UNFS

Upper North Farming Systems

2016
RESULTS

UPPER NORTH FARMING SYSTEMS ANNUAL RESEARCH AND EXTENSION COMPENDIUM

CONTENTS

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THANK YOU TO OUR FUNDING BODIES AND PROJECT PARTNERS

Caring for our Country; Department of Agriculture, Fisheries and Forestry; GRDC; Department of Water and Natural Resources; Rural Solutions SA; Northern and Yorke NRM Board; Eyre Peninsula NRM Board; SARDI; ACTFA, SPAA, SAGIT, Eyre Peninsula Agriculture Research Foundation, Birchip Cropping Group, Central West Farming Systems, Mallee Sustainable Farming and Rufous and Co.

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 Contact List

Upper North Farming Systems
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www.unfs.com.au

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A Message from the Chair

We are pleased to provide this compendium of results of trials and related issues relevant to farming systems in the Upper North over the past 12 months.

Over the past year, the Upper North Farming Systems group has continued to evolve. Following valued input from members and collaborators, our Strategic Plan was launched at the Members Expo in August, 2016. Our mission statement calls for the group to lead primary producers of the Upper North of SA to improve sustainability, profitability and viability. To achieve this, we need to continue to identify key issues for our members and facilitate the effective addressing of these issues. This has remained a key focus at any meetings or events held throughout the year.

The new management structure of the UNFS, which sees strategic direction and governance being address by the Strategic Board whilst operational matters, such as field days and trials, are handled by a separate committee, is working well. The on-going challenge for the UNFS is to maintain relevance to our members at a time when there are many other competing sources of development and extension of agricultural technologies. We are fortunate to enjoy good support from investment bodies in the agricultural sector who value highly the close association we have with our member base.

The UNFS has continued to deliver a number of projects through the year. Our flagship project remains the GRDC funded “Stubble Initiative” with a number of key milestones being met. This project will be completed in 2018- replacing it represents another interesting challenge. The UNFS has continued to seek out new funding opportunities and were successful in receiving SAGIT funding for members events along with a new project looking at the importance of micro-nutrients in our region. A further highlight was winning the Ag Excellence Alliance Annual Grower Group Award which provides financial support to investigate different pasture options as break crops in the Upper North region.

There have been some recent important developments in our staffing arrangements. We have recently welcomed our new full time Project Officer, Hannah Mikajlo to work directly on delivering our project needs, primarily for the Stubble initiative, but also ensuring our other project delivery requirements are met. We also welcome our new part-time Administration Officer, Susan Murray. Mary Timms will continue her role in providing valued support in the finance area. We have also been very well served over the past year by our hard working Executive Officer, Ruth Sommerville and our thanks go out for her excellent efforts. We wish Ruth all the best as she attends to expanding family matters.

I would like to take this opportunity to thank our sponsors for their support over the past year. These include Rabobank, GrainGrowers, Graincorp, EPIC Commodities, Northern Ag, David Hill (MGA Insurance Brokers), LH Perry & Sons, Agtech, Pringles Crouch, PCT, AGT, Kelly Engineering, Centrestate Grain, Flinders Machinery, National Australia Bank and Mid-North Accounting. We welcome new sponsorship proposals.

I would finally like to thank all those that have contributed their time and effort into the Upper North Farming Systems projects over the past year. This applies to all the farmer co-operators, funding collaborators and industry personnel but particularly to all the committee members. The continued success of the group is only possible through your ongoing efforts and support.

Barry Mudge,

Chairperson, Upper North Farming Systems

Upper North Farming Systems Project and Grants 2016

(including projects undertaken in the 2015-2016 FY)

UNFS Project #	Other Names/ References	Full Name	Funding Source	Project Manager
103	2016 Annual Field Day	GRDC Conference Sponsorship - Productive Soils in Low Rainfall Zone Field Day	GRDC	Ruth Sommerville
201	Crop Sequencing	Profitable Crop sequencing in the low rainfall areas of South Eastern Australia	GRDC through SARDI	Micheal Moodie
209	Yield Prophet	Yield Prophet in the Upper North	EPIC & GrainCorp /UNFS	Barry Mudge
211	GRDC Stubble Initiative	Maintaining Profitable farming systems with retained stubbles in Upper North SA	GRDC	Ruth Sommerville
214	Overdependence on agrochemicals	Overdependence on agrochemicals	GRDC/CWFS	Barry Mudge/ Naomi Scholz (SARDI)
216	Controlled Traffic	Application of CTF in the low rainfall zone	ACTFA	Matt McCallum
217	Post Pasture Stubble Demonstrations	Upper North SA - Increase Update of No-till in Post Pasture Cropping Phases (25AGL-507)	National Landcare Program - 25th Anniversary Grants	Peter Baker
219	Up-skilling UNFS Women	Up-skilling the Women of the Upper North in Sustainable and Productive Farming Principles	SAGIT	Jess Koch
		Rural Business Management 101—Up-skilling the women of the Upper North in Sustainable and Productive Farming Principles SGR1-0598	Landcare	Jess Koch
220	Time of Sowing Trial	Upper North Time of Sowing and Yield Loss from Frost/Heat Stress	SAGIT	Ruth Sommerville

Upper North Farming Systems 2016

Event Summary

Date	Event	Location	Participants	Details/Topics
15-02-16	UNFS Nelshaby Hub Consultants Day	Nelshaby	20	Zinc Nutrition, Trace Elements and their role in plant development, Phosphorous Nutrition, Alternate sources of P and other nutrients—Mick McLaughlin, University of Adelaide.
23-02-16 & 09-03-16	UNFS Spray Workshop—Spraying in Stubble	Booleroo Centre & Wandearah	41 & 43	Nozzle types and how they work, Stubble Height and Crop Residue and its effect on herbicide efficacy, Tank Mixes and the role of Adjuvants, Spray Demonstrations using Dye Application, Weather conditions for spraying, Speed, Boom Height and Machinery Setup and its effect on application quality, Operational Spray Units displayed, Drift management.

Upper North Farming Systems 2016

Event Summary (Continued)

Date	Event	Location	Participants	Details/Topics
08-03-16	UNFS Booleroo Centre Hub - ProductionWise Workshop	Booleroo Centre	15	ProductionWise set-up and implementation workshop.
21-06-16	Ladies on the Land Workshop	Booleroo Centre	23	Cereal Types and Growth Stages,Cereal Identification, Zadok Growth Stage, Identification in Practice—Louise Flohr (AgriLink Ag. Consultants).
04-08-16	UNFS Annual Members Expo	Booleroo Centre	94 + 12 school students	Maximising Soil Productivity - Michael Eyres & Edward Scott, (Injekta Field Systems), Website/Strategic Plan/Stubble Guidelines—Ruth Sommerville, Micro & Macro Nutrients—Nigel Wilhelm SARDI, Russian Wheat Aphid Update—Andrew Catford (Northern Ag) & Patrick Redden (Rural Directions), Planning for a Variable Spring: Models for Production—Farmer/Advisor Panel, Crop Phsiology—Grain fill and the effect of heat shock on yield—Paul Telfor (AGT), Maximising Lamb Growth Rates—Daniel Shuppan (Landmark), Nutrition & Business Risk—How to get it right—Kate Burke (Think Agri), Native Grasses and their role in nutrient cycle—Anne Brown (Greening Australia).
21-06-16	Ladies on the Land Workshop	Booleroo Centre	15	Crop Rotations, Role of Legumes & Canola, Identification of issues in paddock: disease, frost, pests, Legume Nodules, Deep Rotting, Pest & Weed ID —Louise Flohr (AgriLink Ag. Consultants).
13-09-16	UNFS Eastern Spring Crop Walk	Booleroo Centre	28	Time of Sowing Trial, Barley Grass/Crop Competition/ Overdependence on AgroChemicals Trial, Fox Control, Grain Marketing.
14-09-16	UNFS/Nelshaby Ag Bureau Western Crop Walk	Nelshaby/ Wandereah	26	Hay Cutting, Russian Wheat Aphid, Grain Marketing, Spading Work, Legumes including Chickpeas and Lentils and Seeder Comparison.
23-09-16	Jamestown Hub Event/Red North Soils Group	Jamestown	38	Learnings from Pinery Bushfire—Luke McCabe (Balaklava Farmer), Dryland cropping systems in Argentina—Manuel Panario (Argentina), How to profit from Farm Sensor Tools and Data Capture—Leighton Wilksch (AgByte), UAV use for farm management—Joe Koch (Breezy Hill Ag), Soil as a template for seasonal management—Ed Scott (Injekta Field Systems), Variable rate seed and foliar management to soil type—Neil Wittwer (AG Schilling).
27-09-16	MMFS/UNFS Business of Sheep & Improving Weaner Management	Black Rock	11	Key drivers of profit and which is worth pursuing, Ewe size influence on profitability and ideal ewe size, Importance of reproductive rates, Weaner management.—Hamish Dickson (AgriPartner Consulting).
05-10-16	GRDC Grain Storage Workshop	Napperby	20	Grain storage options: advantages and disadvantages, Using silos and grain bags successfully, Preventing and controlling weevils in stored grain, Aerating grain for cooling and drying, Pressure testing silos, Storing pulses and oilseeds—Peter Botta (PCB Consulting).
18-10-16	Ladies on the Land Workshop	Booleroo Centre	17	Grain Marketing—Rural Directions, Succession Planning—Judy Wilkinson.
All year	Various Hub Events	Various		

UNFS 2014/2015 Audited Financial Statements

Audited Financial Statements for the 2014/2015 financial year were not available at the time of printing he 2015 UNFS Annual Results Book hence are included in this publication.

UPPER NORTH FARMING SYSTEMS

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2015

	Note	2015 $	2014 $
INCOME			
Field Day Income		22,600.00	-
Hire of Plant		181.82	4,220.00
Interest Received		3,363.72	1,900.10
Membership		6,285.33	-
Merchandise		927.58	-
Sponsorship		-	136.36
Subscriptions		-	736.33
		33,358.45	6,992.79
OTHER INCOME			
Project Administration			
Carbon Account		3,000.00	3,000.00
Fodder Account		-	1,605.00
Nitrous Oxide		-	1,000.00
Pasture Production Zoning		1,754.55	-
Crop Sequencing		67,181.83	-
Retired Projects		7,230.00	-
Grain & Graze 2		10,927.27	-
Spot Spray Weed Technology		1,000.00	-
		91,093.65	5,605.00
Project Income			
Retired Projects		4,112.25	-
Crop Sequencing		75,000.00	-
Pasture Production Zoning		9,000.00	-
Profit & Risk Manangement		4,800.00	-
Better Surface Under Grazing		400.00	30,036.36
Lower Rainfall Bus Trip		4,227.26	10,890.00
Yield Prophet		8,200.00	3,500.00
Field Days		-	2,718.18
Zoning		-	13,000.00
Nitrous Oxide		-	11,650.00
GRDC Stubble Initiative		130,200.00	130,643.24
Spot Spray Weed Technology		9,500.00	-
Onion Weed		9,700.00	-
Controlled Traffic		717.75	-
Post Stubble Demo		18,700.00	-
		274,557.26	202,437.78
		365,650.91	208,042.78
		399,009.36	215,035.57

The accompanying notes form part of these financial statements.

UPPER NORTH FARMING SYSTEMS

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2015

	Note	2015 $	2014 $
EXPENDITURE			
Bank Charges		93.00	139.00
Field Day Expenses		12,523.28	-
Merchandise		-	1,831.00
Publications		363.64	3,995.00
Minor Plant Purchases & Repair		-	4,148.95
Treasurer & Admin Expenses		24,741.83	3,548.00
Finalise Projects			
-Fodder Scrub Systems Project		-	130.60
-Perennial Pasture Project		-	3,702.02
		-	3,832.62
Project Costs			
Crop Sequencing		77,181.83	14,545.45
Fodder Shrub Systems		7,230.00	-
GRDC Stubble Initiative		64,300.76	68,195.11
Better Surface Under Grazing		400.00	-
Yield Prophet		6,200.00	2,465.00
Pasture Production Zoning		8,229.55	15,300.00
Retired Projects		4,017.38	-
Nitrous Oxide		7,000.00	11,434.00
Onion Weed		3,145.00	3,050.00
Spot Spray Weed Technology		9,500.00	-
Low Rainfall Bus Trip		18,914.53	-
Controlled Traffic		1,435.50	-
Overdependence Agrochemicals		240.00	-
Post Stubble Demo		4,596.90	-
Profit & Risk Management		4,800.00	-
Perennial Pasture Project		3,039.87	-
Grain & Graze 2		10,927.27	-
		231,158.59	114,989.56
		268,880.34	132,484.13
Profit before income tax		130,129.02	82,551.44
Profit for the year		130,129.02	82,551.44
Retained earnings at the beginning of the financial year		103,917.07	21,365.63
Retained earnings at the end of the financial year		234,046.09	103,917.07

The accompanying notes form part of these financial statements.

UPPER NORTH FARMING SYSTEMS

BALANCE SHEET
AS AT 30 JUNE 2015

	Note	2015 $	2014 $
ASSETS			
CURRENT ASSETS			
Cash and cash equivalents	3	240,434.09	98,599.07
Trade and other receivables	4	-	5,318.00
TOTAL CURRENT ASSETS		240,434.09	103,917.07
TOTAL ASSETS		240,434.09	103,917.07
LIABILITIES			
CURRENT LIABILITIES			
Trade and Other Payables	5	6,388.00	-
TOTAL CURRENT LIABILITIES		6,388.00	-
TOTAL LIABILITIES		6,388.00	-
NET ASSETS		234,046.09	103,917.07
MEMBERS' FUNDS			
Retained earnings	6	234,046.09	103,917.07
TOTAL MEMBERS' FUNDS		234,046.09	103,917.07

UPPER NORTH FARMING SYSTEMS

NOTES TO THE FINANCIAL STATEMENTS
FOR THE YEAR ENDED 30 JUNE 2015

		2015 $	2014 $
3	**Cash and Cash Equivalents**		
	Bank SA Power Saver 443340	-	0.28
	Freedom Bank Account 92540	55,091.66	16,924.96
	Business Bank Account 93340	185,342.43	78,771.83
	Loan Soil Carbon Stock Project	-	2,902.00
		240,434.09	98,599.07
4	**Trade and Other Receivables**		
	Current		
	GST Account	-	5,318.00
5	**Accounts Payable and Other Payables**		
	Current		
	GST Account	6,388.00	-
6	**Retained Earnings**		
	Retained earnings at the beginning of the financial year	103,917.07	21,365.63
	Net profit attributable to the association	130,129.02	82,551.44
	Retained earnings at the end of the financial year	234,046.09	103,917.07

UNFS 2014/2015 Audited Reports (Cont.)

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

Report on the Financial Report

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 2015, and the income and expenditure statement for the year then ended, notes comprising a summary of significant accounting policies and other explanatory information, and the statement by members of the committee.

Committee's Responsibility for the Financial Report

The committee of the association is responsible for the preparation of the financial report that gives a true and fair view in accordance with Australian Accounting Standards (including the Australian Accounting Interpretations) and the Associations Incorporation Act 1985 and for such internal control as the committee determines is necessary to enable the preparation of the financial report that gives a true and fair view and is free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

My responsibility is to express an opinion on the financial report based on my audit. I conducted my audit in accordance with Australian Auditing Standards. Those standards require that I comply with relevant ethical requirements relating to audit engagements and plan and perform the audit to obtain reasonable assurance about whether the financial report is free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial report. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial report, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation of the financial report that gives a true and fair view in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by the committee, as well as evaluating the overall presentation of the financial report.

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

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

Auditor's Opinion

In my opinion:

The financial report of Upper North Farming Systems is in accordance with the Associations Incorporation Act 1985 including:

(i) giving a true and fair view of the Association's financial position as at 30 June 2015 and of their performance and cash flows for the year ended on that date; and

(ii) complying with the Australian Accounting Standards.

The financial report also complies with International Financial Reporting Standards as disclosed in Note 1.

Name of Firm: Mid North Accounting
Certified Practising Accountant

Name of Principal: Vonnie Lea CPA

Address: 40 Irvine Street Jamestown SA

Dated this 31st **day of** October 2016

UNFS 2015/2016 Audited Financial Statements

UPPER NORTH FARMING SYSTEMS

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2016

	Note	2016 $	2015 $
INCOME			
Field Day Income		4,586.37	22,600.00
Hire of Plant		-	181.82
Interest Received		1,817.54	3,363.72
Membership		5,741.60	6,285.33
Merchandise		-	927.58
Sponsorship		1,136.36	-
		13,281.87	33,358.45
OTHER INCOME			
Project Administration			
Carbon Account		-	3,000.00
Pasture Production Zoning		-	1,754.55
Crop Sequencing		-	67,181.83
Retired Projects		-	7,230.00
Grain & Graze 2		-	10,927.27
Post Stubble Demo		1,700.00	-
Onion Weed		610.00	-
Spot Spray Weed Technology		-	1,000.00
		2,310.00	91,093.65
Project Income			
Retired Projects		-	4,112.25
Crop Sequencing		30,000.00	75,000.00
Pasture Production Zoning		10,379.55	9,000.00
Profit & Risk Manangement		-	4,800.00
Better Surface Under Grazing		-	400.00
Lower Rainfall Bus Trip		3,630.00	4,227.26
Yield Prophet		2,000.00	8,200.00
Nitrous Oxide		10,900.00	-
GRDC Stubble Initiative		-	130,200.00
Spot Spray Weed Technology		-	9,500.00
Onion Weed		-	9,700.00
Controlled Traffic		1,100.00	717.75
Post Stubble Demo		-	18,700.00
Overdependence Agrochemicals		10,000.00	-
Ladies on the Land Workshop		6,600.00	-
		74,609.55	274,557.26
		76,919.55	365,650.91
		90,201.42	399,009.36

UPPER NORTH FARMING SYSTEMS

INCOME STATEMENT
FOR THE YEAR ENDED 30 JUNE 2016

	Note	2016 $	2015 $
EXPENDITURE			
Audit Fees		5,690.00	-
Bank Charges		-	93.00
Field Day Expenses		2,294.35	12,523.28
Merchandise		125.00	-
Publications		4,500.00	363.64
Treasurer & Admin Expenses		12,331.74	24,741.83
Project Costs			
Crop Sequencing		14,545.45	77,181.83
Fodder Shrub Systems		-	7,230.00
GRDC Stubble Initiative		64,729.37	64,300.76
Better Surface Under Grazing		-	400.00
Yield Prophet		-	6,200.00
Pasture Production Zoning		10,229.55	8,229.55
Retired Projects		-	4,017.38
Nitrous Oxide		3,165.00	7,000.00
Onion Weed		3,505.00	3,145.00
Spot Spray Weed Technology		-	9,500.00
Low Rainfall Bus Trip		-	18,914.53
Controlled Traffic		2,646.23	1,435.50
Overdependence Agrochemicals		710.00	240.00
Post Stubble Demo		5,325.30	4,596.90
Profit & Risk Management		-	4,800.00
Perennial Pasture Project		-	3,039.87
Grain & Graze 2		-	10,927.27
		104,855.90	231,158.59
		129,796.99	268,880.34
(Loss) Profit before income tax		(39,595.57)	130,129.02
(Loss) Profit for the year		(39,595.57)	130,129.02
Retained earnings at the beginning of the financial year		234,046.09	103,917.07
Retained earnings at the end of the financial year		194,450.52	234,046.09

UNFS 2015/2016 Audited Financial Statements (Continued)

UPPER NORTH FARMING SYSTEMS

BALANCE SHEET
AS AT 30 JUNE 2016

	Note	2016 $	2015 $
ASSETS			
CURRENT ASSETS			
Cash and cash equivalents	3	197,889.52	240,434.09
TOTAL CURRENT ASSETS		197,889.52	240,434.09
TOTAL ASSETS		197,889.52	240,434.09
LIABILITIES			
CURRENT LIABILITIES			
Trade and Other Payables	4	3,439.00	6,388.00
TOTAL CURRENT LIABILITIES		3,439.00	6,388.00
TOTAL LIABILITIES		3,439.00	6,388.00
NET ASSETS		194,450.52	234,046.09
MEMBERS' FUNDS			
Retained earnings	5	194,450.52	234,046.09
TOTAL MEMBERS' FUNDS		194,450.52	234,046.09

UPPER NORTH FARMING SYSTEMS

NOTES TO THE FINANCIAL STATEMENTS
FOR THE YEAR ENDED 30 JUNE 2016

		2016 $	2015 $
3	**Cash and Cash Equivalents**		
	Freedom Bank Account 92540	30,729.55	55,091.66
	Business Bank Account 93340	167,159.97	185,342.43
		197,889.52	240,434.09
4	**Accounts Payable and Other Payables**		
	Current		
	GST Account	3,439.00	6,388.00
5	**Retained Earnings**		
	Retained earnings at the beginning of the financial year	234,046.09	103,917.07
	(Net loss) Net profit attributable to the association	(39,595.57)	130,129.02
	Retained earnings at the end of the financial year	194,450.52	234,046.09

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

Report on the Financial Report

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 2016, and the income and expenditure statement for the year then ended, notes comprising a summary of significant accounting policies and other explanatory information, and the statement by members of the committee.

