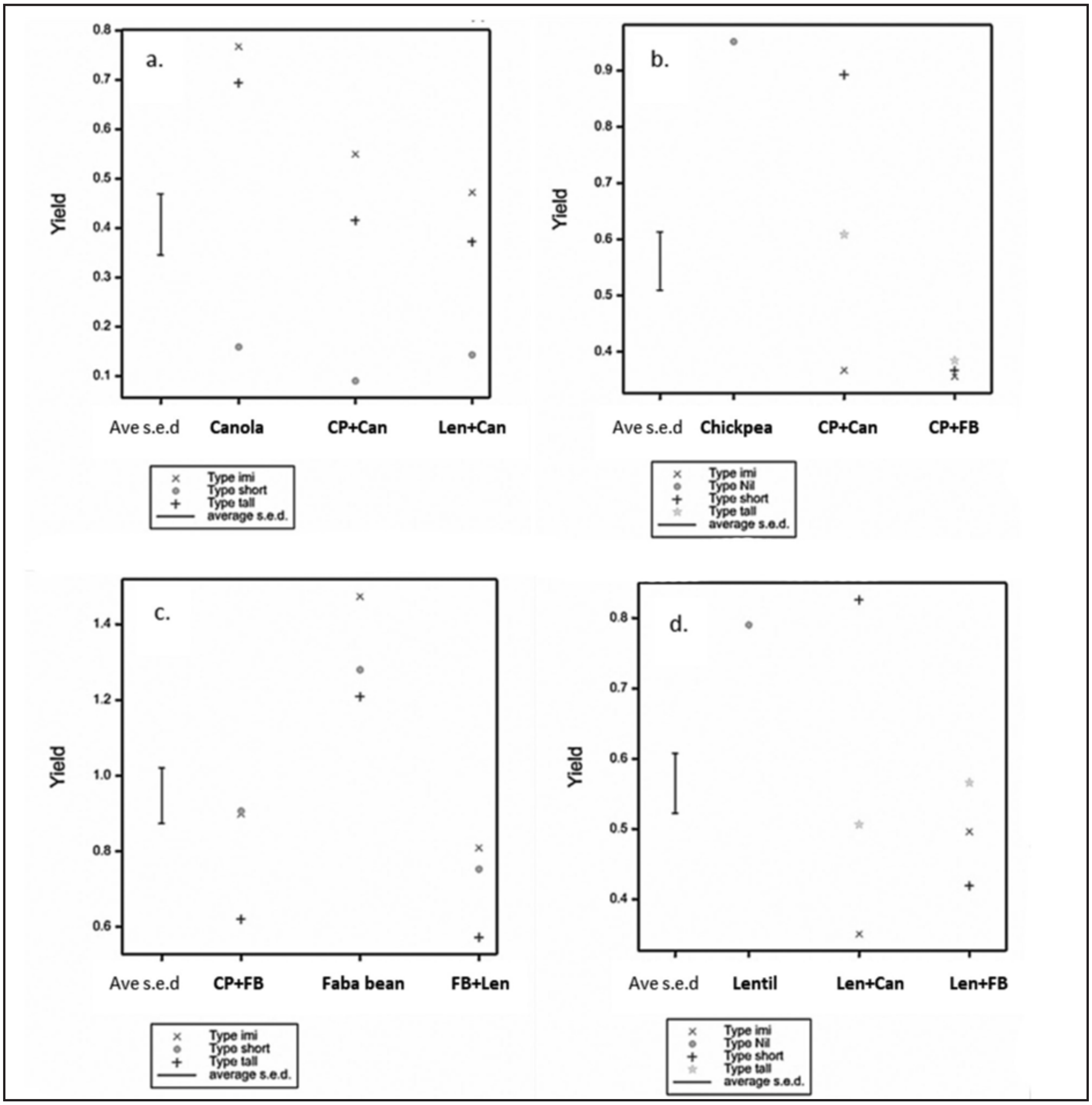

Figure 2. Grain yield (t/ha) was generally reduced in intercrop compared to the sole crop treatments a) canola, b) chickpea, c) faba bean, and d) lentil. Key: CP = chickpea; Can = canola; FB = faba bean; Len = lentil.

What does this mean?

This work demonstrated the suitability of intercropping in the medium rainfall zone of the Eyre Peninsula for some combinations. Whilst the data represents only one season, results are consistent with previous intercropping work undertaken in the low to medium rainfall zones of South Australia and it is reasonable to conclude that some intercropping combinations can be more productive than monoculture cropping in this environment. All intercrop combinations in these trials over-yielded, meaning they were more productive than growing the components as monoculture crops. The best intercropping combinations measured by productivity gain (LER) in this trial were canola-pulse and lentil-faba bean. This supports previous work demonstrating vetch-canola and vetch-lentil as the most promising combinations for the lower rainfall environments.