Committee's Responsibility for the Financial Report

The committee of the association is responsible for the preparation of the financial report that gives a true and fair view in accordance with Australian Accounting Standards (including the Australian Accounting Interpretations) and the Associations Incorporation Act 1985 and for such internal control as the committee determines is necessary to enable the preparation of the financial report that gives a true and fair view and is free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

My responsibility is to express an opinion on the financial report based on my audit. I conducted my audit in accordance with Australian Auditing Standards. Those standards require that I comply with relevant ethical requirements relating to audit engagements and plan and perform the audit to obtain reasonable assurance about whether the financial report is free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial report. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial report, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation of the financial report that gives a true and fair view in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by the committee, as well as evaluating the overall presentation of the financial report.

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

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

Auditor's Opinion

In my opinion:

The financial report of Upper North Farming Systems is in accordance with the Associations Incorporation Act 1985 including:

(i) giving a true and fair view of the Association's financial position as at 30 June 2016 and of their performance and cash flows for the year ended on that date; and

(ii) complying with the Australian Accounting Standards.

The financial report also complies with International Financial Reporting Standards as disclosed in Note 1.

Name of Firm: Mid North Accounting
Certified Practising Accountant

Name of Principal: Vonnie Lea CPA

Address: 40 Irvine Street Jamestown SA

Dated this 31st day of October 2016

Income and Expenditure by Project—1st July 2016 to 31st March 2017

Below is a Draft Cashflow detailing income and expenditure for each UNFS Project for the period 1st July 2016 to 31st March 2017. This information is preliminary and subject to adjustments and modifications. Adjustments and modifications to the below information may be identified during the course of the audit work, which could result in significant differences from this preliminary unaudited financial information.

Upper North Farming Systems - Summary of Income & Expenditure - For Period 01/07/16 to 31/03/17

	101 Group Managment	103 Field Days & Tours	104 Commercial Paddock	204 Carbon	207 Zoning	209 Yield Prophet	210 Nitrous Oxide	211 Stubble Initiative	212 Low Rainfall Bus Trip 2014	214 Overdependence on agrochemicals	216 Controlled Traffic	217 Post Stubble Demo	219 Ladies on the Land Workshops	220 Time of Sowing Trial	221 Weed Seed Burning	OVERALL TOTAL
OPENING BALANCE 01/07/16	80,205	18,540	-	1,512	- 1,000	10,140	951	63,618	- 167	9,050	- 2,264	8,778	6,600	-	-	195,962
INFLOWS																
Equipment Hire	750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	750
Interest	1,039	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,039
Membership	4,477	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,477
Merchandise	241	-	-	-	-	-	-	-	-	-	-	-	-	-	-	241
Project Administration	4,951	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,951
Project Income	-	6,450	22,908	-	-	8,000	-	195,300	167	30,000	-	-	2,700	24,385	-	289,910
Sponsorship	1,500	982	-	-	-	3,000	-	-	-	-	-	-	-	-	-	5,482
TOTAL INFLOWS	12,958	7,432	22,908	-	-	11,000	-	195,300	167	30,000	-	-	2,700	24,385	-	306,850
																-
OUTFLOWS																-
Administration	24,139	4,633	-	1,512	-	-	951	-	-	4,000	-	-	893	-	-	36,127
Advertising	- -	153	-	-	-	-	-	-	-	-	-	-	153	-	-	-
Audit Fees	5,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,700
Bank Fees	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90
Merchandise Expense	1,930	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,930
Publications	913	-	-	-	-	-	-	806	-	-	-	-	-	-	-	1,719
Event Expenses																
Event Catering	-	908	-	-	-	-	-	-	-	-	-	-	451	-	-	1,359
Event Expense	-	2,988	-	-	-	-	-	-	-	-	-	-	895	-	-	3,883
Field Day Expenses	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hub Expenses	-	759	-	-	-	-	-	-	-	-	-	-	-	-	-	759
Presenter	-	2,400	-	-	-	-	-	-	-	-	-	-	4,736	-	-	7,136
Project Expenses																
Project Management	-	-	-	-	-	-	-	7,395	-	-	-	-	-	1,913	-	9,308
Project Expenses	-	-	688	-	-	11,695	-	23,914	-	21,485	-	5,280	242	6,580	254	70,138
TOTAL OUTFLOWS	32,772	11,534	688	1,512	-	11,695	951	32,115	-	25,485	-	5,280	7,370	8,493	254	138,148
OVERALL TOTAL	- 19,814	- 4,102	22,220	- 1,512	-	- 695	- 951	163,185	167	4,515	-	- 5,280	- 4,670	15,892	- 254	168,702
CLOSING BALANCE 31/03/17	60,391	14,438	22,220	-	- 1,000	9,445	-	226,803	-	13,565	- 2,264	3,498	1,930	15,892	- 254	364,664

UNFS is now part of the World Wide Web

www.unfs.com.au

In mid 2016, UNFS engaged the services of Jamestown Designer, Tracey Dewell to create a website from content provided by UNFS staff.

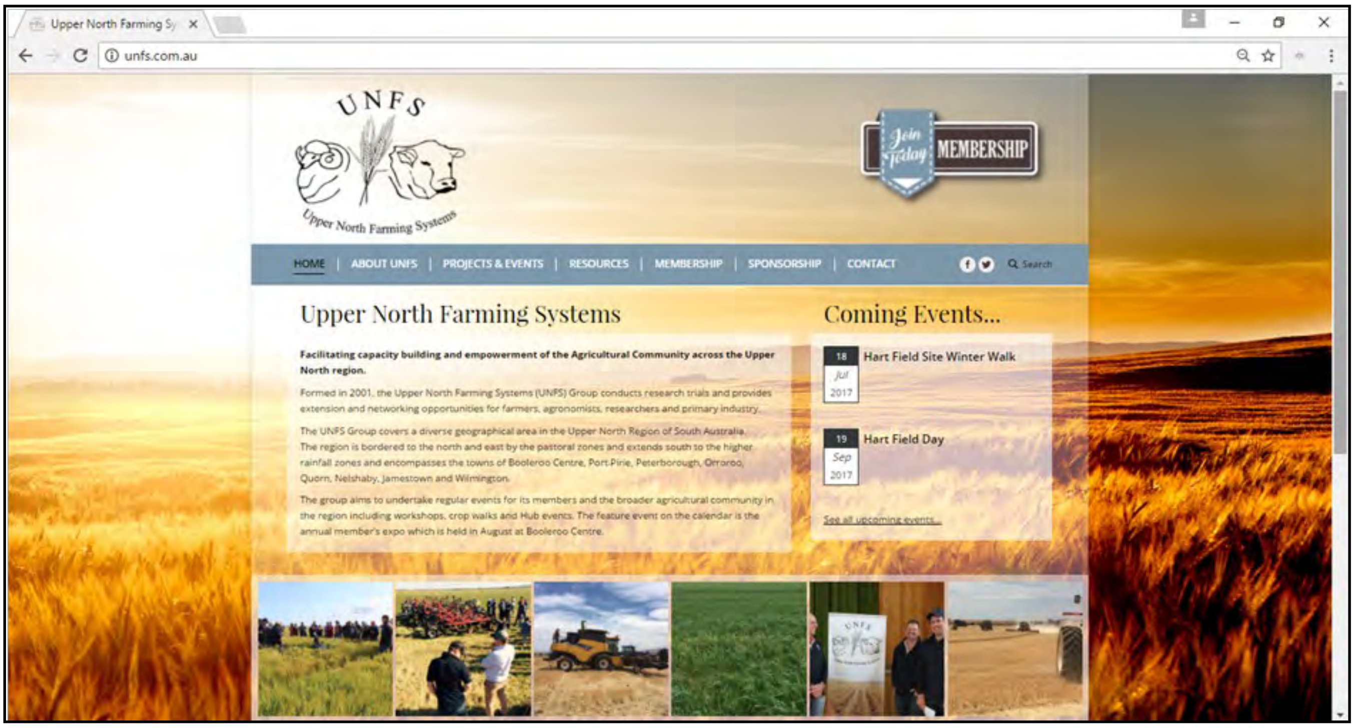
The purpose of the website was threefold, firstly, to provide a platform for information for UNFS members, sponsors and the wider community to easily access. Secondly, the website provides creditability to the group as potential funding bodies and partners are able to gain an insight into the corporate governance, and projects and events run by UNFS through a simple internet search. And finally, by having a website, UNFS is able to expand the potential audience for its research publications from a local to a global audience.

The website has five main sections. The Home and About Us sections provide an overview of organisation as well as UNFS's aims and goals, committee and staff members. Details and publications from UNFS's current and historical projects are outlined in the Projects and Events section. In the Resources section, you can find publications including case studies, short videos and the Annual Results Book. Yield Prophet reports, Newsletters and Media and Industry Codes are also located within the Resources section. The Membership page highlights the benefits of becoming a UNFS member with a downloadable membership form. Likewise the Sponsorship page acknowledges the support received by the UNFS sponsors and encourages others to consider sponsoring the group with a downloadable Sponsorship Prospectus. Details of how to contact committee and staff members are provided on the website.

The website was showcased at the UNFS Members Expo in August and officially launched in December with the video clip "Twas the night before Christmas - Harvest Edition". The video was a little bit of fun, but with a good cause. As a new website, it is hard for people to find you. Hence the light hearted video aimed to raise the website's profile and encourage visits to the website to make it more accessible through online search engines.

The website is routinely maintained by UNFS staff to ensure content is up-to-date.

Check out: www.unfs.com.au to view upcoming events, read the latest newsletter or Yield Prophet report, download a membership form or contact a committee member.



UNFS Yield Prophet in 2016

Author: Barry Mudge

Funded By: GRDC Stubble Initiative, GrainCorp, EPIC and participating landowners

Project Title: UNFS Yield Prophet

Project Duration: 2016 cropping season

Project Delivery Organisation: Barry Mudge Consulting

Key Points:

- **The UNFS delivered the Yield Prophet program on 10 sites throughout the Upper North in 2016.**
- **The performance of the Yield Prophet model remained reasonable on many sites in 2016 but results were compromised by a number of factors at others.**
- **The information provided by Yield Prophet can be useful in adjusting inputs (mainly nitrogen) as the season evolves.**

Background

UNFS operated 10 Yield Prophet sites across the Upper North 2016. Sponsorship was obtained from Graincorp and EPIC with the balance of project funding provided by the GRDC Stubble Initiative and participating farmers. Deep soil sampling was completed early in May with soils being analysed for moisture content and nitrogen along with other parameters to enable the appropriate soil to be selected for the Yield Prophet program. The program was then set up for each of the sites. Outputs were regularly updated throughout the season, with results e-mailed to members.

How Does Yield Prophet Work

Yield Prophet is the web-based interface which allows users to access outputs from the crop production model, APSIM. Inputs include detailed soil characterisation information along with measurements of soil water and deep nitrogen status at the start of the season. Specific crop information (sowing date, variety, fertiliser applications etc.) along with daily rainfall data are then entered for each site to provide updated estimates of yield expectations if historical rainfall patterns are repeated (see Figure 1). It is therefore important to recognise that the results are very specifically location based- these can then be extrapolated to other locations based on knowledge of the particular characteristics of each location.

Yield Prophet can provide an estimate of yield expectations as we move through the season, which can be used to aid management decisions (e.g. value of fungicide applications) and possibly giving more confidence in forward marketing of grain. YP also provides an ongoing estimate of the nitrogen status of the crop and can be used to assess the value or otherwise of applying additional N.

The cost to run Yield Prophet in 2016 was an annual subscription of $180 ($120 if a member of BCG Cropping Group) plus the cost of the soil sampling. Once the subscription has been made, there is no limit on the number of times the information can be updated throughout the year.

How did Yield Prophet perform in 2016

In previous seasons, Yield Prophet has been shown to be quite good at predicting crop yields in a range of seasons.

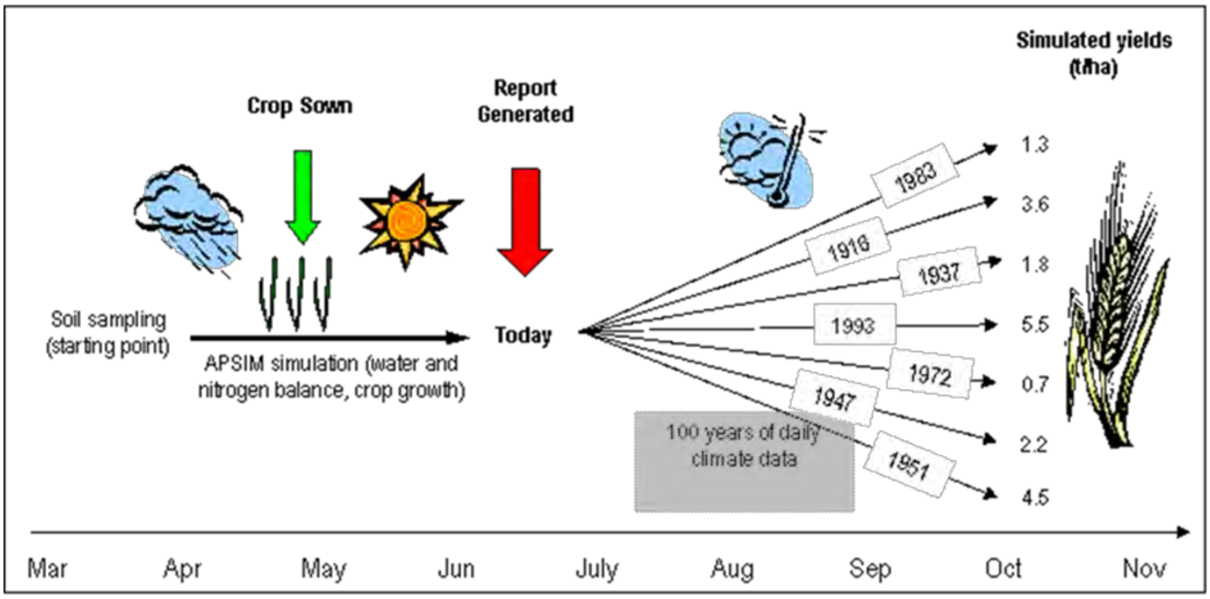


Figure 1. Diagrammatic representation of Yield Prophet

In 2016, starting soil moisture levels varied across the region, but were generally in the low to moderate range. Seeding was either delayed, or proceeded under marginal moisture conditions. Then excellent rainfalls recorded in late May and June saw the season consolidate. Seeding of some crops did not occur until well into June, which had the potential to compromise final yields. Good rainfalls continued to be received at most sites for the balance of the growing season. Most locations also saw mild spring temperatures which assisted yield development. All sites ended up receiving Decile 7 rainfall or better for the growing season. Yield limiting factors were late season frosts and a lack of finishing rains for later sown crops.

UNFS Yield Prophet site locations in 2016 are shown in Figure 12. Summaries of the output from each of the sites are included below. Each figure shows the 10th, 50th and 90th percentile of predicted yield (for each date that the model was run) along with the actual yield obtained at each site. To interpret these results, and as an example, the 90th percentile yield shows that yield which is expected to be equaled or exceeded in 90 years out of 100. This changes as the season evolves with inclusion of more seasonal information- the three lines eventually converge at the completion of the season with the convergent point being the final yield prediction.

It is important to recognise that the yield output given in these results is the water and nitrogen limited prediction. This adjusts through the season as additional seasonal information is fed into the model (e.g. daily rainfall) but also adjusts as additional nitrogen applications occur. The model also produces another set of yield outputs (not shown in this report) which incorporate yield adjustments based on some assessments of possible yield reductions from frost or spring heat spikes.

Crouch (25 km south of Port Pirie)

The model has performed reasonably well at this site. Chris would suggest that the difference between the predicted yield of 4.6 tonne/Ha and the actual yield achieved of 4 tonne/Ha is largely about not setting the crop up for these (rare) years of very high yield potential.

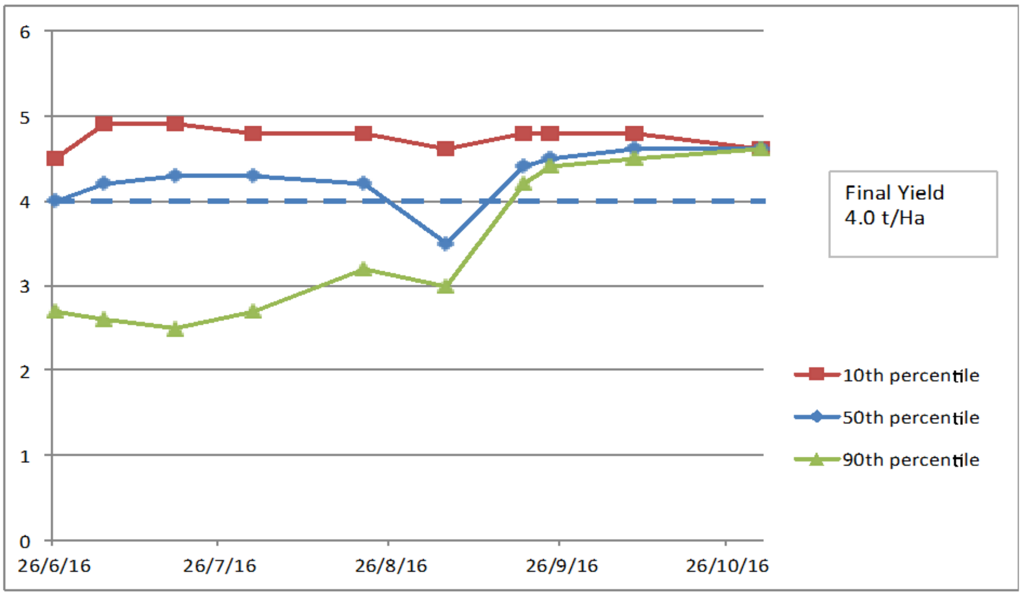


Figure 2. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Crouch site 25km south of Port Pirie

Johns (14 km south east of Port Pirie)

Again, the model has performed reasonably well at this site.

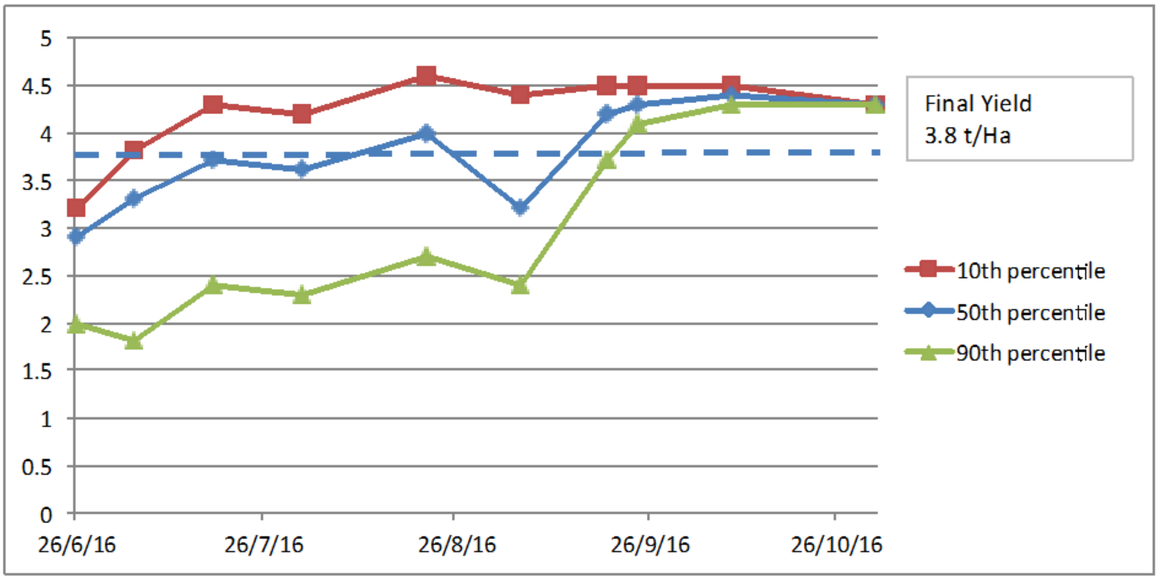


Figure 3. (Left) Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Johns site 14km south east of Port Pirie

Dennis (11 km north of Port Germein)

This was a very early sown wheat crop (sown April 5th) into stubble of a high yielding wheat crop from 2015. Nitrogen was applied through the season but the model continued to show deficiencies in N supply. Yield potential was always quite satisfactory but limited to an extent by the very early sowing of a short growing season spring wheat and low N availability. Final crop yield was significantly below model expectations.

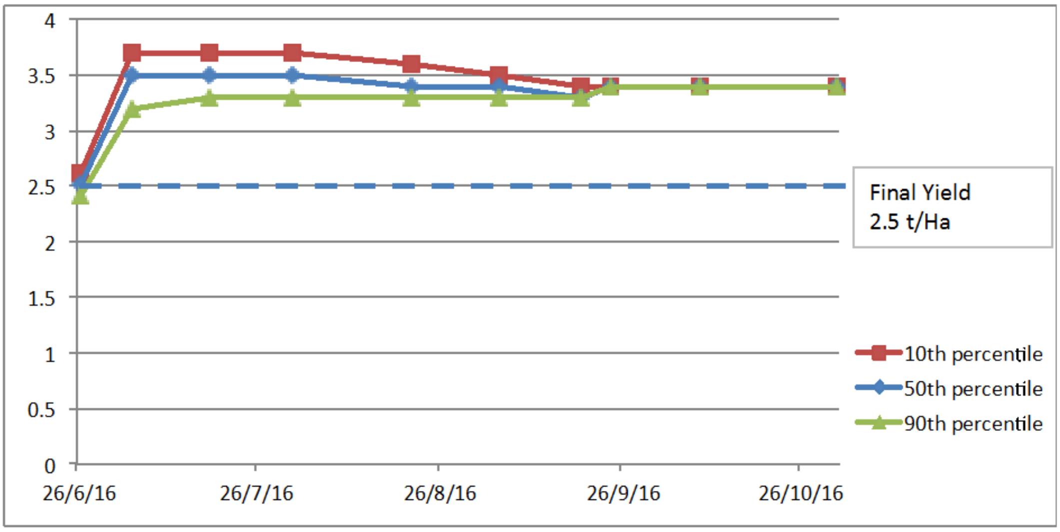


Figure 4. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Dennis site 11km north of Port Germein

Mudge (16 km north of Port Germein)

The model has performed reasonably well at this site.

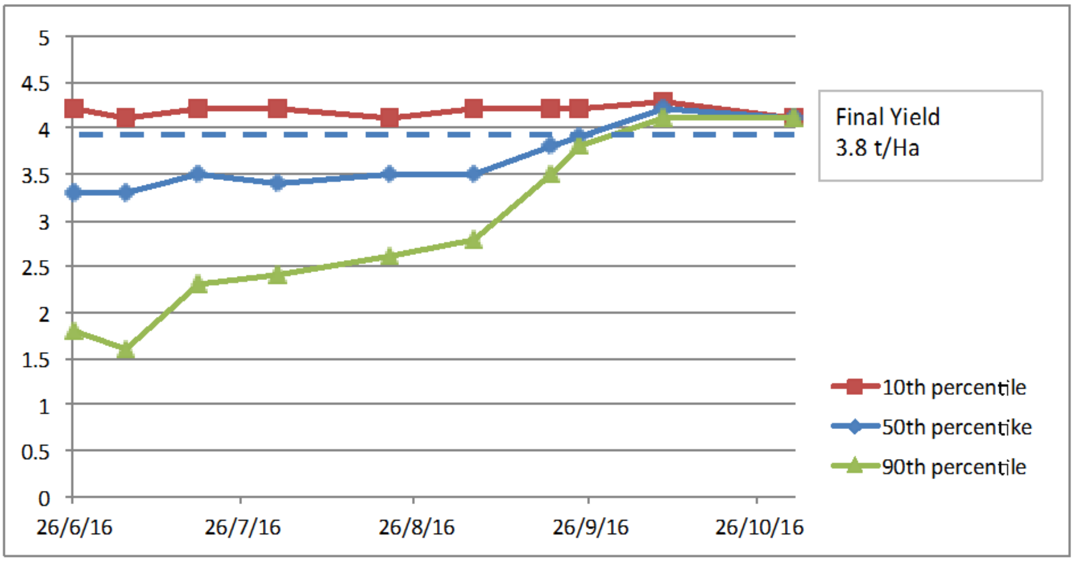


Figure 5. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Mudge site 16km north of Port Germein

Barrie (9 km north east of Willowie)

This site caused some early issues with results from the soil testing conducted at the site showing very high levels of sodicity at depth which, according to the model, were severely limiting to crop growth and yield. These results were subsequently adjusted to those more commonly shown in previous soil tests in the area with the model then performing reasonably well. Final yield was very close to the predicted yield.

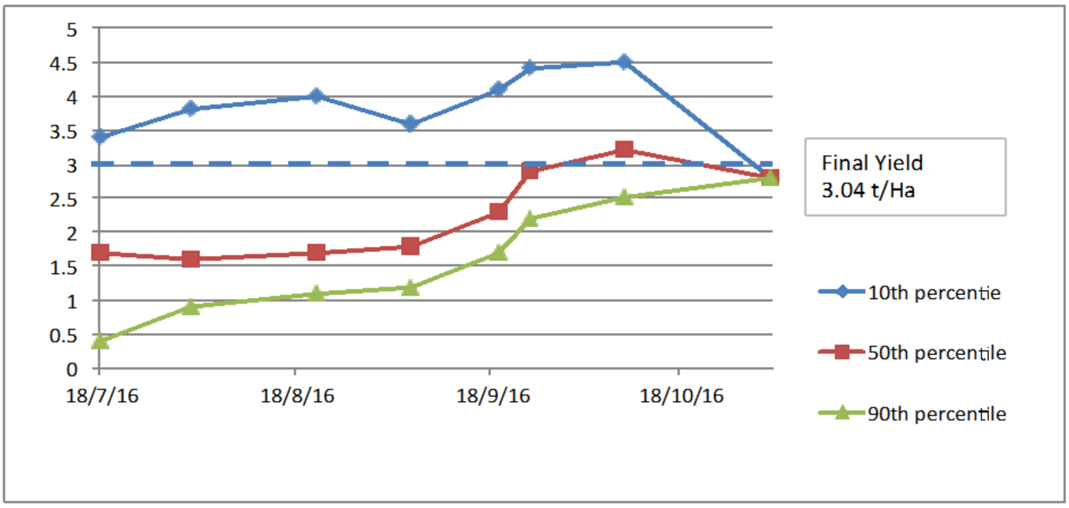


Figure 6. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Barrie site 9km north east of Willowie

Catford (2 km south west of Morchard)

This was one of the sites which the model did not perform well at in 2016. Yield prediction was consistently lower that many other sites and also below visual expectations. Final crop yield significantly exceeded the predicted yield. The reason for the difference has not been established- the model showed adequate nitrogen levels were available throughout the season, which also was in line with visual observations.

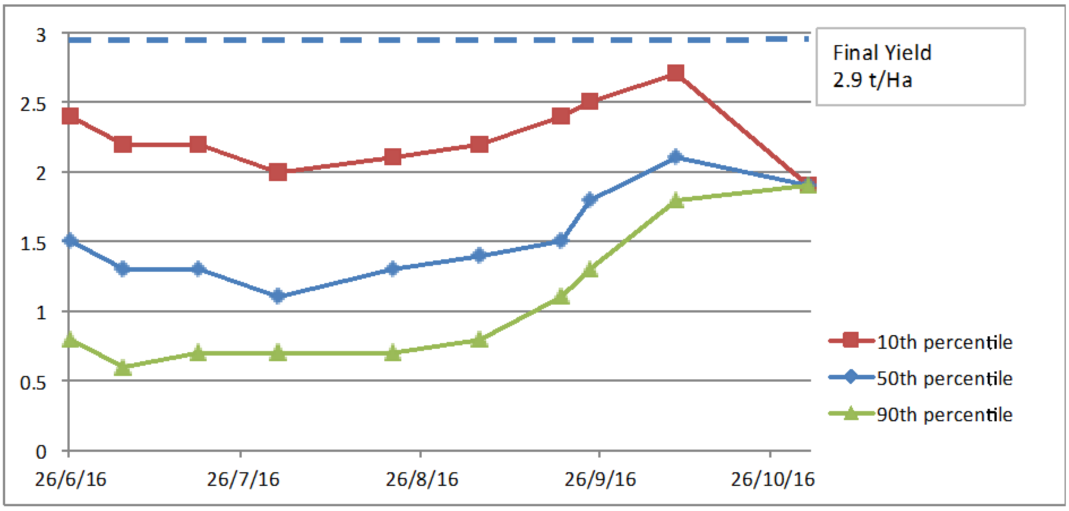


Figure 7. (Left) Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Catford site 2 km south west of Morchard

McCallum (9 km north Booleroo)

The final result saw a significant under-prediction of yield at this site, which was similar to the Catford result. A probable explanation is that the model underestimated the yield advantage of the very favourable spring finishing conditions.

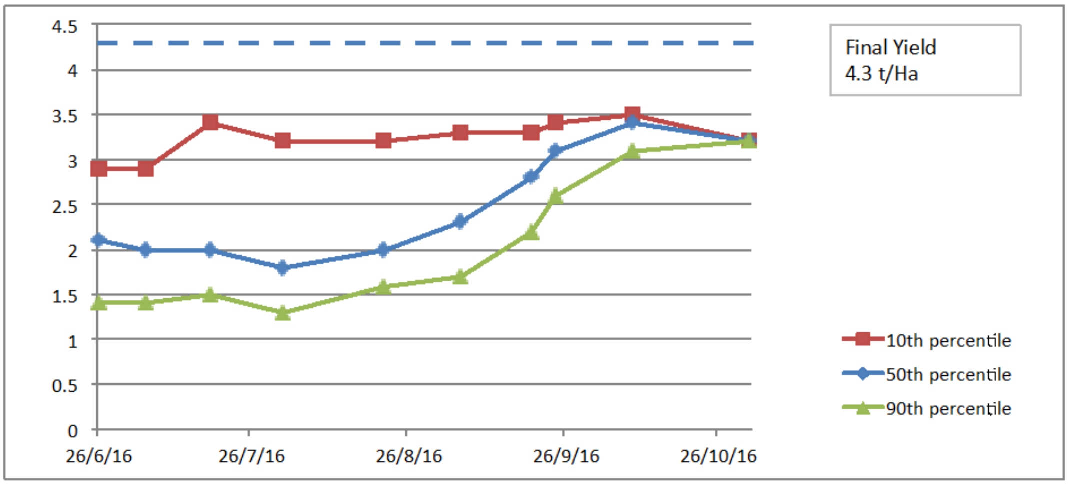


Figure 8. (Left) Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the McCallum site 9 km north of Booleroo Centre

Kuerschner (Black Rock)

The model did not perform well at this site, with the final yield of 3.24 tonne/Ha being about double that predicted by the model. The difference relates to nitrogen supply- the model was consistently showing that nitrogen was significantly yield limiting which was in contrast to visual observations which showed adequate N supply. Final grain protein levels were around 8%, which showed that yield was possibly achieved at some expense of grain protein.

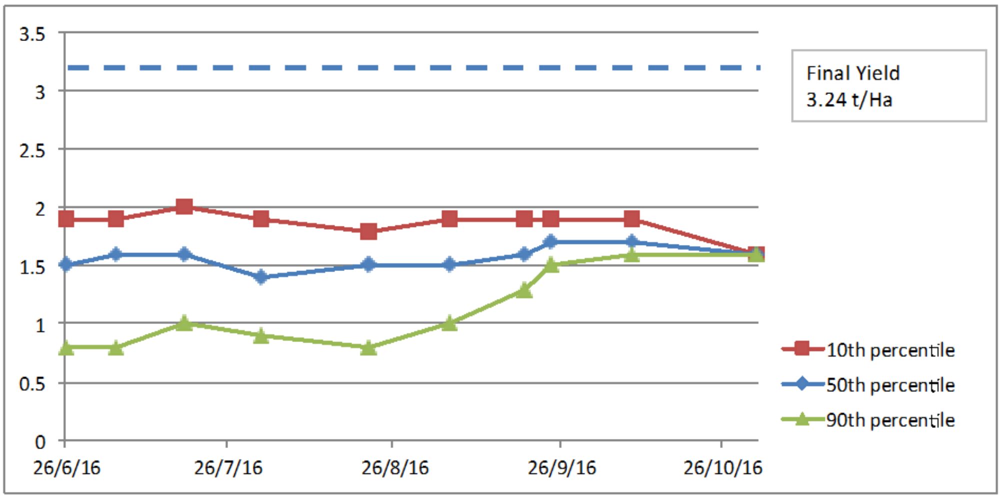


Figure 9. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Kuerschner site at Black Rock

Ritchie (7 km north west Appila)

This was the site of the GRDC funded Overdependence on Chemicals trial looking at cultural control of Barley Grass using different cereal varieties and crop seeding rates. Yield potential as shown by the model was always very high if favourable seasonal conditions were received. The crop visually looked satisfactory all year although yield potential visually did appear to be less than that predicted. The final result was heavily affected by severe frost which effectively destroyed crop potential. Wheat final yield was around 1.5 tonne/Ha of unmarketable grain. Barley at the same site was still frost affected but yielded around 3.5 tonne/Ha.

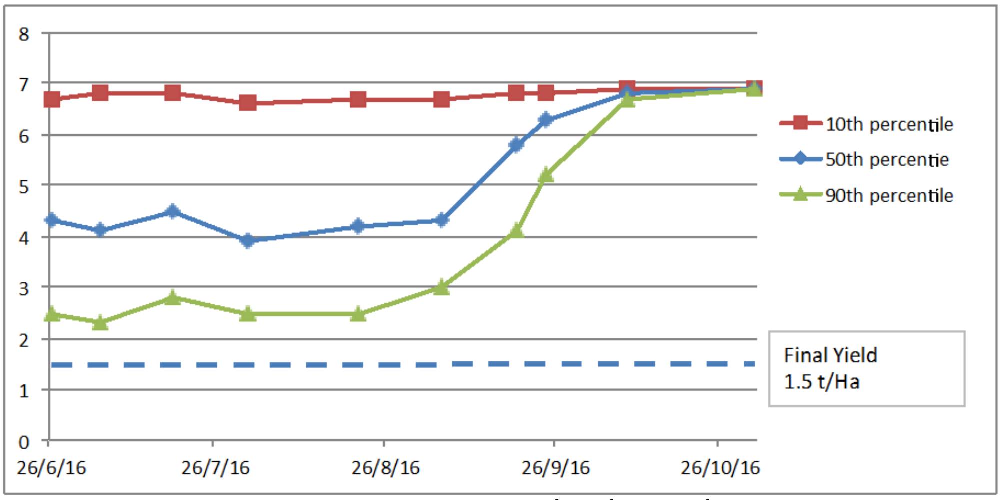


Figure 10. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Ritchie site 7 km north west of Appila

Clark (10 km south of Jamestown)

This site is in a frost prone region which provides significant management complications. The final yield map for the paddock showed significant frost damage in parts, down to a yield of less than 1.0 tonne/Ha. The paddock average was around 5.5 tonne/Ha.

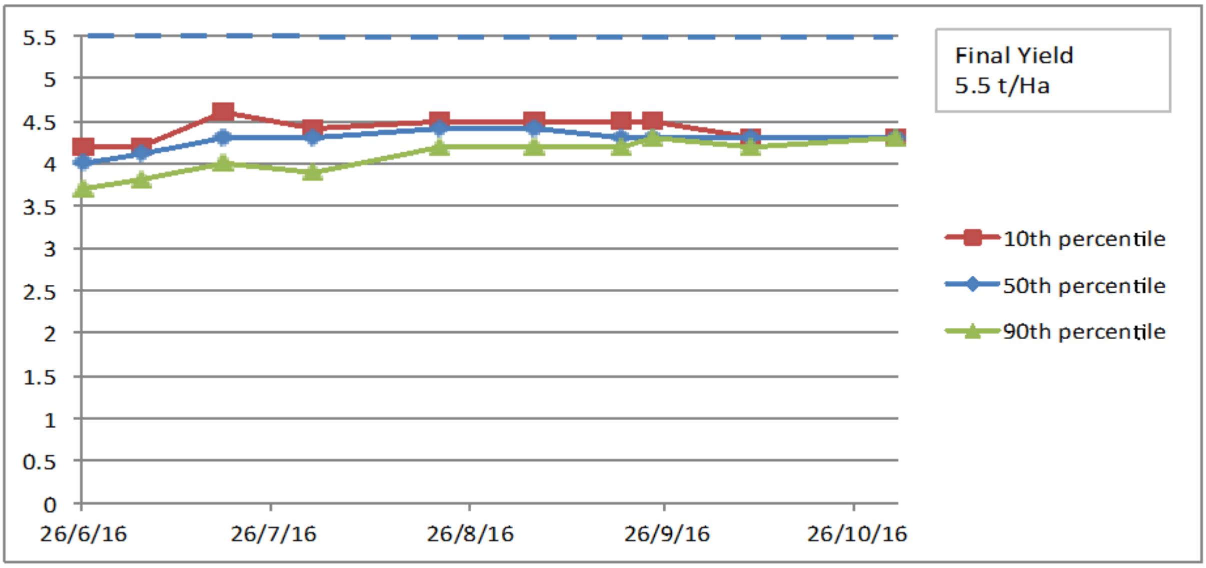


Figure 11. (Left) Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Clark site 10 km south of Jamestown

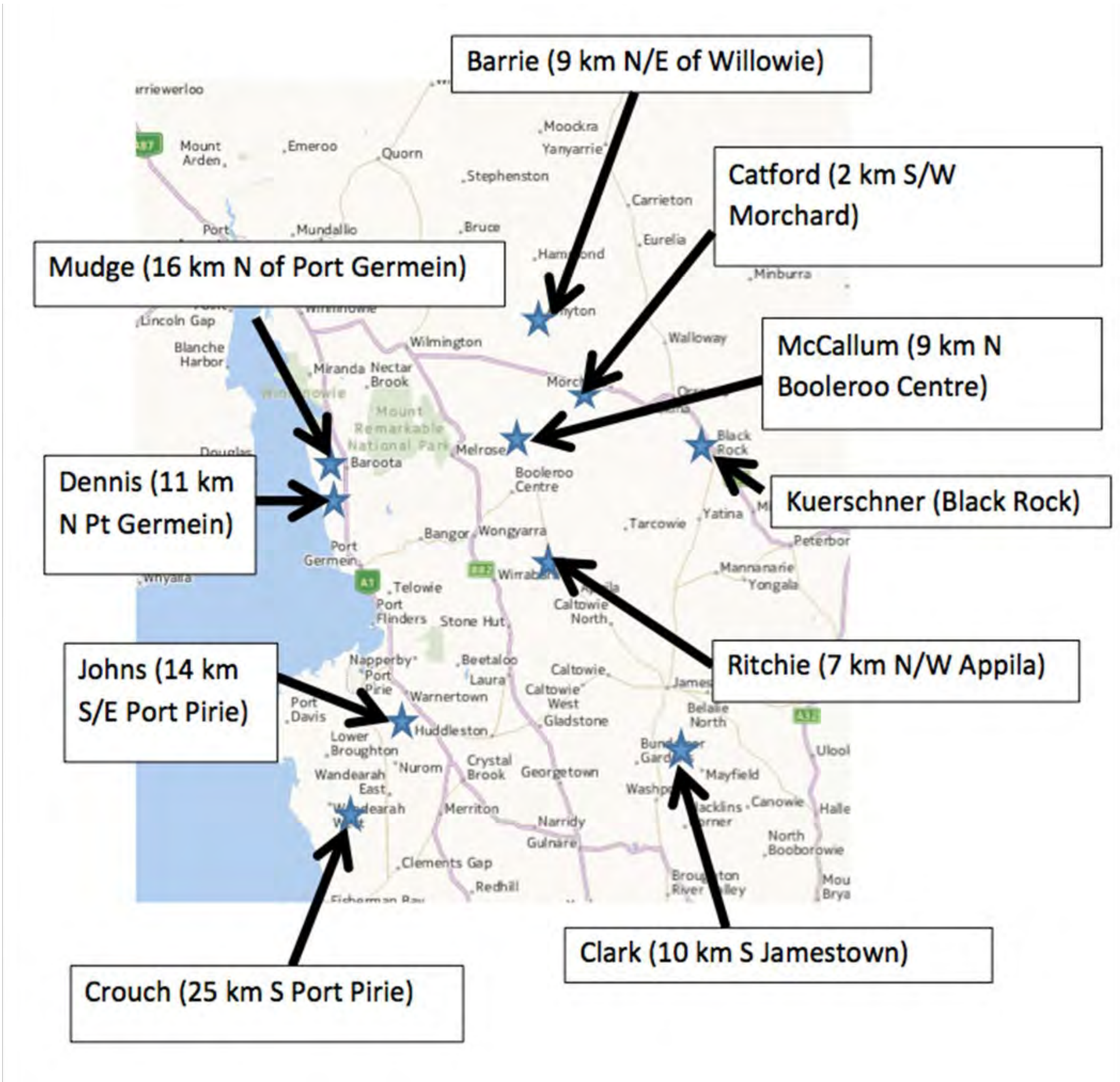


Figure 12. Yield Prophet sites in 2016

Summary and Conclusions

The 2016 year in the Upper North was generally a year of exceptional yield possibilities. The high seasonal rainfall and cool spring aided crop potential while frosts and sometimes a conservative approach to nitrogen management restricted yields. The performance of the Yield Prophet model remained reasonable on many sites in 2016 but results were compromised by a number of factors at others. However, it remains a useful tool to assess water and nitrogen limited yield potential as the season evolves and to assist with in-crop input decision making, particularly in-season nitrogen applications.