The additional complexity of intercropping systems includes logistical challenges during sowing, harvest, handling and grain storage. Some types of intercropping lend themselves to a more seamless integration into current farming practices than others. However, with careful planning including the species mix, variety choice, and the logistics of seeding, weed control and harvest, these systems can be successfully adopted at a broadacre scale as demonstrated by grower adoption of intercropping in Australia. To support an increase in adoption of intercropping systems there is a need to support growers through a combination of peer-to-peer learning and further focused research and validation trials.

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Mixed cover crops for sustainable farming

Fiona Tomney[1] and Mark Stanley[2]

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

Location
Minnipa Ag Centre, paddock S8
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2020 Total: 367 mm
2020 GSR: 255 mm
Paddock history
2019: Mixed Cover Crop species trial
2018: Medic pasture
2017: Scepter wheat
Soil type
Red sandy loam
Plot size
12 m x 1.5 m x 4 replicates

Key messages

- **Crop intensive farming systems are running down soil carbon.**
- **Mixed species cover cropping offers a new approach that may address the issue.**
- **The cover crop species grown in 2019 had no influence on the growth, yield and grain quality of the wheat over-sown in 2020.**

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.

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.

This article reports a trial at Minnipa which investigated mixed species cover crops grown over winter and their impact on wheat production the following year.

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.

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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 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 is a hay variety 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 sheep.

Mandy's Mix was included because oats and medic produced the most dry matter of the mixes included in a 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 the 2011 - 2014 'Crop Sequences' trial.

Fi's Mix was selected to represent a balance of species from cereals/ grasses, legumes and brassicas.

Dry matter cuts were taken on 13 September 2019 at early grain fill as a measure of maximum biomass. The trial was terminated with glyphosate on 2 October 2019 to prevent seed set and further water use.

Table 2. Average yield (t/ha) for wheat sown at Minnipa, 9 November 2020.

Cover crop species	Wheat yield (t/ha)
PM-250 strand medic	2.21
Volga vetch	2.51
Field peas	2.29
Mulgara oats	2.48
Safeguard annual ryegrass	2.43
Cereal rye	2.33
Triticale	2.34
Stingray canola	2.64
Tillage radish	2.18
Narbon beans	2.45
Control (fallow)	1.84
Ten Species Mix	2.58
Jake's Party Mix (oats, vetch & canola)	2.72
Mandy's Mix (oats & medic)	2.66
Fluff's Mix (canola & field peas)	2.34
Fi's Mix (tillage radish, ryegrass, cereal rye, oats, field peas & vetch)	2.68
LSD (P=0.05)	*ns*

On 11 May 2020 the trial was sown to Scepter wheat to evaluate the impact of each cover crop option on crop performance. Plant emergence and crop vigour (estimated by a Green Seeker) were assessed. The wheat was harvested on 9 November 2020 and grain quality measured.

What happened?

In 2019 Mulgara oats produced the most dry matter of all treatments with 2.94 t/ha at early grain fill. Of the mixes Fi's Mix produced the most dry matter with 2.60 t/ha. The PM-250 strand medic produced the lowest amount of dry matter with 0.48 t/ha.

The cover crop species grown in 2019 had no influence on the growth of the wheat over-sown in 2020. The average wheat yield across the trial was 2.42 t/ha. The 2019 cover crop mixture of oats, vetch and canola (Jake's Party Mix) produced the highest wheat yield in 2020 with 2.72 t/ha and the wheat sown over the fallow the lowest with 1.84 t/ha, however no variation in wheat yield was statistically different. Grain quality of the harvested wheat was similar for all treatments.

What does this mean?

Whilst some cover crop species were shown to grow more vigorously and/or produce more biomass than some of the traditional break crop options, this had no influence on the growth, yield nor grain quality of the following wheat crop. Cover crops can potentially improve soil health, nutrient cycling, organic carbon, and soil moisture; decrease weed populations and increase the population of beneficial insects, however these aspects were not monitored in this trial.

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.