Acknowledgements

Participating farmers- Chris Crouch, Brendon Johns, Robert Dennis, Peter Barrie, Gilmour Catford, Matt McCallum, Jim Kuerschner, Kevin and Ben Ritchie, Luke Clark.
GRDC for funding the UNFS Stubble Initiative
Graincorp and EPIC for Sponsorship of the UNFS Yield Prophet project in 2016

Time of Sowing Trial at Booleroo Centre, 2016: Frost and Heat Effects on Crop Development and Yield

***Author**: Ruth Sommerville, Rufous and Co*

***Funded by**: South Australian Grains Industry Trust*

Project title: UNFS Time of Sowing Trial

Project duration: 2016 – 2018

Project delivery organisation: UNFS and Rufous and Co

Key Messages:

- **Optimal soil moisture at flowering and grain fill will enable most varieties to compensate for grain losses caused by frost or heat stress events.**
- **Trojan and Cutlass out yielded the two slower developing varieties of Mace and RAC2341 but this came with a protein penalty.**
- **Hatchet was the only variety to show a difference in yields as a result of time of sowing in 2016.**
- **Understanding development factors of each variety being sown is essential to minimising frost and heat effects and maximising grain quality and quantity.**

Background

Exposure of wheat during the flowering window to frost and heat events has a significant effect on yield. Understanding the optimum flowering period for different varieties in the highly variable climate of the Upper North of South Australia is difficult and compounded by the exposure of the region to both frost and heat events during the spring period.

Once this flowering window is understood, timing sowing to ensure the wheat crop is established so that they flower during the optimal period for yield is difficult, especially with increased farm sizes. Whilst no-till and dry-sowing have been used successfully in SA to get more area of crop flowering on time, an opportunity exists to take advantage of early breaking rains and retained soil moisture to start sowing crops earlier than currently practiced. It is also possible to utilise fast developing varieties to take advantage of late breaking rains and sowing in late May to early June.

Methodology

The South Australian Grains Industry Trust funded trial was sown 2kms south of Booleroo Centre on the Booleroo Centre to Appila Road in 2016 on a uniform red clay with 5 varieties at three times of sowing (TOS 1 - mid April (15/04/2016), TOS 2 - early May (05/05/2016) and TOS 3 - mid-late May(24/05/2016)).

Limited seed bed moisture at the early time of sowing resulting in watering of the entire site (sown and unsown plots) on the 21st of April with 5ml of simulated rain applied with a follow up of 5ml simulated rain on the 26th of April. This resulted in a successful germination of the early time of sowing and sufficient moisture for the second time of sowing. 26mm of rain fell over the 25/26th of May, resulting in successful establishment of all three times of sowing.

The varieties are described in **Table 1**. A new winter wheat that is being developed by Australian Grain Technologies (AGT) (RAC2341) was also tested. This line is derived from Mace, and whilst being winter in habit (needs to experience a winter before it will run up to head), it is very fast developing once it has vernalised. This means it is better adapted to the SA environment than existing winter wheats such as Wedgetail which tend to flower too late.

All plots were sown with 63kg/ha Urea + 67kg/ha MAP at 70-75kg/ha of seed. The plots were sown with a Primary Sales Plot Seeder on loan to UNFS. The site was sprayed with 118g/ha Sakura + 1.4l/ha Agro on the 15th of April prior to the first time of sowing. Additional Nitrogen was spread on the 5th of July 2016 at 70kg/ha of Urea and 30kg/ha of SOA across the entire trial site. The trial site was sprayed on the 18/07/2016 @80l/ha with Icon Zinc 100mls/ha, Amine 700 1L/ha and Lontrel 60mls/ha.

Table 1. Commercial wheat varieties used in the UNFS Time of Sowing Trial at Booleroo Centre in 2016.

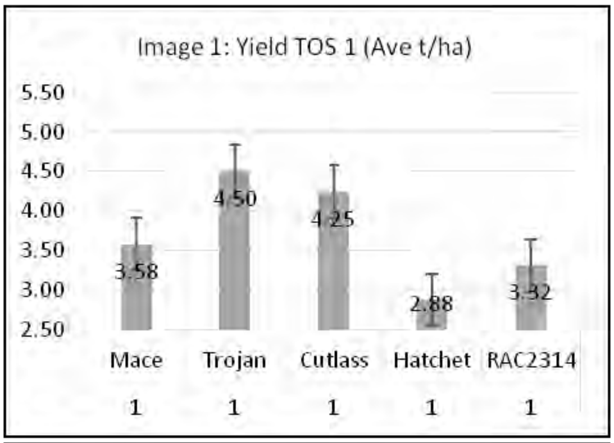
Variety	Maturity	Comments
Trojan	Midfast maturing spring (moderate vernalisation, moderate photoperiod)	APW has demonstrated good adaption to SA and has an unusual photoperiod gene which may allow it to be sown in late April and flower at the optimal period.
Mace	Fast maturing spring (weak vernalisation, weak photoperiod)	Australian Hard (AH) Regional Standard. SA main season benchmark and in the trial as the trial control.
Cutlass	Mid maturing spring (weak vernalisation, strong photoperiod)	APW probably the slowest maturing recently released variety with good adaption to SA. Not suited to sowing much before 20 April in most environments.
Hatchet CL Plus	Very fast maturing spring (very weak vernalisation, very weak photoperiod)	Australian Hard (AH). Clearfield tolerant. Derived from Axe, with faster maturity.
RAC2341 (AGT)	Winter wheat with fast maturity once vernalisation achieved	Mace derivative with Winter Wheat vernalisation requirements. Under development by AGT.

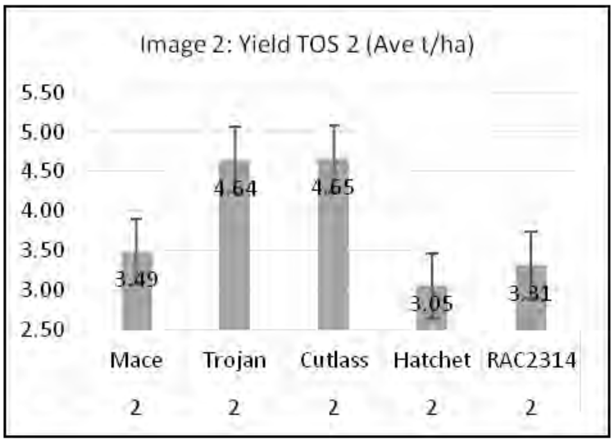
Seasonal conditions were recorded at the site for soil temperature at sowing and canopy temperature. Unfortunately the temperature sensors at canopy height failed on the 22nd of August and as such temperature data for the flowering window was not recorded. Data presented here relates to the Bureau of Meteorology Data from the nearest weather station, Yongala, approximately 40km from the site.

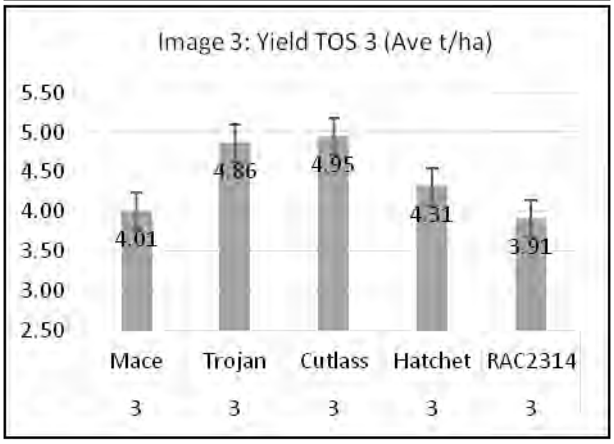
Results

Yield Results from the 2016 trial are presented in **Images 1-4**. At all times of sowing Trojan and Cutlass outperformed Mace, Hatchet and RAC2341 in t/ha (statistically significant). There was no significant different between Mace, Hatchet and RAC2341 in t/ha at either of the times of sowing. There was also no significant difference between Trojan and Cutlass yield at any of the three times of sowing.

A comparison of each variety and the effect of time of sowing on its individual performance resulted in no difference in yield for four of the five varieties (statistically similar results), with only Hatchet showing a significant yield response from variation in time of sowing. Hatchet produced a significantly higher yield (t/ha) when sown at the later time of sowing (24/05/2016) than either of the earlier times of sowing (**Image 4**).







Images 1-3. Yield Comparisons between varieties at the three times of sowing at Booleroo Centre in 2016. Anova analysis conducted at kg/ha, data presented as t/ha. Time of Sowing 1 $F(4,10) = 15.679$, $P<0.003$, Time of Sowing 2 $F(4,15) = 12.381$, $P<0.001$, Time of Sowing 3 $F(4,15) = 41.41$, $P<0.003$

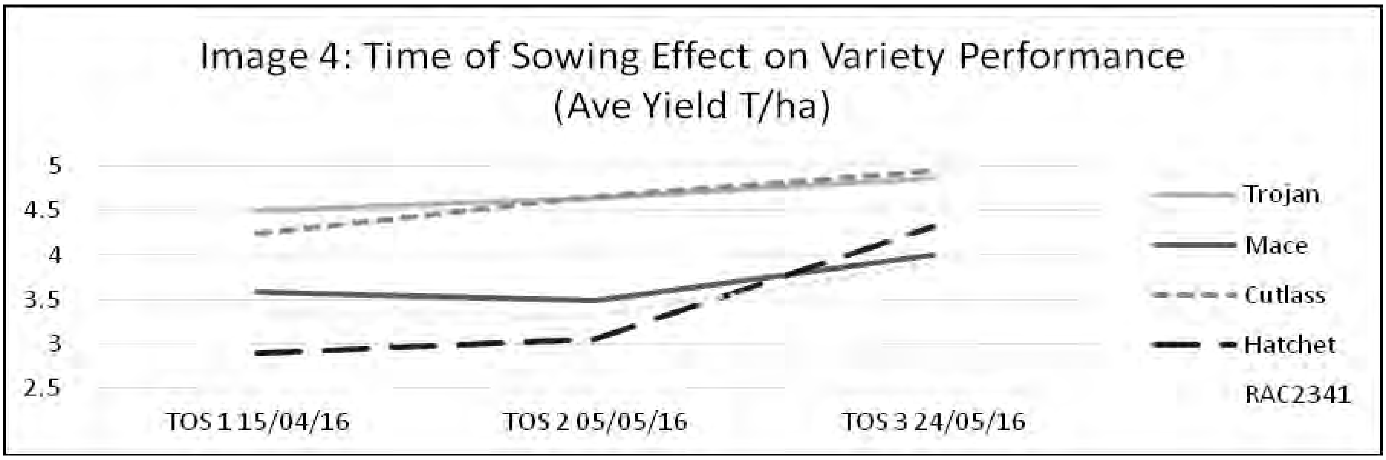


Image 4. Yield Comparisons between Time of Sowing for the 5 varieties at Booleroo Centre in 2016. Anova analysis conducted at kg/ha, data presented as t/ha. Trojan F(2,6) = 0.45, P=0.657, Mace F(2,6) = 2.34, P=0.177, Cutlass F(2,6) = 4.62, P=0.061, Hatchet F(2,6) = 11.88, P=0.008, RAC2341 F(2,6) = 3.14, P=0.116.

Grain quality results from the 2016 trial are shown in **Table 2**. Protein increased due to yield concentration effects and showed a slight penalty in some varieties for the late time of sowing. This resulted in the third time of sowing being downgraded, with potentially significant income implications. Test weight and Screenings for all varieties and times of sowing were well within minimum standards for all grades.

Table 2. Grain Quality and Grades of the 5 varieties across three times of sowing.

	Yield t/ ha	**protein %**		**screenings %**		**test wt kg/ hL**		**Grade**
Time of Sowing 1								
Trojan	4.504	8.617	a	3.145	a	81.807	a	ASW1
Mace	3.579	11.100	b	1.489	bc	78.207	b	H1
Cutlass	4.245	8.573	a	2.804	a	80.807	a	ASW1
Hatchet	2.881	13.000	b	2.080	b	78.933	b	H1
RAC2341	3.315	12.400	b	0.775	c	78.167	b	AUH2
SD	0.664	1.971		0.999		1.854		
P		<0.001		0.002		0.017		
Time of Sowing 2								
Trojan	4.639	8.457	a	2.154	a	82.367	a	ASW1
Mace	3.487	10.860	bc	1.990	a	78.333	bc	H1
Cutlass	4.654	8.697	ac	2.959	a	80.053	ac	ASW1
Hatchet	3.051	13.333	b	2.114	a	78.107	bc	H1
RAC2341	3.314	13.033	b	0.686	b	78.827	bc	H1
SD	0.836	2.185		0.816		2.084		
P		<0.001		<0.001		0.038		
Time of Sowing 3								
Trojan	4.863	8.607	b	1.656	a	82.107	a	ASW1
Mace	4.006	10.210	a	1.636	a	78.933	bc	APW1
Cutlass	4.949	9.037	b	2.708	a	80.000	b	ASW1
Hatchet	4.314	10.967	a	2.289	a	80.940	ac	APW1
RAC2341	3.911	10.967	a	0.728	b	78.733	bc	APW1
SD	0.469	1.103		0.733		1.466		
P		<0.001		<0.001		0.002		

NB. Grades shown here as determined by GrainCorp 2016/2017 Segregations.

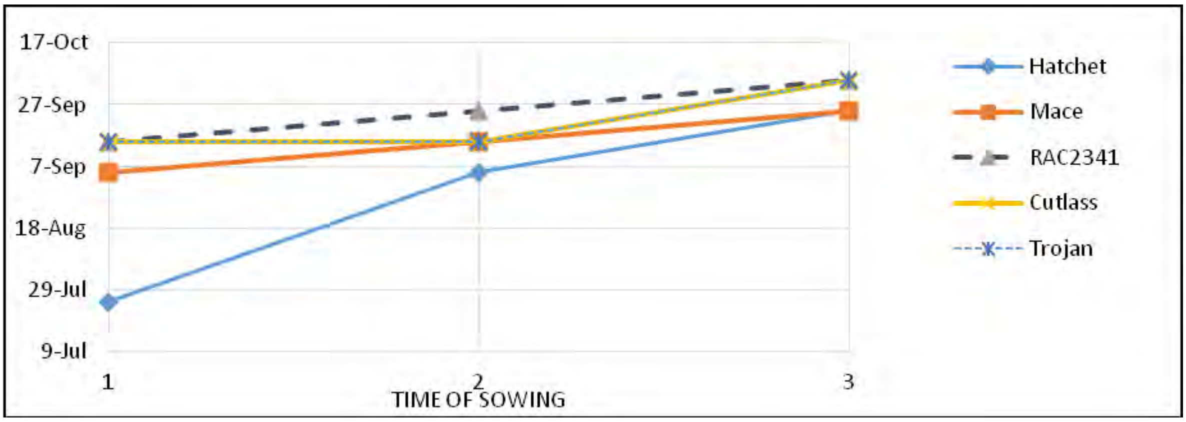


Image 5. Anthesis date for cultivars at the three times of sowing in 2016.

Seasonal Conditions:
Due to failure of the two canopy sensors on site the data of temperature on the site is limited. The Bureau of Meteorology (BOM) data for the nearest weather station at Yongala shows 5 frost events in July, 6 in August and 3 in both September and October. The in-paddock canopy temperature sensors recorded 7 frost events in July and 10 frost events in August prior to ceasing to log. This supports recent data showing that canopy temperatures are often significantly lower than those recorded by the district weather monitoring network. No heat events of significance to flowering were recorded in July-October by the BOM, however the canopy sensors recorded 4 events in August where the canopy temperature reached above 30degC, whilst the BOM recorded temperature was 20 - 25degC for this period.

Rainfall Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	*Nov*	*Dec*	*Annual*
2016	44.8	4.2	61.8	6.6	50.8	64.8	30.6	67.8	126.4	29.1	*15.8*	*91.8*	*594.5*
Mean	22.2	21.8	17.7	27.3	39.2	47.1	42.4	45.5	41.6	36.3	*28.4*	*24.5*	*393.9*
95th %ile	83.3	81.8	64.2	78.7	97.5	102.4	81.9	80.6	92.4	89.6	*70.9*	*73.6*	*567.8*

2016 was a kind year with above average annual rainfall (Decile 10) and a significantly higher than average rainfall for the spring at Booleroo Centre. These optimum moisture conditions resulted in all varieties and times of sowing yielding well with minimum screenings and required test weights. The majority of the varieties yielded similarly at each time of sowing, with only Hatchet, a fast growing variety with minimal photoperiod requirement, showing a significant yield penalty from being sown early. No varieties showed a yield penalty for a later time of sowing. This is not what is to be expected across the majority of seasons, with the number and severity of frost and heat events supressed in 2016 as a result of the high September and October rainfall and the ability of the crops to recover well and compensate for lost grains due to adequate moisture.

Despite these optimum growing conditions, each variety and time of sowing did show frost damage in the heads when visually assessed. This damage varied from 10-50% of heads showing aborted grains or aborted rows of grains.

Each variety did develop as expected with Hatchet showing that early time of sowing and lack of photoperiod requirement results in a very early flowering window and yield penalty. The varieties that did show high yields, Cutlass and Trojan, showed similar flowering periods at all times of sowing. RAC2341 was slower to develop than Mace and despite this showed similar yields, supporting its fit as an early sowing variety for the Upper North of SA.

Two varieties, Trojan and Cutlass, out yielded the other three varieties at most times of sowing, however this resulted in a protein penalty and downgrading across the 3 times of sowing. This may have a significant effect on the economic return on these varieties if not taken into consideration with fertiliser applications.

Not clearly recorded is the biomass production of these 5 varieties. RAC2341, may show potential as a dual purpose wheat, showing significant biomass production in comparison to the other varieties at the early times of sowing. It also showed very low screening levels at all times of sowing.

Although only one year of data is presented here, and the trial will continue in 2017 and potentially 2018, the results clearly show that a clear understanding of the appropriate sowing window for each variety and the resulting implications for yield and nitrogen requirements will have a significant impact on crop returns. Growers with larger wheat sowing programs will benefit from utilising multiple cultivars of different development types in order to allow them to start early enough. It is important to consider other factors when increasing the sowing window and utilising multiple varieties. Early sown paddocks should be selected for low grass competition and disease levels; ryegrass competition and root diseases can be exacerbated by early sowing. In addition early established crops can be more susceptible to disease and insect pressure. Controlling summer weeds and removal of green bridges can assist with this, in addition to seed dressings and vigilant monitoring of insect pests in early plant establishment.

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Surface Cover Grazing Systems Trial

Author: Mary-Anne Young

Funded By: GRDC Stubble Initiative

Project Title: Surface Cover Grazing Systems Trial

Project Duration: 2014-2017

Project Delivery Organisation: PIRSA Rural Solutions SA & Don Bottrall, UNFS

Key Points:

- **This trial investigated the effects of rotational grazing versus set stocking of stubble residues on surface cover in arable paddocks.**
- **Neither treatment had an advantage over the other in maintaining adequate surface cover for protection against soil erosion.**
- **Rotational grazing might be better as a stubble management practice for flattening and spreading stubbles more evenly.**

Project Outline:

Experiences of farmers using rotational grazing on stubbles (putting high numbers of stock on paddocks for short periods of time) suggest that more surface cover remains and less tracking is evident compared to paddocks where a lower stocking density for longer periods is used.

Figure 1: Set stocked paddock, ungrazed area fore.

A 7 ha paddock on Don Bottrall's property was split into 2, with one half set-stocked with half a mob of sheep; the other half further subdivided into 3 "blocks" which were each grazed for a few days in turn by the remainder of the mob. The two halves were grazed at the same time for the same period of time. A small area between the two was fenced off and not grazed at all.

Figure 2. Rotationally grazed (south) paddock

Assessments of surface cover were made (dry matter t/ha; proportion of bare ground / surface cover; and an erosion risk rating system used by the Department of Environment, Water and Natural Resources) prior to the sheep going onto the paddock and immediately after their removal.

Yearly summary of results:

2014

Wheat stubble grazed for 18 days in June by 220 ewe lambs (split into 2 mobs). Summer and autumn rains caused significant growth of weeds and volunteer cereals before paddock was grazed.

Table 1.

	Dry Matter t/ha		**Surface Cover %**		**Surface Cover Rating**	
	Before grazing	After grazing	Before grazing	After grazing	Before grazing	After grazing
Control		1.99		97		2
Rotational Grazing	1.84	1.44	91	91	2	3
Set Stocking	2.31	1.50	90	91	2	3

Table 2.

Stock Tracking (no. / m transect)	
	Tracks / m
Rotational Grazing	0.20
Set Stocking	0.18

There was a greater reduction in dry matter on the set stocking paddock but this had a greater amount of cover before grazing. There was no real change in percentage surface cover but a change in surface cover rating predominantly because of flattening and trampling of stubble. A similar amount of stock tracking on both treatments was observed.

2015

Wheat stubble of 2.2 t/ha crop reaped in December 2014 grazed for 9 days in March 2015. No summer weeds or volunteer cereal growth. Grazed by 208 ewes and 4 rams split into 2 mobs.

Table 3.

	Dry Matter t/ha		**Surface Cover %**		**Surface Cover Rating**	
	Before grazing	After grazing	Before grazing	After grazing	Before grazing	After grazing
Control	1.83	2.00	87.8	89.5	2	2
Rotational Grazing	1.58	1.03	85.3	77.6	3	5
Set Stocking	1.58	1.57	92.4	87.3	3	5

Table 4.

Stock Tracking (no. / m transect)	
	Tracks / m
Rotational Grazing	0.03
Set Stocking	0.03

This stubble was grazed for a relatively short period of 9 days due to the thin nature of the stubble and lack of summer weed and volunteer cereal growth. As a result of the shortened period, less tracking was observed. Stock trampling flattened the stubbles which is reflected in the change in Surface Cover Rating from 3 to 5. The Surface Cover Rating of 5 is regarded as at the threshold for adequate cover for erosion protection and both treatment areas were at this level when stock were removed.

2016

Barley stubble from a 2.7 t/ha crop reaped in November 2015. Grazed by 194 ewes and 4 rams split into 2 mobs for 27 days from late January. No summer weed or volunteer cereal growth.

Table 5.

	Dry Matter t/ha		**Surface Cover %**		**Surface Cover Rating**	
	Before grazing	**After grazing**	**Before grazing**	**After grazing**	**Before grazing**	**After grazing**
Control	2.84	2.67	98	96	2	2
Rotational Grazing	2.50	2.14	97	90	2	4
Set Stocking	2.26	1.86	93	84	2	4

Table 6.

Stock Tracking (no. / m transect)	
	Tracks / m
Rotational Grazing	0.28
Set Stocking	0.30

This stubble was grazed within 3 months of the paddock being reaped. There was no other feed such as volunteer cereals or summer weeds before stock went in however rain at the end of January could have stimulated some growth of feed. The paddocks were grazed for longer periods than during the previous 2 years. Changes in cover levels and ratings, and stock tracking frequency were about the same on both treatments. More than adequate cover remained when stock were removed.

2017

Stubble from a hail-damaged oat crop was grazed for 21 days from late April by a mob of 118 Merino wether hoggets (59 per treatment). Stubble was estimated to be that of a 5 t/ha grain crop (grain reaped was 3.1 t/ha). Summer rain caused germination of summer weeds and volunteer cereals; 72 mm of rain just prior to sheep going into the trial paddock stimulated germination of plants during the grazing period.

Table 7.

	Dry Matter t/ha		**Surface Cover %**		**Surface Cover Rating**	
	Before grazing	**After grazing**	**Before grazing**	**After grazing**	**Before grazing**	**After grazing**
Control	4.40	7.89	100	100	2	2
Rotational Grazing	3.19	2.99	99	96	2	3
Set Stocking	3.60	3.57	99	97	2	2

Table 8.

Stock Tracking (no. / m transect)	
	Tracks / m
Rotational Grazing	0.03
Set Stocking	0.09

The effect of rain just before stock went into the paddocks is reflected by the increase in biomass on the control plot and it is expected that germination of volunteer cereals provided feed for stock in the grazing areas. More dry matter was lost from the rotational grazing area but cover levels remained very high after grazing. More stubble was flattened on the rotational grazing plots which is indicated by the slightly higher Surface Cover Rating score for this area. Stock tracking was more evident on the set stocked area and only evident on the rotational grazing area that was the last grazed.

Summary of results 2014-2017

Comparison of changes in surface cover measures before and after grazing were made to determine if the type of grazing treatment (rotational or set stocking) had a consistent effect on surface cover.

There was no clear difference between treatments, with generally adequate levels of surface cover for erosion protection remaining after stock were removed in all years.

Visible differences evident in photos of the site show the rotationally grazed paddocks tending to have more flattened, even surface cover compared to more clumps of standing stubble on the set stocked paddock.

Table 9.

Grazing details	**2014**	**2015**	**2016**	**2017**
Date stock removed	22nd June	23rd March	20th February	19th May
No. of days	18	9	27	21
Stubble type	Wheat	Wheat	Barley	Oat
DSE's / treatment	110	127	119	59
Grazing intensity (DSE x days)	1980	1143	3213	1239

Table 10.

Changes in after grazing:	**Dry Matter t/ha**				**Surface cover %**				**Surface Cover Rating**			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Rotational	-0.4	-0.6	-0.4	-0.2	0	-8	-7	-3	-1	-2	-2	-1
Set Stocking	-0.8	0.0	-0.4	0.0	0	-5	-9	-2	-1	-2	-2	-0

Table 11.

No. of stock tracks / m transect	**2014**	**2015**	**2016**	**2017**
Rotational grazing	0.20	0.03	0.28	0.03
Set Stocking	0.18	0.03	0.30	0.09

The type of grazing system did not appear to influence stock tracking. The greatest difference appeared in 2017 when more tracks were evident on the set stocking treatment and on only one phase of the rotational grazing treatment.

Over the 4 years of the trial, neither rotational grazing nor set stocking of a stubble paddock has consistently proved to be better than the other in terms of maintaining surface cover. The rotationally grazed stubbles tended to be more flattened than the set-stocked ones and the greatest difference in stock tracking appeared in the last year when the set stocked area had more tracks than the rotationally grazed area.

The highest nutritional value of stubbles is immediately after harvest so stock need to go into stubbles at this time to capitalise on this value. However, setting up a rotational grazing system immediately after a paddock has been reaped and moving sheep as required does not suit many cropping farmers' programmes.

While there appears to be no grazing benefit of one system over the other, the benefits of grazing as a stubble management practice might be better in a rotational grazing system. The more intense stocking tended to flatten stubbles more and not leave clumps of standing stubble. More even, flattened stubble might be more beneficial for stubble management making it more trafficable for machinery and less favourable for snails.

More even distribution of dung (and therefore nutrients) could be encouraged by rotational grazing as sheep will not be able to consistently camp in the same place every day.

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Maintaining profitable farming systems with retained stubble across various rainfall environments in SA, Victoria and central and southern NSW

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Keywords: stubble retention, yield, profitability, management strategies, crop diversity, livestock, N cycling, harvest efficiency.

Take home messages:

- **In 2017, don't let stubble compromise the big things (weeds, disease, timeliness).**
- **If the intent is to retain stubble:**
  - ⇒ **Pro-actively manage the stubble for your seeding system.**
  - ⇒ **Diversify (add legumes to rotation), deep band N and manage invertebrates. Mice could also be a major problem.**
  - ⇒ **For tined seeders, reduce stubble load by mulching, incorporation + nutrients, baling, grazing and consider sowing at 15-19 degree angle to previous sown row.**
- **If stubbles are too thick to sow through, consider strategic late burn, especially before 2nd wheat crop or if sowing canola into large stubbles.**
- **Early monitoring is essential to see how effective actions are to allow for re-planning.**

Background

Following a GRDC review that identified gaps regarding the impact of stubble retention in southern cropping systems, a five year program was initiated by GRDC in 2014. Ten projects comprising sixteen farming systems groups and research organisations which include BCG, CSIRO, CWFS, EPARF, Farmlink Research, Hart Field Site group, ICC, LEADA, MFMG, MSF, Riverine Plains, SARDI, UNFS, VNTFA, Yeruga Crop Research are currently involved in exploring the issues that impact on the profitability of retaining stubbles across a range of environments in southern Australia with the aim of developing regional guidelines and recommendations that assist growers and advisors to consistently retain stubbles profitably.

In 2016, grain yields have been high across most of southern and south-eastern Australia, with many cereal crops yielding ≥ 5t/ha and often up to 8t/ha which indicates there will be a residual stubble load of 7.5-12 t/ha. This paper examines two main management options to deal with high stubble loads (≥ 5t/ha) in 2017, and incorporates many of the main findings from the stubble initiative to date.

<u>Option 1: How to manage stubble if you plan to retain the stubble at all costs</u>

a. Tine = 1. Harvest high (≥30cm) and mulch or incorporate
2. Harvest low (≤ 20cm), use chopper/power spreader to smash and spread straw evenly across swath at harvest or soon afterwards

b. Disc = Stripper fronts/harvest high, good diverse rotation

<u>Option 2: How to manage stubble if you have a flexible approach to retaining stubble</u>

Harvest big crops high, graze, burn, bale straw as necessary to reduce stubble to amounts that sowing equipment can manage. Focus on reducing stubble in paddocks where the stubble is likely to impact the 2017 crop yield e.g. wheat on wheat paddocks.

It has been well documented that to successfully establish a crop into a full stubble retained system requires an integrated management approach incorporating three main stages of stubble management - pre-harvest, post-harvest/pre-sowing, and finally at sowing (ref 1,2,3,4,5,6). During these periods, a series of questions (some outlined below) will need to be addressed by farmers to successfully establish a crop (ref 4).

- What is my preference for tillage system?
- What is my seeding system?
- What is my row spacing and accuracy of sowing?
- What crop will be planted into the paddock in 2017?
- What is the type of crop residue?
- What is the potential grain yield and estimated amount of crop residue?
- Is the crop lodged or standing at harvest?
- What is the desired harvest speed and harvest height?
- How uniform is the spread of straw from my harvester?
- Should I spread residue or place in a narrow windrow?
- Do I have a weed problem which requires intensive HWSC, chaff carts or chutes?
- Will the stubble be grazed by livestock?
- Am I prepared to process stubble further post-harvest: mulch, incorporate, bale?
- If incorporating stubble, should I add nutrients to speed up the decomposition process?
- What is the risk of stubble-borne disease to the 2017 crop?
- Am I likely to encounter a pest problem in 2017: mice, slugs, earwigs, weevils, snails?
- What is the erosion risk based upon soil type and topography?
- Do I need to burn or what else can I do?

Prior to harvest, all crops should be assessed to estimate grain yield, potential stubble load and weed issues. The GRDC Project YCR00003 is developing an App to assist farmers and consultants. As a rule of thumb, the stubble load following harvest will be approximately 1.5 to 2 times the grain yield for wheat and between 2 to 3 times the grain yield for canola (ref 4, 5, 6).

Remember, there is no perfect stubble management strategy for every year. Crop rotations, weeds, disease, pests, stubble loads, sowing machinery and potential sowing problems will largely dictate how stubble should be managed.

Option 1: How to manage stubble if retaining at all costs

A recent survey was undertaken in the Yorke Peninsula and Mid-North of SA which showed that 82% of farmers use tined seeders, with the remaining 18% using discs (Yeruga Crop Research). The proportion of farmers using either disc or tined seeders would be similar to the YP and mid-north areas, although the percentage using tined seeders would be higher in many areas. In relation to establishing a crop in stubble retained systems, the following issues arose:

- About 21% of farmers were totally committed to retaining stubbles at all costs while about 79% would consider burning stubbles if absolutely necessary;
- Herbicide efficacy was extremely important (80+% in both tine and disc);
- Managing weeds (approx. 65% both tine and disc);
- Managing slugs and snails (> 50% in tine and disc);
- Efficiency and ease of sowing (82% in tine and 58% in disc);
- More important at seeding:
    - Straw length (70% tine)
    - Chaff fraction (50% disc)
    - Hair pinning (15% tine, 84% disc)

Stubble height

Using a stripper front or harvesting high is the quickest and most efficient method to produce the least amount of residue that needs to be threshed, chopped and spread by the combine. Harvesting high (40-60 cm) compared to 15 cm increased grain yield and combine efficiency by reducing bulk material going through the header and reduced harvests costs by 37 to 40% (Table 1). As a general rule, there is a 10% reduction in harvest speed for each 10cm reduction in harvest height (Tables 1 and 2, ref 4, 5, 8). Slower harvest speed across a farm also exposes more unharvested crop to the risk of weather losses (sprouting, head/pod loss, lodging) during the harvest period, and the cost of this is not accounted for in Table 1.

Table 1. Harvesting wheat low or high using a JD9770 combine in 2014 (Ref 7). Ground speed was altered to achieve similar level of rotor losses at both harvest heights. Values are means of three replicates STS yield monitor and all differences are significant (P<0.05). Operating costs determined at $600/hr.

Harvest height		**Efficiency (ha/h)**	**Speed (km/hr)**	**Fuel (l/ha)**	**Yield (t/ha)**	**Cost $/ha**	**Cost $/ton**
60cm		9.5	10.6	5.4	2.19	$63.2	$28.7
15cm		5.7	6.2	9.6	2.05	$105.3	$50.1
% Change to 15cm		**-41%**	**-42%**	**+78%**	**-6%**	**+40%**	**+57%**

However, there are some negatives to retaining tall wheat stubble, with several groups in the initiative finding that wheat sown into taller wheat stubble (45cm cf 15cm) received less radiation and were exposed to cooler temperatures. This can reduce early growth and significantly reduce tiller numbers. In a Riverine Plains experiment in 2014, there was a significant reduction in grain yield (4.98t/ha cf 5.66t/ha with lsd @ P<0.05 = 0.45t/ha) in tall compared to short stubble. In 2015 the group found no difference in grain yield. In 2016, significantly less tillers were found in several trials in tall stubble, however in all of these trials, this did not result in any difference in grain yield.

Table 2. Harvesting wheat low or high using a Case 8230 combine with a 13m front in 2015 (ref 7). Ground speed was altered to achieve similar level of rotor losses at both harvest heights. Operating costs determined at $600/hr. (*ns* = no significant difference)

Harvest height		**Efficiency (ha/h)**	**Speed (km/ hr)**	**Fuel (l/ha)**	**Harvest efficiency (t/hr)**	**Grain Yield (t/ha)**	**Cost $/ha**	**Cost $/ton**
40cm		12.0	8.5	6.6	45	3.8	$50.0	$13.5
15cm		7.5	6.0	10.6	30	3.9	$80.0	$20.2
% Change to 15cm		**-38%**	**-29%**	**+61%**	**-33%**	***ns***	**+37%**	**+33%**

In 2016 like many previous years, herbicide resistant weeds, especially annual rye grass (ARG) continue to be a problem. Harvest weed seed control (HWSC) which includes narrow windrow burning, chaff carts, chaff lining, direct baling, and mechanical weed seed destruction is an essential component of integrated management to keep weed populations at low levels and thus slow the evolution and spread of herbicide resistance. HWSC requires crops to be harvested low in order for weed seeds to be captured in the chaff fraction from the combine, and if practiced provides an additional reason to harvest low. The prototype Integrated Harrington Seed Destructor (iHSD) was tested in Temora, NSW in December 2015, Inverleigh in December 2015 and Furner, SA in January 2016 at a constant speed of 4km/hr to compare the efficiency and cost with non-weed seed destruction methods (Table 3). The three large scale field trials in both states are being monitored for changes in annual ryegrass populations before and after sowing between 2015 and 2018.

In 2016 there has been less opportunity to harvest cereal crops very high in many areas due to lodged or leaning crops, and variable head heights. Cereal crops such as Compass barley often lodged badly resulting in the need to harvest very low.

Table 3. A Case 9120 harvesting wheat conventionally at 30cm, harvesting at 15cm for baling or narrow windrow burning and harvesting at 15cm with a prototype iHSD at Furner, SA in 2016. (Data supplied by GRDC project SFS00032)

	Harvest height	**Grain Yield (t/ha)**	**Speed (km/hr)**	**Engine Load (%)**	**Fuel (l/ha)**	**Fuel Efficiency (l/hr)**
Conventional Harvest - Burn	**30cm**	4.7	3.8	59.8	14.3	52.7
Windrow Bale/burn	**15cm**	4.6	4.0	65.5	16.4	59.5
iHSD	**15cm**	4.6	4.0	88.7	22.7	87.8
lsd @ P<0.05)		**ns**	**ns**	**2.26**	**1.36**	**2.18**
% Change to 15cm				**+9%**	**+11%**	**+11%**
% change to iHSD				**+33%**	**+37%**	**+40%**

MULCH and incorporate

Lightly incorporating the stubble into the surface soil using a disc chain or disc machine (i.e. Speed tiller, Grizzly, Amazone Cattross, Vaderstad Topdown or Lemken Heliodor) soon after harvest while the stubble is higher in nutritional value is another option for farmers wanting to maintain all of their stubble, especially where a tined seeder is the primary sowing implement, or where lime and stubble needs to be incorporated into the soil in a disc-seeding system. On the lighter sandier soils in SA, the recommendation would be to delay incorporation until 3-4 weeks before seeding as these soils are more prone to wind and water erosion. Mulching and incorporation requires soil moisture, warm soil temperature, soil/stubble contact and nutrients to convert a carbon rich feed source into the humus fraction. Early mulching and incorporation allows time for the stubble to decompose and immobilise N well before sowing, reducing the likelihood of reduced N availability.