Upper North Farming Systems Membership List 2020 - 2021

Title	First Name	Last Name	Partners Name	Town or Business
Mr	Ashley	Afford	Les	Port Pirie
Mr	Jordan	Arthur		Booleroo Centre
Mr	Tim	Arthur		Melrose
Mr	Peter	Barrie	Di	Orroroo
Mr	Howard	Bastian	Toni	Booleroo Centre
Mr	Braden	Battersby	Emilie	Wilmington
Mr	Michael	Battersby	Catherine	Wilmington
Mr	Colin	Becker	Joy	Caltowie
Mrs	Joy	Becker	Colin	Caltowie
Mr	Henry	Bennett	Adele	Tarcowie
Mr	William	Bennett	Emma	RSD Pekina
Mr	Dustin	Berryman		Northern Ag PL
Mr	Shaun	Borgas	Marisa	Booleroo Centre
Mr	Donald	Bottrall	Heather	Jamestown
Mr	Kyle	Bottrall	Emma	Jamestown
Mr	Damian	Bradford		ADM Australia PL
Mr	Brendon	Bradtke		Jamestown
Mr	William	Bray		Jamestown
Ms	Anne	Brown		Wirrabara
Mr	Malcolm	Buckby		SAGIT
Mr	Benjamin	Bury		Wilmington
Mr	Bevin	Bury		Wilmington
Mr	David	Busch	Lisa	Tothillbelt
Mrs	Emily	Byerlee		Orroroo
Mr	Malcolm	Byerlee		Orroroo
Mr	Neil	Byerlee		Orroroo
Mr	Todd	Carey		Wilmington
Mr	John	Carey		Wilmington
Mr	John (JP)	Carey	Nicole	Booleroo Centre
Mr	John (Snr)	Carey		Booleroo Centre
Mrs	Nicole	Carey	John	Booleroo Centre
Mr	Ben (Jnr)	Carn		Quorn
Mr	Ben (Snr)	Carn	Susan	Quorn
Mr	Andrew	Catford	Gilmour & Michelle	Orroroo
Mr	David	Catford		Gladstone
Mr	Gilmour	Catford	Michelle & Andrew	Orroroo
Mr	Grant	Chapman		Orroroo
Mr	Dion	Clapp		Peterborough
Mr	Luke	Clark	Dette	Jamestown
Mr	Scott	Clark	Jaimie	Jamestown
Mr	David	Clarke		Booleroo Centre
Mr	Ian	Clarke		Booleroo Centre
Mr	Piers	Cockburn	Peter & Toni-Louise	Wirrabarra
Mr	Peter	Cockburn	Toni-Louise & Piers	Wirrabarra

Upper North Farming Systems Membership List 2020 - 2021 *cont.*

Title	First Name	Last Name	Partners Name	Town or Business
Mrs	Anne	Collins	Glenn	Quorn
Ms	Amanda	Cook		Uni of Adelaide
Ms	Pru	Cook		Birchip Cropping Group
Mr	Michael	Cousins		Crystal Brook
Mr	Ben	Crawford	Beck	Georgetown
Mr	Bruce	Crawford	Jan	Georgetown
Mr	John	Crawford	Jan	Georgetown
Mr	Luke	Crawford	Trevor	Jamestown
Mr	Mark	Crawford	Heidi	Georgetown
Mr	Trevor	Crawford	Christine	Jamestown
Mr	Chris	Crouch	Iris	Wandearah via Crystal Brook
Mr	Graeme	Crouch	Cathy	Wandearah
Mr	Nathan	Crouch		Wanderah
Mr	Wayne	Davis	Nicholas	AWB Davis Grain
Mr	Brad	Dennis		Baroota
Mr	Matt	Dennis		Baroota
Mr	Robert	Dennis		Baroota
Mr	Phillip	Dibben	Rosalie	Jamestown
Mrs	Rosalie	Dibben	Phillip	Jamestown
Mr	Damian	Ellery	Ian and Sue	Orroroo
Mr	Ian	Ellery	Sue and Damian	Orroroo
Mrs	Sue	Ellery	Ian and Damian	Orroroo
Mr	Zac	Ellis		ADM Australia PL
Mr	David	Evans		GrainGrowers Ltd
Mr	Dean	Fielke		Loxton
Mr	Bentley	Foulis	Michelle	Willowie
Mr	Matt	Foulis		Northern Ag PL
Mr	Douglas	Francis		Quorn
Mr	Rehn	Freebairn		S & W Seed Co.
Mr	Kym	Fromm		Orroroo
Mr	Gurjeet	Gill		Uni of Adelaide
Mr	Caleb	Girdham		Melrose
Mr	Brendan	Groves	Beverly Ann	Booleroo Centre
Mr	Patrick	Guerin		BALCO
Miss	Rebecca	Gum	Geoff	Orroroo
Mr	Trevor	Gum	Dianne	Orroroo
Mr	Jonathan	Hancock		Brinkworth
Mr	Kym	Harvie	Leeanne	Booleroo Centre
Mr	James	Heaslip		Appila
Mr	Jim	Heaslip	Genevieve	Appila
Mr	Will	Heaslip		Appila
Mr	Daniel	Henderson		Caltowie
Mr	Andrew	Henderson		Caltowie
Mr	David	Henderson	Joy	Caltowie