When trying to decompose a large quantity of stubble in a short period of time (i.e. to convert stubble into humus), it may be beneficial to add some nutrients to the stubble prior to incorporation. To assist in minimising the amount of fertiliser required to add to the stubble, determining the concentration of the nutrients in the stubble is important. As humus is so nutrient rich and the stubble residues are relatively nutrient poor, only a small proportion of the total carbon in the crop residues can be converted into humus. Dr Clive Kirkby has found that a maximum of 30% of the total carbon from stubble residues could be converted to humus, so recommends lowering the humification rate to 20% rather than 30%. In our example (Table 4), the quantity of fertiliser (sulphate of ammonia) that would need to be applied to the 10t/ha residual cereal stubble load where the stubble had a nutrient concentration of 0.7%N, 0.1%P and 0.1%S and the farmer wanted a humification rate of 20% would be 33.1kg/ha of nitrogen and 7kg/ha of sulphur at an estimated cost of $14.90/ha for nutrients only. In contrast, if a farmer was trying to build up their organic carbon concentration in the soil from this stubble residue to the maximum possible amount (30% humification rate), the quantity of nutrients required increases to 45.4kgN/ha, 3.8kgP/ha and 7.6kgS/ha, at a cost of $74.40 for nutrients (Table 5). The nutrients applied are not lost, but should form a source of slow release nutrition to the following crop as humus while avoiding “nutrient tie-up” caused by late incorporation of nutrient poor residues. Thus, later inputs could potentially be reduced if costs were of concern.

Table 4. A screenshot of Dr Clive Kirkby's stubble nutrient humification calculator to estimate the amount of fertiliser (N and S only) as Sulphate of ammonia (kg/ha) that would need to be applied to a cereal stubble load of 10t/ha with a humification rate of 20% to assist in rapid breakdown of the residual stubble.

Stubble Nutrient Humification Calculator		C	N	P	S
Stubble load (kg/ha)	10000				
Humification required (%)	20				
Stubble nutrient concentration (%)		45.0	0.700	0.100	0.100
Nutrients already in stubble (kg/ha)		4500	70	10	10
Carbon to be humified & nutrients required (kg)		900	77.0	9.2	11.7
Carbon remaining (kg)		3600			
Extra nutrients required (kg/ha)			7.0	-0.8	1.7
1. Fertiliser type and Nutrient concentration (%)	SOA		21.0		24.0
2. Fertiliser type and Nutrient concentration (%)					
Fertiliser required to supply exact nutrients (kg/ha)			33		7
Fertiliser cost ($/ha)			$14.9		
Fertiliser and spreading cost ($/ha)			$23.4		

(Financial support provided by NIEI, EH Graham Centre, CSIRO and GRDC project DAN00152)

Table 5. A screenshot of Dr Clive Kirkby's stubble nutrient humification calculator to estimate of the amount of fertiliser (N:P:S) as Urea and Single Superphosphate (kg/ha) that would need to be applied to a cereal stubble load of 10t/ha with a humification rate of 30% to assist in more rapid breakdown of the residual stubble.

Stubble Nutrient Humification Calculator		C	N	P	S
Stubble load (kg/ha)	10000				
Humification required (%)	30				
Stubble nutrient concentration (%)		45.0	0.700	0.100	0.100
Nutrients already in stubble (kg/ha)		4500	70	10	10
Carbon to be humified & nutrients required (kg)		1350	115.4	13.8	17.6
Carbon remaining (kg)		3150			
Extra nutrients required (kg/ha)			45.4	3.8	7.6
1. Fertiliser type and Nutrient concentration (%)	Urea		46.0		
2. Fertiliser type and Nutrient concentration (%)	Single super			8.8	11.0
Fertiliser required to supply exact nutrients (kg/ha)			99	43	69
Fertiliser cost ($/ha)			$74.4		
Fertiliser and spreading cost ($/ha)			$82.9		

(Financial support provided by NIEI, EH Graham Centre, CSIRO and GRDC project DAN00152)

In an experiment at Harden, NSW between 2008 and 2011, Dr Kirkby incorporated between 8.7 and 10.6 t/ha of cereal or canola stubble without nutrients or with nutrients at a humification rate of 30%. In May 2009, following the incorporation of 8.7t/ha wheat stubble in February 2009, they measured the quantity of wheat stubble that had broken down and found that only 24% of the stubble remained where nutrients had been added whereas 88% remained where the stubble had been incorporated only (Kirkby *et al*. 2016). A couple of groups (Riverine Plains, MFMG) have included light incorporation (+/-) nutrients in their treatment mixes. Although no group specifically examined residue breakdown, they found that the cultivated (+ nutrient) treatment often yielded the same or more than cultivated (no added nutrient) treatment (i.e. Wheat grain at Yarrawonga January 2017 in Cultivate +40kgN/ha = 6.7t/ha compared to Cultivate only = 5.9t/ha, lsd = 0.58).

Diverse cropping sequence

A diverse cropping sequence provides many benefits for farmers wanting to retain all their stubble annually. Diversity allows each crop to be sown into a less antagonistic stubble by reducing physical, disease, pest and weed constraints.

A fully phased systems experiment was established in Temora in 2014 at a site with high levels of Group B resistant ARG to examine if a diverse crop rotation ('Sustainable' - vetch hay-TT canola-wheat-barley) could improve the profitability of stubble retained no-till (Flexi-Coil tine seeder with Stiletto knife points and deep banding & splitting boots) and zero-till (Excel single-disc seeder with Arricks' wheel) systems. Three cropping systems (Aggressive, Conservative and Sustainable) were compared with the rotations for each as Aggressive (RR canola-wheat-wheat), Conservative (TT canola-wheat-wheat) and sustainable (as above). In the cereal crops in the Aggressive and Sustainable system, new-generation pre-emergent herbicides (Sakura® and Boxer Gold®) were used for grass weed control. In the Conservative system, trifluralin and diuron were used for grass weed control in the tine system, and diuron alone in the disc system.

The introduction of diversity in the Sustainable system has allowed it to achieve a net margin ($512/ha/year) which is higher than in the Aggressive systems ($498/ha/year) and at lower cost ($465 *cf* $517/ha/year) and thus higher profit:cost ratio ($1.12 *cf* $0.98) (Table 6). The reduced costs in the Sustainable system are driven by lower fertiliser N inputs from the inclusion of vetch hay, which requires no fertiliser N itself and provides residual N for subsequent crops. The barley phase of the Sustainable system has also been more profitable than the second wheat crop in either the Aggressive or Conservative system (Table 6), despite record low barley prices in this 2016/17 season.

The Riverine Plains group compared a wheat-faba bean-wheat rotation against a wheat-wheat-wheat (+/- burning) and found there was no significant difference in wheat yield following wheat stubble that was retained or burnt (average 3.42t/ha), but there was a 2t/ha increase in wheat yield following faba beans. The wheat stubble also acted as a trellis assisting to keep the beans off the ground and improve airflow and the higher nitrogen concentration following the bean crop combined with the increased decomposition of the wheat stubble resulted in the bean crop "resetting" the system and burning was not required. Similar findings have been observed by the Hart Field Site group in relation to lentils using the wheat stubble as a trellis. Earlier maturing varieties such as Blitz were found to be taller with increasing stubble height (30 and 60cm stubble height *cf* 15cm or baled). They also found that the type of stubble was important for the following crop, with wheat maintaining its supportive structure better than barley.

Tables 6. Average net margins (EBIT) – effect of crop strategy at Temora, NSW, 2014-2016

Cropping system	Crop Type	Average Total Cost 2014-16	Average Net Margin 2014-16	Average 3yr Profit: Cost ratio
		($/ha/yr)	($/ha/yr)	($/ha/yr)
Aggressive	Canola RR	$524	$722	1.4
Aggressive	Wheat (yr 1)	$525	$378	0.7
Aggressive	Wheat (yr 2)	$504	$394	0.8
Conservative	Canola TT	$452	$694	1.5
Conservative	Wheat (yr 1)	$415	$289	0.7
Conservative	Wheat (yr 2)	$419	$261	0.6
Sustainable	Vetch (Hay)	$463	$416	0.9
Sustainable	Canola TT	$426	$769	1.8
Sustainable	Wheat	$492	$422	0.9
Sustainable	Barley	$478	$441	1.0
SYSTEM AVERAGES				
Aggressive		$517	$498	$0.96
Conservative		$429	$415	$0.95
Sustainable		$465	$512	$1.12

Establishing crops with disc and tined seeders

It has been well documented that a disc seeder can handle higher stubble loads in comparison to a tined seeder, have less variability in seeding depth and higher sowing efficiencies than a tined seeder. Over the three year trial at Temora, there has been little difference in the net margin of either the disc or tine openers where ARG was effectively controlled by pre-emergent herbicides in the Aggressive and Sustainable cropping systems. However, in the Conservative system, the combination of trifluralin and diuron were able to achieve a reasonable ARG control in the tined system, but diuron alone was largely ineffective in the disc system, and this has reduced yields and profit in this system (Table 7).

Table 7. Average net margins across all crop types for each crop system by opener type between 2014 and 2016 at Temora, NSW.

	Net Margins 2014 ($/ha)		Net Margins 2015 ($/ha)		Net Margins 2016 ($/ha)		Average Net Margins 2014-2016 ($/ha/yr)		Profit:Cost ratio 2014-2016	
	Tine	Disc	Tine	Disc	Tine	Disc	Tine	Disc	Tine	Disc
Aggressive	$424	$422	$569	$591	$533	$449	$508	$487	$0.98	$0.94
Conservative	$441	$171	$540	$463	$537	$336	$506	$323	$1.14	$0.75
Sustainable	$488	$493	$520	$525	$552	$495	$520	$504	$1.14	$1.10

Southern Farming Systems have been comparing the advantages of establishing crops with a disc and tined seeder over the past 3 years. They found that although there was no significant difference in wheat yield at the 95% confidence level (0.5 t/ha increase in yield at the 90% confidence level),
there were significant improvements in efficiencies in the disc system with quicker sowing, quicker harvesting (harvest high) and fuel savings in 2015 (Table 8). It must be remembered that both types of seeders have advantages and disadvantages in different circumstances and the main aim is to establish seed reliably in a wide range of sowing conditions!

Table 8. Cost calculations for sowing efficiency, harvest efficiency and fuel usage in a Southern Farming Systems disc vs tine trial in Victorian HRZ in 2015.

	Sowing	Harvest time	Fuel Usage
Disc vs tine	4.8km/hr faster*	1.81 ha/hr faster#	2.11 L/ha##
Value of difference	$2.10	+$13.23	$2.53

(* contract sowing at $45/hr, # increased speed at harvest $400/hr, ## fuel @ $1.20L)

Deep banding vs surface applied Nitrogen at sowing

One mechanism by which large amounts of retained cereal stubble can reduce yields in subsequent crops is through immobilization of N. Banding N fertiliser either at sowing using a deep, side or mid-row banders or in -crop using mid-row banders is a way of separating fertiliser N from high carbon stubble that microbes use as an energy source when immobilising N. In 2016, an experiment was established at Temora on 5.1 t/ha of retained wheat stubble where 122 kg/ha N as urea was either banded beside and below wheat seed using Stiletto splitting boots, or spread on the soil surface before sowing with the same boots. Starting soil mineral nitrogen concentration was 58 kg/ha N (0-150cm) and no additional nitrogen was applied. By Z30 more nitrogen had been taken up by the plant where the N was deep banded (4.3% *cf* 3.8%), a pattern which continued with greater plant dry matter and nitrogen uptake at anthesis and higher grain yield (Table 9). However, there was no significant interaction with the presence/absence of stubble, indicating that banding N may improve N use efficiency in all systems (with or without stubble).

Table 9. Wheat (Lancer) emergence, dry matter, % nitrogen in the tissue, nitrogen uptake and grain yield where 122kgN/ha was applied at sowing either below the seed using stiletto points or on the surface pre-sowing into either 5.1t/ha of wheat stubble or where stubble was removed at Temora in 2016.

Pre-sowing Nitrogen Application	Emergence Plants/m^2	GS30 Plant Dry Matter (t/ha)	GS30 Plant nitrogen (%N)	GS30 Nitrogen uptake (kgN/ha)	Anthesis Plant Dry Matter (t/ha)	Anthesis Nitrogen uptake kgN/ha)	Grain Yield (t/ha)
Deep	132	1.4	4.3	60.0	9.2	136.4	5.2
Surface	137	1.4	3.8	51.6	7.9	102.5	4.1
P value (interaction)	0.257	0.570	0.016	0.074	<0.001	0.007	0.001
lsd (P<0.05)	ns	ns	0.394	ns (9.58)	0.3	17.0	0.43

Option 2: How to manage stubble if you have a flexible approach to retaining stubble

There are many reasons why a flexible approach to retaining stubble may be required as there is no perfect stubble management strategy for every year. Crop rotations, weeds, disease, pests, stubble loads, sowing machinery and potential sowing problems will largely dictate how stubble is managed
A flexible approach to manage stubble means crops can be harvested high or low depending on the season and situation, stubbles can then be grazed with considerable economic advantage, or straw baled and sold, or burnt.

Grazing: For mixed farmers, the option to graze the stubble soon after harvest can be quite profitable. In a long term no-till controlled traffic grazing experiment in Temora between 2010-2015 with crop rotation of canola-wheat-wheat, 4 treatments were compared including a full stubble retention system (nil graze, stubble retain) and a post-harvest grazing of the stubble (stubble graze, stubble retain). Each of these were split to accommodate a late burn pre-sowing (i.e. nil graze, stubble burn & stubble graze, stubble burn) (Table 10). All plots were inter-row sown with deep knife points and machinery operations conducted using controlled traffic. Stubble grazed plots were grazed within 2-3 weeks of harvest at approx. 300 DSE/ha for 5 days ensuring > 3t/ha remained for soil protection and water retention. All plots were sown, fertilised and kept weed free such that weeds, disease and nutrients did not limit yield. Over seven years, the experiment has shown that there is a $44/ha increase in gross income where sheep were used to graze the stubbles compared to nil grazing if no grazing value was assumed. This increase was related to higher yields and grain quality in subsequent crops driven by greater N availability in the grazed stubble. There was a $159/ha increase if a grazing value for the stubble was assumed (see GRDC paper 2015 Hunt et al. for details).

One of the negatives of using a less diverse rotation (canola-wheat-wheat) in a full stubble retained system is that there can be a significant reduction in the grain yield in the 2nd wheat crop (Table 11). This difference is presumably due to lower N availability due to immobilisation in the retained stubble treatment (as establishment was good and weeds, pests and disease were controlled).

Table 10. Gross income per year averaged across two phases where stubble was either grazed post-harvest or not, and either burnt just before sowing or retained, 2010-2015 at Temora, NSW.

Graze treatment	Stubble treatment	Gross income ($/ha/year)	
		Assuming grazed stubble has no	**Assuming grazed stubble has value**
Nil graze	**Retain**	$1,153	$1,153
	Burn	$1,179	$1,179
Stubble graze	**Retain**	$1,197	$1,312
	Burn	$1,193	$1,307

Table 11. Grain yield of wheat and canola sown using deep knife points in two phases between 2009 and 2016 where stubble was either retained or burnt (pre-sowing) at an experiment in Temora, NSW.

		Grain Yield 2009-2016							
Phase	Stubble Treatment	2009	2010	2011	2012	2013	2014	2015	2016
1	Retain	1.7	4.2	4.6	**4.4**	0.7	3.8	**4.1**	3.2
1	Burn	1.7	4.0	4.6	**5.0**	1.0	3.8	**4.6**	3.2
2	Retain		6.3	3.4	4.5	**2.0**	2.0	5.5	**5.2**
2	Burn		6.2	3.5	4.8	**3.4**	2.0	5.3	**5.7**
	Red = Canola crops					frost			

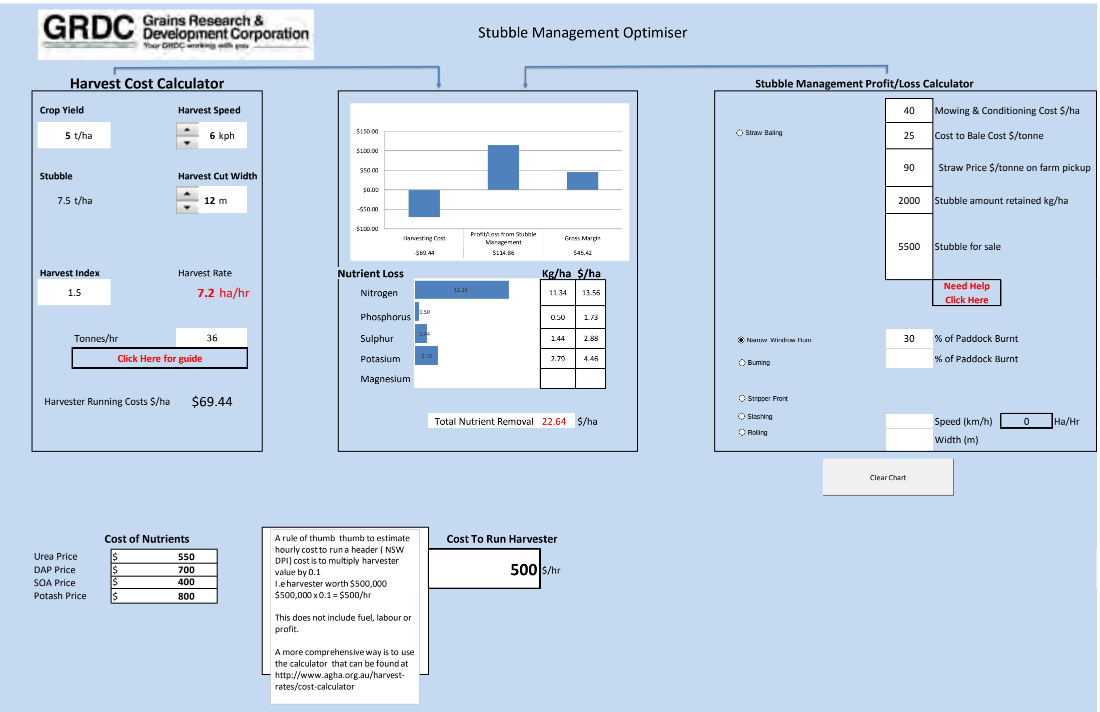
Similar results were observed in a crop systems experiment where wheat (1st wheat) was either sown into canola stubble or into 7.2 t/ha wheat stubble (2nd wheat) in April 2016. The wheat was deep banded with 40kgN/ha at sowing in both treatments to assist in supplying N to the crop,
however, there was a 0.6-0.8t/ha reduction in wheat yield in the 2nd wheat crop (Table 12). Many farmers in the south west slopes also observed decreases in the grain yield of their 2nd consecutive wheat crop compared to wheat sown after canola in 2016 in stubble retained systems.

Table 12. Wheat grain yield in crop following canola (wheat yr 1) compared to 2nd wheat crop at crop systems experiment at Temora, NSW 2014-2016 in disc and tines x systems

Cropping system	Crop	2016 Disc	2016 Tine
Aggressive	Wheat (yr 1)	5.5	6.0
Aggressive	Wheat (yr 2)	4.9	5.3
P value = <0.001	lsd (P<0.05)	0.54	

Computer applications (Apps) for stubble management!!

GRDC Project YCR00003, led by Yeruga Crop Research is finalising a computer/smart phone application (App) which may be of great benefit to farmers and consultants. It provides a quick and efficient method to indicate what the benefit or cost could be for different stubble management decisions such as narrow windrow burning, burning or baling a crop to reduce stubble. A couple of examples are highlighted below for narrow windrow burning (Figure 1) and baling (Figure 2) the stubble from a 5t/ha wheat grain crop.



For more information, contact Yeruga Crop Research. The tool was developed by Stefan Schmitt in conjunction with Bill Long, Mick Faulkner, Jeff Braun and Trent Potter.

Figure 1. (Left) The estimated effect on profit from harvesting a 5t/ha wheat yield with 7.5t/ha stubble load remaining that is narrow windrow burnt, valuing the loss of nutrients.

Narrow windrow burning (NWB): NWB has been practiced for several years now and has proven to be an effective tool in reducing weed seeds. One advantage of NWB compared to entire paddock burn is the reduction in nutrients lost from the stubble residue. The stubble management optimiser indicates that approximately $22.60/ha is lost from the paddock if NWB compared to approximately $76/ha if the entire paddock is burnt (Figure 1). One constraint with narrow windrow burning as AHRI indicated, would be the increased risk if the wheat grain yield was greater than 2.5t/ha (> 4t/ha stubble residue). In 20114/15 NWB was successfully undertaken in wheat crops between 3-3.75t/ha with an estimated stubble load of 4.5-6t/ha in the Riverina, NSW (Grassroots Agronomy 2014). Due to the high stubble loads in 2016/17, narrow windrow burning may be restricted to canola stubbles and other lower DM crops. It must be acknowledged that a wet cool autumn can severely reduce the efficiency of burns leading to weed strips in the paddock.

Baling: In many areas across southern Australia, a significant area of stubble has been baled in 2016/17 season. Baling allows the farmer to harvest high and efficiently (use stripper front if possible), and reduce the stubble load in the paddock to minimise problems at sowing. One of the negatives of baling stubble is the loss of nutrients from the paddock. The stubble management optimiser shows the farmer the cost to make hay including the cost of nutrient loss (Figure 2).

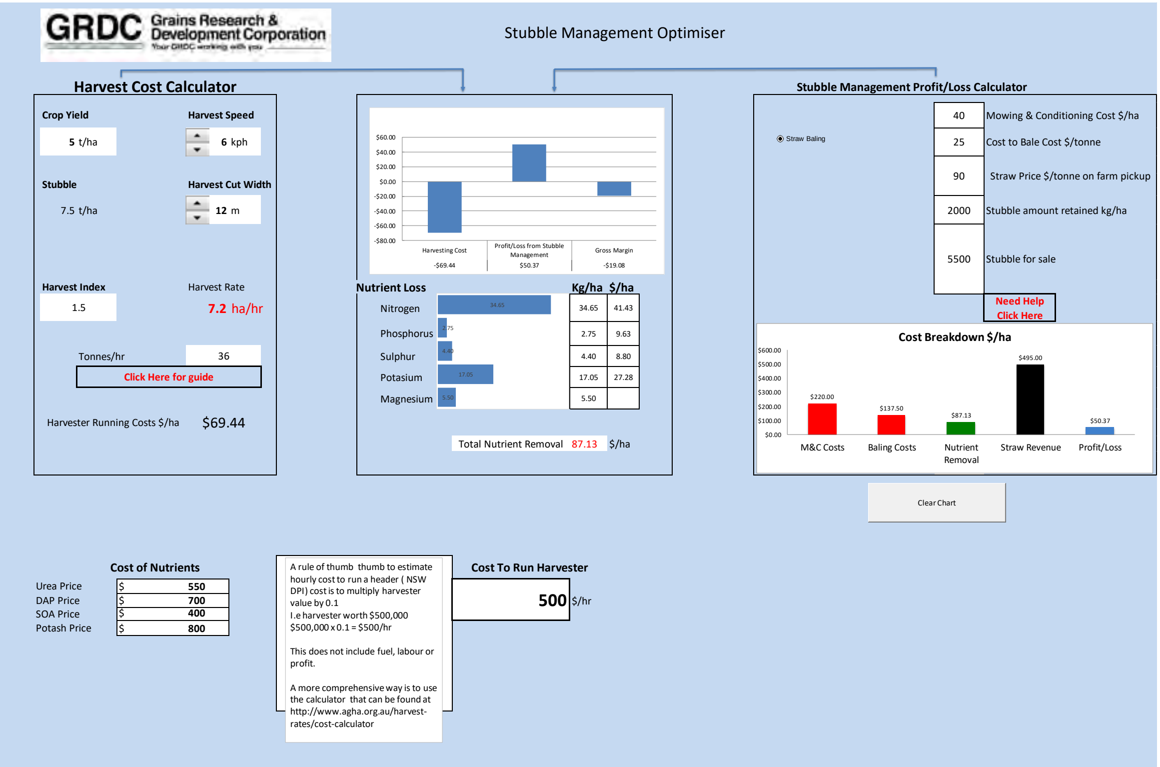


Figure 2. The estimated effect on profit from harvesting a 5t/ha wheat yield with 5.5t/ha of the remaining 7.5t/ha stubble load being baled and sold (valuing the loss of nutrients).

Pests

Invertebrate and vertebrate pests will potentially be a major problem in 2017, and may in some cases provide justification for strategic burning and tillage. Snails, slugs, mice and other insect numbers are currently being monitored and the cool wet spring has provided excellent conditions for increased numbers. The large stubble loads and plentiful grain on the ground from shedding and harvest losses is providing an excellent environment for breeding, so this needs to be factored into the equation if retaining stubble in 2017. Monitor mice numbers after harvest and bait as required.

The wet cool spring in the Victorian HRZ has resulted in an increase in the population of slugs and earwigs pre-harvest. The populations of slugs (Figure 3) and earwigs are expected to pose a greater threat to establishing crops in 2017 (Figure 3). Plan to roll then bait at sowing for slugs, monitoring problem areas and keep baiting if using cheap bran based baits. More information on slug and snail baits may be found at: http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/286735/Snail_and_slug_baiting_guidelines.pdf

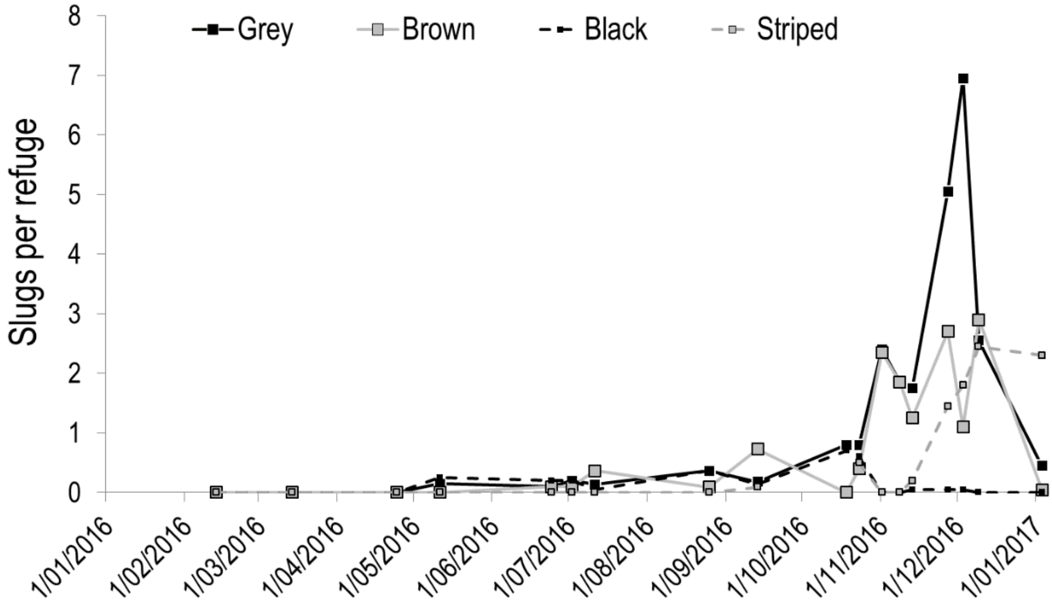


Figure 3. The change in population of four slug species between May 2016 and January 2017 at one site in south west Victorian (GRDC slug ecology project DAS00160)

Snails: A field trial on the Lower Eyre Peninsula, SA demonstrated the benefits of using mechanical snail control methods over retaining tall standing stubble – either light tillage or heavy (ribbed) rolling – in conjunction with a baiting strategy (Figure 4). Carried out under optimal conditions (late February, 35°C $^{+}$ and low humidity) the mechanical treatments proved effective to reduce snail numbers initially, whilst also appearing to improve the accessibility of baits applied in March.

This project demonstrated a number of key points for the coming growing season. Mechanical rolling, light tillage or cabling in the right conditions (hot & dry) is an effective action which can reduce the breeding population before a crop is present when there is less time pressure from other tasks (Figure 4). Baiting efficacy after this mechanical strategy is likely to be improved, as snails will find the baits easier in a rolled/ tilled surface, rather than where tall stubbles remain, providing “bridges” for snails over and around baits.

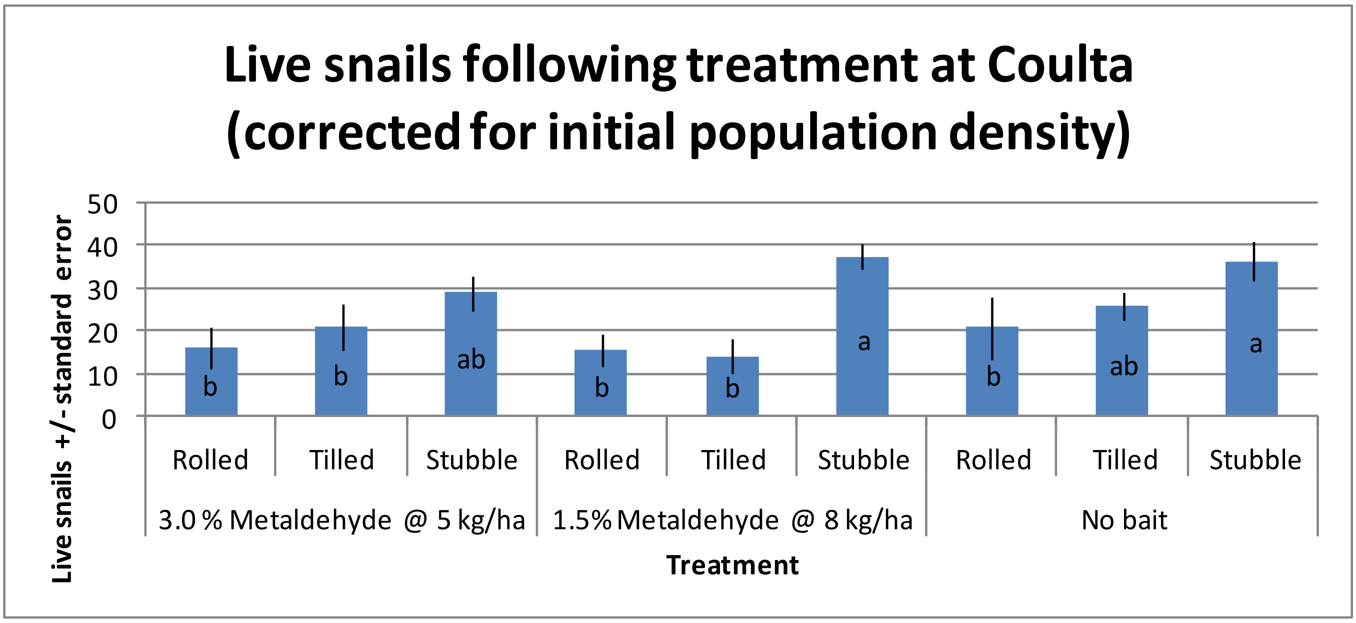


Figure 4. Mechanical treatment by baiting experiment in canola stubble at Coulta, Lower Eyre Peninsula, SA

Baiting should not be applied during the same hot, dry conditions as cultural controls! Baiting should commence during moist, cool conditions. The same field trial incorporated time lapse video and micro weather station monitoring to monitor snail activity and found high levels of night time activity where RH went above 85-90 %, and feeding during wet periods in early March.

The key with all management strategies is to try to reduce the breeding population prior to reproduction. This research showed snails feeding and increasing sexual maturity during March with egg laying taking place April 21st – prior to the break of season and seeding. Baiting at seeding may be too late where snails have already laid eggs. For further information http://www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter/pestfacts_issue_15_2016/summer_snail_activity_and_control

It is also important to consider using insecticide seed treatments in canola and legumes with to supress or control early seedling pests including earwigs, slaters, aphids, millipedes and earth mites (always adhere to label guidelines).

Herbicide efficiency in retained/burnt stubble systems

Two separate experiements were setup in the EP and LowerEP to compare the effectiveness of pre-emergent herbicides in stubble retained systems compared with burnt stubble in 2015. In both experiments, cereal crops were harvested low with straw spread evenly across the swath and either retained or burnt late pre-sowing. Standing stubble was also compared at one experiment. Residual stubble load was between 5 to 6.9t/ha. In both experiments there was no significant difference in the effectiveness of Sakura ®, Avadex Xtra ®, or Boxer Gold ® on the emergence of ryegrass post sowing where the spraying water application rates was 100L/ha or higher**.** An important finding was that a spray water volumn of 100L/ha was required to improve the effectivness of the herbicides, but this must be put in context with spray quality and nozzle type (Table 13).

Table 13. The reduction in ryegrass populations with increasing water rate in the LEP in 2015

Water Rate (L/ha)	Reduction in ryegrass numbers compared to control (%)
50	52^{a}
100	73^{b}
150	75^{b}

The wet season in 2016 throughout much of south-eastern Australia resulted in farmers not being able to manage weeds to their normal high standard. The combination of high annual weed populations in large cereal stubble residues may mean that farmers may need to consider burning problem paddocks in 2017 to reduce weed populations and improve herbicide effectiveness where stubble loads and ground cover percentage is high. The higher the percentage of ground covered by residue, the higher the percentage of herbicide captured by the stubble (Shaner 2013).

Burning

Burning is an effective, inexpensive method of removing stubble, assisting in reducing disease carryover, reducing certain seedling pests and weed populations and if using a flexible managament approach should be considered in strategic situations. With careful planning and diverse management, burning can be kept for those occassions where the system needs to be reset which can result in farmers retaining stubble for another series of years. A late burn, conducted wisely just prior to sowing to minimise the time the soil is exposed is one option farmers may need to consider in 2017. In a long term experiment at Harden in NSW, burning late just prior to sowing is still producing some of the highest grain yields after 28 years of continuous cropping, which would indicate that a single strategic burn to re-set the sequence may do little damage. In general, late burning resulted in the largest yield benefits in wetter years, and had little impact in other years. Across a number of trials in the Riverine Plains, Victorian HRZ and those conducted by the MacKillop Farm Management group, the comparision between burning or stubble retain treatments has resulted in variable results. More often than not, there was no significant difference in grain yield between the burn and stubble retain treatment in 2014-15. However, in some years the burn treatment has resulted in good early crop vigor,

more early biomass and the crop has become moisture stressed with reduced grain yield where there has been an early end to the season with a hot and dry spring.
Some negatives to burning include loss of nutrients (amount depends on temperature), increased regulation and potential losses of soil from erosion. Increasing restrictive regulations are being implemented that also make burning more difficult in the future. In some shires, a single burn requires 6 people, 2 fire control units (1 with 5000L and the other with 500L) and you are not able to leave the paddock until NO smoke is detected.

Conclusion
This paper has outlined many of the overall findings from the "Stubble Initiative" project to date and incorporated these into a series of regional guidelines to assist farmers deal with the high stubble loads from the 2016/17 harvest.

It is extremely important for farmers to NOT compromise managing weeds, disease or being able to sow their crop in 2017 due to excessive stubble loads. Farmers need to be pro-active in managing their stubble which should have commenced before harvest and continued until sowing in 2017 to ensure their stubble management will suit their seeding system. It has been shown that by diversifying a crop rotation (increasing the number of pulse crops and barley), deep banding nitrogen, managing pests and diseases, managing stubble by mulching, baling, grazing and if sowing with a tined seeder, sowing at 15-19 degrees from the previous direction, that it is easier to manage stubble without the need to burn. However, if the stubble load remains too large or the potential weed/disease/pest burden remains too high, then a one off strategic late burn can be used to "re-set" the system. In a year where stubble residue loads are greater than ever before experienced, it is also important that as new techniques are tried, to keep monitoring the results early to see how effective the actions have been.

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capability to each farming systems group to ensure the project in their region is producing the highest quality of work. To keep the list of co-authors to one cricket team (rather than many), only one person from each group was included as authors.

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Yeruga Crop Research

Herbicide efficacy in retained stubble systems

Authors: Amanda Cook and Ian Richter

Funded By: GRDC

Project Title: Maintaining profitable farming systems with retained stubble – upper EP

Project Duration: 2015-2017

Project Delivery Organisation: SARDI, Minnipa Agricultural Centre

Key messages:

- **Herbicides which may be influenced by high stubble loads include trifluralin, triallate, pyroxasulfone, prosulfocarb and metalochor products. If grass weeds are an issue in paddocks with high stubble loads (greater than 50% stubble cover), removal of some stubble may maximise the herbicide activity and grass weed control.**
- **In-crop germination patterns are later for barley grass than for other grass weeds in MAC paddocks, which is limiting early control with pre-emergence herbicides.**
- **If you expect most of your grass weeds to emerge straight after sowing, maybe 2 L/ha trifluralin (plus an added herbicide depending on cost and risk factors such as seasonal conditions, soil type, rotation etc.) is the best value for your system.**
- **If you have a later germinating population, and aim to reduce the seed bank, you may be better investing in some of the more expensive herbicide mixes even though they may cost more in the first season.**

Why do the trial?

The GRDC project 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' aims to improve farm profitability while retaining stubble in farming systems on upper Eyre Peninsula (EP). Weed control in stubble retained systems can be compromised when stubbles and organic residues intercept the herbicide and prevent it from reaching the desired target, or the herbicide is tightly bound to organic matter. Reduced herbicide efficacy in the presence of higher stubble loads is a particular issue for pre-emergence herbicides. Current farming practices have also changed weed dormancy in barley grass genotypes in many paddocks on Minnipa Agricultural Centre (MAC).

As a part of the stubble project this trial was undertaken to assess herbicide efficacy (effectiveness) in different stubble management systems. To understand how herbicides perform it is important to know the properties of the herbicide, the soil type and how the herbicide is broken down in the environment. The availability of a herbicide is an interaction between the solubility of a herbicide, how tightly it is bound to soil particles and organic matter, soil structure, cation exchange capacity and pH, herbicide volatility, soil water content and the rate of herbicide applied (EPFS Summary 2015, p132).

This article reports on the results of the second year of the trial, with a third year of the trial to be conducted in 2017.

How was it done?

The 2016 trial was sown into paddock S3N, a CL Grenade wheat stubble which yielded 2.4 t/ha in 2015, and was grazed before the trial site was selected in February 2016. The trial was sown on 30 May into good moisture conditions with Mace wheat @ 60 kg/ha and DAP (18:20:0:0) @ 60 kg/ha. Stubble treatments were standing stubble with burnt windrows (burnt on 31 March) and slashed stubble also with a burnt windrow (slashed on 8 April).

The trial area received a knockdown of 1.2 L/ha of Roundup Attack on 29 May. The herbicide treatments listed in Table 2 were individually mixed in small pressure containers and applied on 11 and 12 May using a shrouded boomspray at 100 L/ha of water. The trial was sown at 3-4 cm depth with an Atom-Jet spread row seeding system with press wheels.

Measurements taken were stubble load pre-seeding, plant emergence counts, early, in- crop and late grass weed counts and dry matter production, grain yield and grain quality. Soil was collected on 26 February for weed seed bank germination, with monthly assessments on emergence over the next 12 months. Soil moisture and soil nutrition were sampled on 18 April. Stubble load was measured on 30 May. Plant establishment and weed counts were taken on 22 June. Late weed counts were taken on 11 October. The trial was harvested on 4 November.

Data were analysed using Analysis of Variance in GENSTAT version 16.

What happened?
At seeding the stubble load was 1.48 t/ha of standing stubble and 1.28 t/ha of slashed stubble. The 2016 trial site had both barley grass and ryegrass present (Figure 1). The slashed stubble treatment had lower grass weed numbers and the only difference between the blocks was that the standing stubble was closer to the fence line. The 2016 grass weed germination shows in-crop weeds are emerging late in the cropping season, with greater numbers in August than June, despite good seeding and early germination conditions.

Barley grass germination pattern from in-crop soil samples in 2015 (Figure 2) showed differences from the 'fenceline' barley grass indicating cropping with pre-emergent herbicides has selected for later germinating genotypes. This has resulted in moving the barley grass population to a type which has dormancy, supporting previous germination timing results collected at MAC (Ben Fleet, Univ of Adelaide).

Stubble treatments
Plant establishment was the same with either standing stubble or slashed, but there were differences in dry matter and crop yield (Table1). Slashed stubble resulted in higher yields than standing stubble which may be due to extra grass weed competition, especially ryegrass numbers, which were higher with standing stubble (Figure 1). There were no differences in grain quality due to stubble treatments with averages being; test weight of 80.6 kg/hL, protein of 10.8% and screenings of 1.3% (data not presented).

Ryegrass during the growing season was more dense than barley grass (Figure 1). There was more ryegrass in standing stubble than in the slashed stubble trial block (which was further from the fence line, 60 metres into the paddock).