Upper North Farming Systems Membership List 2020 - 2021 *cont.*

Title	First Name	Last Name	Partners Name	Town or Business
Miss	Alison	Henderson		Caltowie
Ms	Jessica	Henderson		NYNRM
Mr	David	Hill		MGA Insurance
Mr	Neil	Innes	Anne	Booleroo Centre
Mr	Tony	Jarvis	Jane	Booleroo Centre
Mr	Ben	Jefferson		Tarcowie
Mr	Brendon	Johns	Denise	Port Pirie
Mr	Leighton	Johns		Port Pirie
Mr	Phillip	Johns		Port Pirie
Mr	Steven	Johns		Port Pirie
Mr	Bart	Joyce		Wanderah West
Mr	Ian (Danny)	Keller		Wirrabarra
Mr	Matt	Keller		Wirrabarra
Mr	Andrew	Kitto	Maria	Gladstone
Mr	Joe	Koch	Jess	Booleroo Centre
Mr	Jamie	Koch	Jody	Maitland
Mrs	Jess	Koch	Joe	Booleroo Centre
Mr	Robert	Koch	Joyleen	Georgetown
Mr	Jim	Kuerschner	Gaye	Orroroo
Mr	Sam	Kuerschner		Orroroo
Mr	Tom	Kuerschner		Orroroo
Mr	David	Kumnick	Katrina	Booleroo Centre
Mr	Jaxon	Kumnick		Booleroo Centre
Mr	Neil	Lange	Judy	Laura
Ms	Tracey	Lehmann		E.P.I.C.
Mr	Kevin	Lock		Booleroo Centre
Mr	Andrew	McCallum	Melissa	Booleroo Centre
Mr	Cameron	McCallum	Toni	Melrose
Mrs	Carly	McCallum	Nicholas	Melrose
Mr	David	McCallum	Joel & Jesse	Melrose
Mr	Jesse	McCallum	David & Joel	Melrose
Mr	Joel	McCallum	David & Jesse	Melrose
Mr	Matt	McCallum	Heidi & Ross	Laura
Mr	Nicholas	McCallum	Carly	Melrose
Mr	Ras	McCallum		Flinders Machinery
Mr	Richard	McCallum	Michelle	Booleroo Centre
Mr	Warren	McCallum	Jennifer	Booleroo Centre
Miss	Emma	McInerney		Ag Ex Alliance
Mr	Larn	McMurray		Global Grain Genetics
Mr	Robert	Mills		Booleroo Centre
Mr	Tom	Moten		Pekina
Mr	Barry	Mudge	Kristina	Port Germein
Mr	Jonathon	Mudge		Port Germein
Mrs	Alice	Nottle	Matt	Booleroo Centre

Title	First Name	Last Name	Partners Name	Town or Business
Mr	Matthew	Nottle	Alice	Booleroo Centre
Mr	Len	Nutt	Carolyn	Orroroo
Mr	Morgan	Nutt	Joy	Orroroo
Mr	Stuart	Ockerby		Tatton
Mr	Mitch	Orrock		Murray Town
Mr	Todd	Orrock	Brooke	Murray Town
Ms	Kate	Pearce		NYNRM
Mr	Marcus	Perry		LH Perry & sons
Mr	Nicholas	Piggott	Emily	Booleroo Centre
Mr	John	Polden		Booleroo Centre
Mr	Thomas	Porter		Washpool
Mr	Matt	Quinn	Sam	Hallett
Mr	Patrick	Redden		Clare
Mr	Josh	Reichstein		Intergrain
Mr	Mark	Reichstein		Appila
Mr	Daniel	Reid		GrainGrowers Ltd
Ms	Jodie	Reseigh	National Landcare/Red Meat & Wool Growth Programs	
Mr	Jim	Richards		Crystal Brook
Mr	Michael	Richards		Crystal Brook
Mr	Steve	Richmond		Jamestown
Ms	Penny	Roberts		SARDI
Mr	Paul	Rodgers		Quorn
Mr	Joe	Ross		Emu Downs
Mr	Alex	Schwark		Booleroo Centre
Mr	Gavin	Schwark	Alex (Son)	Booleroo Centre
Mr	Daniel	Vater		AGT
Mr	Henry	Voigt		CentreState Exports
Mr	Andrew	Walter	Lydia	Melrose
Mr	Ken	Walter	Denise	Melrose
Ms	Sharon	Watt		GRDC
Mr	Stephen	Whillas		E.P.I.C.
Mr	Andrew	Zanker		Laura
Mr	Bryan	Zanker		Booleroo Centre
Mr	Eric	Zanker	Raelene	Booleroo Centre
Mr	Graham	Zanker	Lyn	Laura
Mr	Jason	Zohs	Kim	Crystal Brook
Mrs	Kim	Zohs	Jason	Crystal Brook
Mr	Michael	Zwar		Ag Tech Services
Mr	Samuel	Young		Port Pirie
Mr	Wayne	Young		Port Pirie