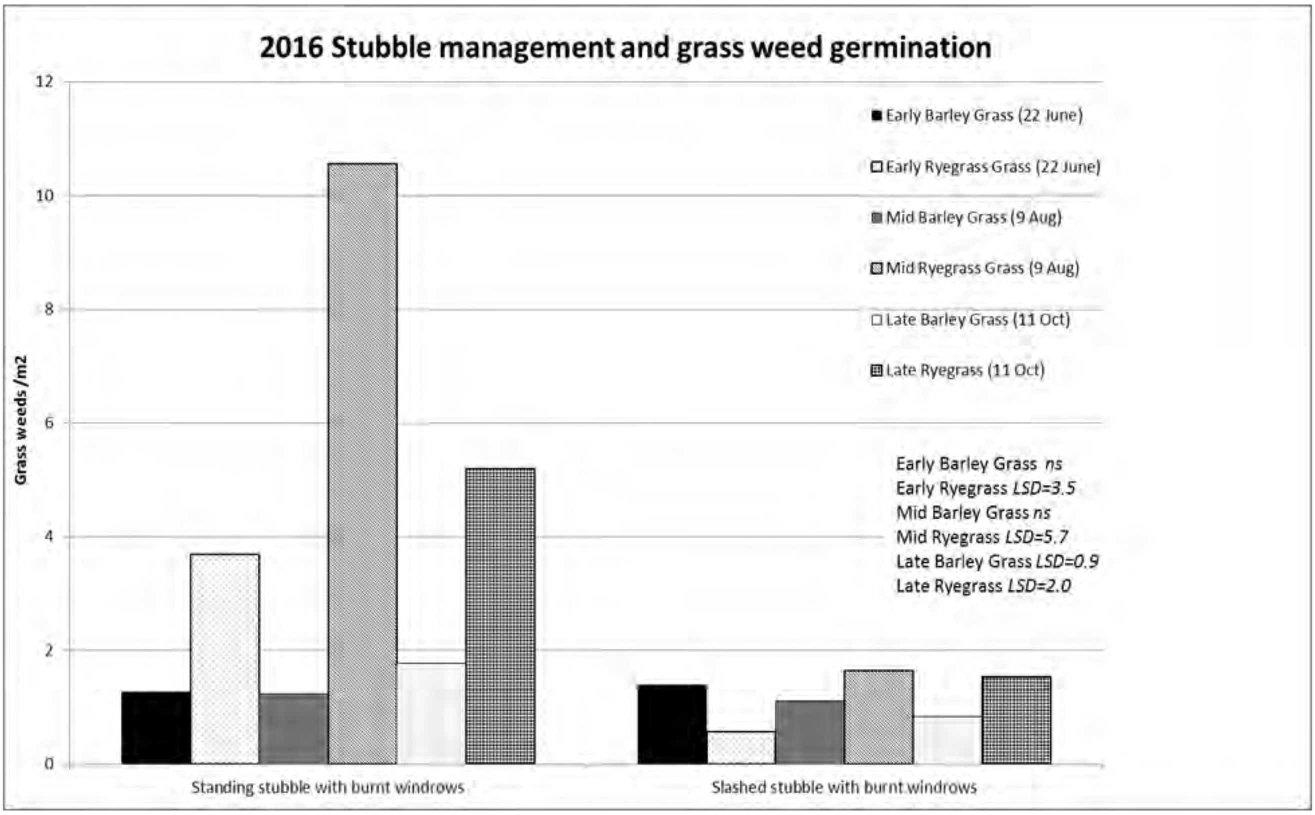

Figure 1. Stubble management and grass weeds/m² at different timings during the 2016 season (LSDs in the graph are comparing between stubble treatments for the same weed species at the same time at P=0.05)

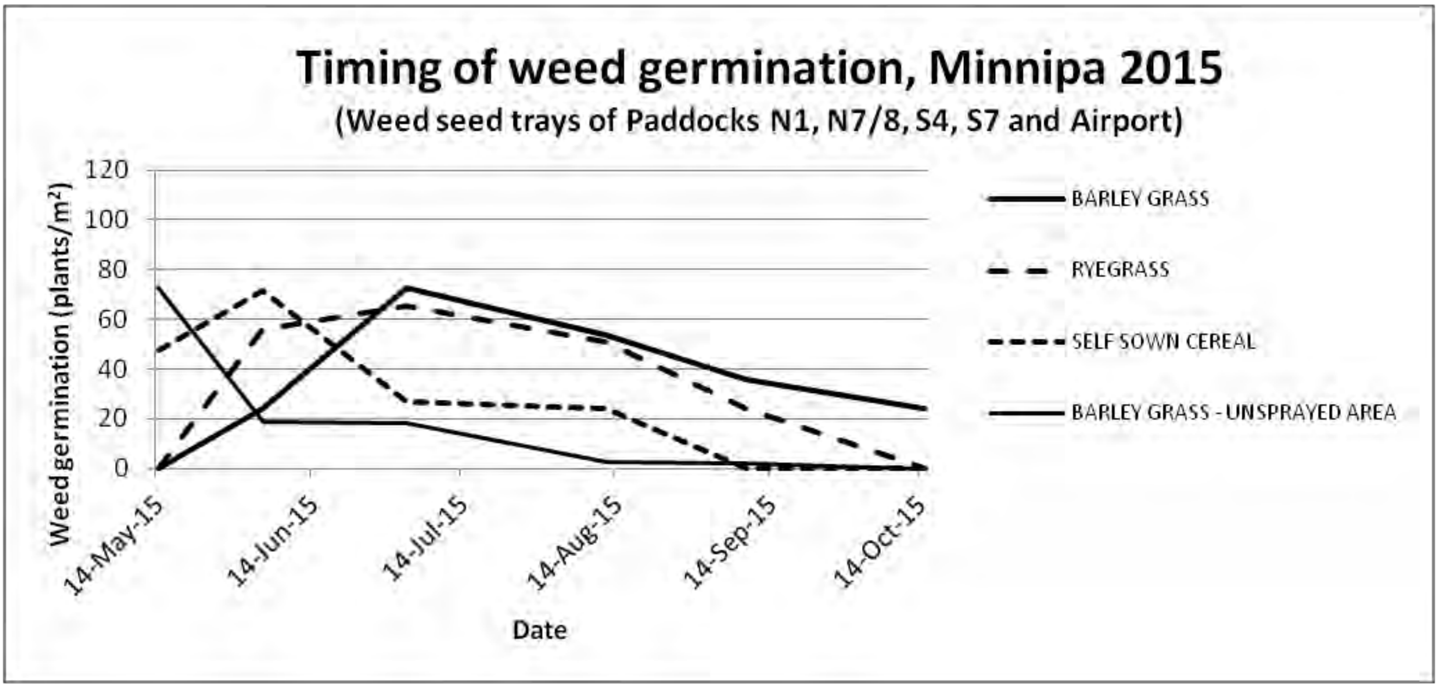

Figure 2. (Left) Weed germination patterns from in-crop soil samples taken from harvest 2014 to early 2015

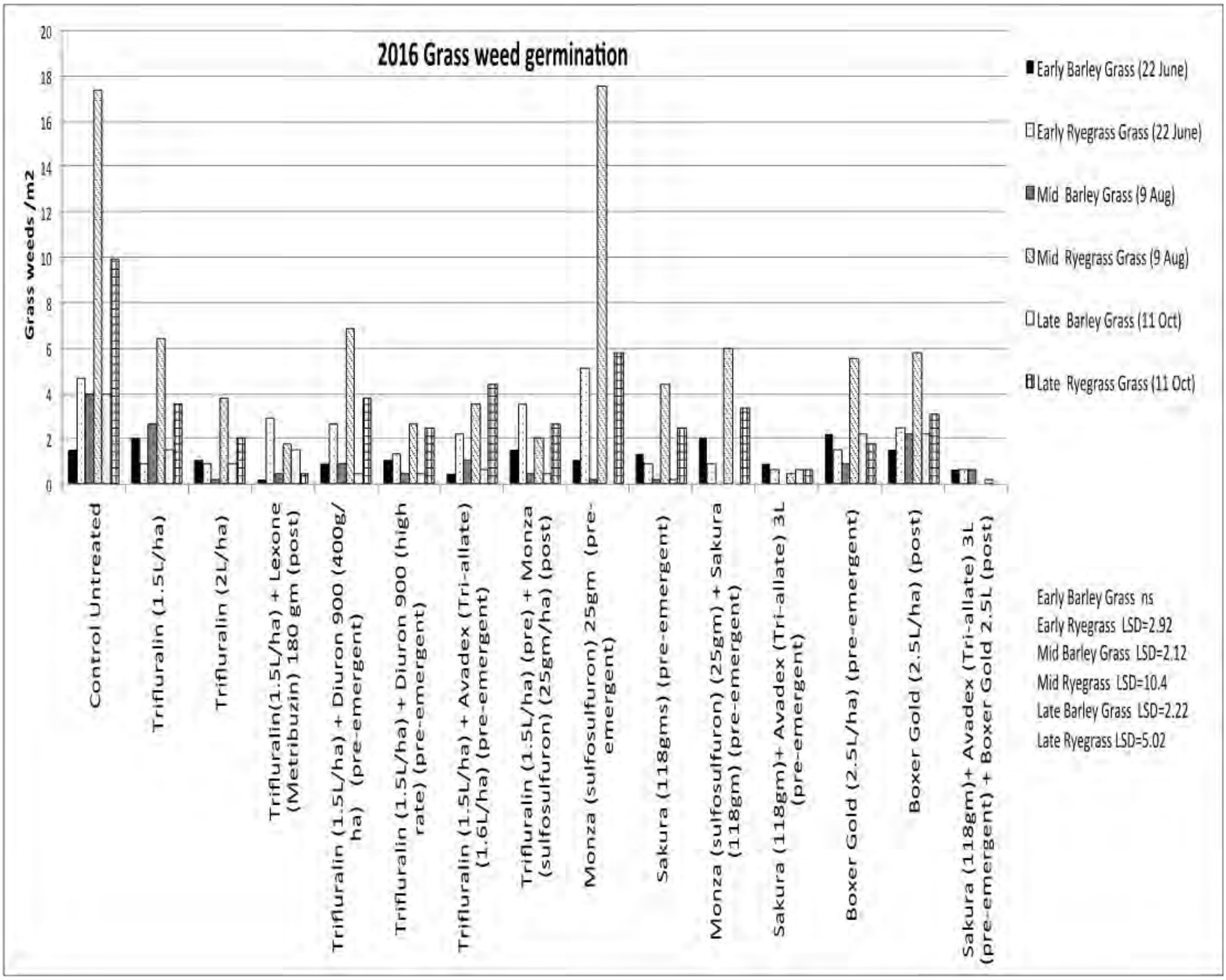

Figure 3. Effect of herbicide treatments on grass weed control during the season (LSDs in the graph are comparing between stubble treatments for the same weed species at the same time at P=0.05)

*some treatments in the trial are for research purposes only

Table 1. Effect of stubble management on crop establishment, dry matter and yield of wheat in 2016

	Establishment (plants/ m²)	Early crop dry matter (t/ha)	Late dry matter (t/ha)	Yield (t/ha)
Standing stubble with burnt windrows	94.6	0.38	4.35	2.17
Slashed stubble with burnt windrows	98.0	0.41	4.67	2.25
LSD (P=0.05)	*ns*	*0.03*	*0.20*	*0.04*

Table 2. Effect of herbicide treatments on crop establishment, dry matter and yield in 2016

Herbicide treatment	Group	Establishment (plants/m²)	Early dry matter (t/ ha)	Late dry matter (t/ha)	Yield (t/ha)	Herbicide cost ($/ha)	Income# less herbicide
Control Untreated		109 a	0.54 a	4.79 a	2.22 a	0	428
Trifluralin (1.5 L/ ha)	D	92 c	0.35 efg	4.80 a	2.23 a	9	421
Trifluralin (2 L/ha)	D	88 cd	0.39 cde	4.64 abc	2.28 a	12	428
Trifluralin (1.5 L/ ha) + Lexone (Metribuzin) 180 g	D+C	107 ab	0.44 bcd	4.71 ab	2.26 a	15	421
Trifluralin (1.5 L/ ha) + Diuron 900 (400 g/ha) (pre-	D+C	102 abc	0.45 bc	4.61 abcd	2.21 a	14	413
Trifluralin (1.5 L/ ha) + Diuron 900 (high rate) (pre-	D+C	91 c	0.36 ef	4.22 bcdef	2.28 a	19	421
Trifluralin (1.5 L/ ha) + Avadex (Tri-allate) (1.6 L/ha)	D+J	76 d	0.26 h	4.30 abcde	2.16 a	25	392
Trifluralin (1.5 L/ ha) (pre) + Monza (sulfosulfuron) (25	D+B	95 bc	0.44 bcd	4.83 a	2.24 a	35	397
Monza (sulfosulfuron) 25 g (pre-emergent)	B	101 abc	0.37 def	4.43 abcde	2.17 a	26	393
Sakura (118 g) (pre -emergent)	K	96 abc	0.33 efg	4.21 cdef	2.21 a	40	387
Monza (sulfosulfuron) (25 g) + Sakura (118 g)	B+K	89 cd	0.28 gh	3.84 f	1.99 b	66	318
Sakura (118 g)+ Avadex (Tri-allate) 3 L (pre-emergent)	K+J	97 abc	0.36 ef	4.03 ef	2.20 a	70	355
Boxer Gold (2.5 L/ ha) (pre-emergent)	K+J	97 abc	0.45 bc	4.82 a	2.29 a	37	405
Boxer Gold (2.5 L/ ha) (post)	K+J	99 abc	0.47 b	4.79 a	2.19 a	37	386
Sakura (118g)+ Avadex (Tri-allate) 3 L (pre-emergent) + Boxer Gold 2.5 L	K+J	91 c	0.30 fgh	4.14 def	2.18 a	107	314
LSD (P=0.05)		*13.4*	*0.07*	*0.50*	*0.12*		

 # Wheat price of $193/t used for ASW on 1 December 2016 at Port Lincoln, less herbicide cost.
*some treatments in the trial are for research purposes only

Herbicide treatments
There were no impacts of stubble management on the performance of individual herbicide treatments so results presented in this section are averaged over the two stubble management treatments.

Wheat establishment was between 88 and 109 plants/m^2, with several herbicide treatments causing significantly less establishment than the untreated control (Table 2). All herbicide treatments reduced early dry matter compared to the untreated control (Table 2), but only the pyroxasulfone treatments reduced late dry matter and yield of Mace wheat.

Due to the low grass weed densities, no herbicide treatment was more profitable than the control (Table 2).

Most herbicide treatments were providing better weed management than the untreated control (Figure 3). Some of the newer herbicides with greater residual activity were showing better in-crop grass weed control.

What does this mean?
In both seasons of this work most herbicide treatments have lowered all grass weed types compared to the untreated control. The 2015 and 2016 results suggest that under the production regimes of upper EP, stubble management; standing stubble, burnt windrows, slashed stubbles and stubble removal by whole paddock burning is unlikely to impact on the performance of pre-emergent herbicides targeting grassy weed control, with adequate water rates. However, this trial did not place the herbicide packages "under pressure" because grassy weed populations were quite low. Under low populations of barley grass weaker herbicide options may perform adequately compared to high weed population situations.

If grassy weeds are an issue in paddocks with high stubble loads (greater than 50% stubble cover), removal of some stubble may be a benefit to maximise the herbicide activity and grass weed control. Other research has shown the herbicides which may be influenced by high stubble loads include trifluralin, triallate, pyroxasulfone, prosulfocarb and metalochor products.

In-crop germination patterns are later for barley grass in MAC paddocks, which is limiting early grass control with pre-emergent herbicides. Check paddocks before crop anthesis (flowering) for late germinating grass numbers. Keep records at harvest of what grass is the biggest issue in paddocks, barley grass, ryegrass or both and have short and long term management plans. If you expect most of your grass weeds to emerge straight after sowing maybe 2 L/ha trifluralin (plus an added herbicide) is the best value for your system. If you have a dormant/later germinating population, and aim to reduce the seed bank, you may be better investing in some of the more expensive herbicide mixes with greater longevity even though they may cost in the first season for longer term grass control. Two year breaks during the pasture/ break crop phase can also be effective in reducing the grass weed seed bank.

The differences in a herbicide's ability to bind to organic matter and move through the soil profile with soil water influences the uptake of the herbicide by the target weeds, the crop, and the impact on both. Soil texture and soil chemical properties can affect herbicide movement and availability in the soil profile. Some herbicides will have greater activity and mobility and be "hotter" in lighter sandier soils than the MAC loam in this trial. The dry seeding conditions and lack of post sowing rainfall at the start of the 2015 season resulted in less damage to the crop than expected with some herbicides (e.g. the diuron mixes) due to lower soil mobility. Seeding systems and speed at sowing may also influence soil throw and hence herbicide movement in soil water.

Acknowledgements
Thanks to Ben Fleet, Andy Bates, Nigel Wilhelm and Rick Llewellyn for help with this trial and to Sue Budarick, Tegan Watts, Lauren Cook and Katrina Brands for their help collecting and processing samples. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).
Registered products: see chemical trademark list.

Locaion
Minnipa Agricultural Centre, paddock S3N
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
Yield
Potential: 3.6 t/ha (W)
Actual: 2.2 t/ha
Paddock history
2016: Mace wheat
2015: Grenade wheat
2014: Spray topped medic pasture
Soil type
Red loam
Plot size
20 m x 2 m x 3 reps

UNFS SILVER SPONSORS

Impact of retaining stubble in low rainfall farming systems

Authors: Amanda Cook[1], Ian Richter[1] and Chris Dyson[2]

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

Funded By: GRDC

Project Title: Maintaining profitable farming systems with retained stubble – Upper EP

Project Duration: 2013-2016

Project Delivery Organisation: SARDI

Key points:

- **Barley sown into standing stubble yielded higher (between 0.15-0.33 t/ha) than cultivated or removed stubble in 2016**
- **Standing stubble cut low (15-17 cm) resulted in the highest level of stubble being maintained into the following season**
- **Maintaining standing stubbles may be the best option for yield and stubble carry over, but adequate nitrogen must be maintained**
- **In 2014 and 2015 stubble management and seeding position did not impact strongly on weeds, disease or pests with relatively high stubble loads in a low rainfall farming system at Minnipa**

Why do the trial?

The GRDC project 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' aims to produce sustainable management guidelines to control pests, weeds and diseases while retaining stubble to maintain or improve soil health, and reduce exposure to wind erosion. The major outcome to be achieved is increased knowledge and skills allowing farmers and advisers to improve farm profitability while retaining stubble in farming systems on upper Eyre Peninsula (EP).

The Minnipa Agricultural Centre (MAC) S7 stubble retention trial was established to determine if we could maintain or improve crop production through applying alternative weed, disease and pest control options in pasture wheat rotations in the presence of crop residues. The trial was established in 2013 with wheat and different stubble treatments imposed at harvest annually. It was sown either inter row or on row each season to determine the impacts of stubble management on crop production, weeds, disease and pests in low rainfall farming systems.

How was it done?

The replicated plot trial was established in 2013 in MAC S7 paddock within the district practice non-grazed zone. Stubble treatments imposed at harvest each season were; (i) Stubble removed after mowing to ground level, (ii) Stubble harvested low (15 cm) (iii) Stubble harvested high (30 cm) /standing (district practice) or (iv) Stubble harvested high then cultivated with offset disc in April.

In each season the trial was sown either (i) Inter row (between last season's stubble) or (ii) On row (in same position every season over the top of the previous crop rows) with a base fertiliser of DAP @ 60 kg/ha. See previous Eyre Peninsula Farming Systems Summaries for details of the treatments imposed.

In 2016 the trial was sown on 13 May to Scope barley at 60 kg/ha, and as per previous seasons all plots were split with urea being added to one half at 40 kg/ha applied at seeding. This rate was estimated to match annual nitrogen tie up with the retained stubble loads using 5.8 kg N required per tonne of stubble to break it down (Kirby et al. 2004). Another 40 kg/ha of urea was also spread on 21 July to the urea treatments only, since there was some nitrogen deficiency present due to the seasonal conditions.

The trial was sprayed on 13 May 2016 with a knockdown of 1.5 L/ha of trifluralin, 1.5 L/ha of glyphosate and 80 ml/ha of carfentrazone-ethyl. The trial was sprayed with 750 ml/ha of imazamix and imazapyr on 20 June.

The trial was scored for Rhizoctonia and samples for root scoring taken on 28 July. The trial was harvested on 3 November 2016.

Measurements taken during the season were stubble load, soil moisture, emergence count, grass weed counts (at establishment and at harvest), Rhizoctonia patch score and root disease score, snail numbers at harvest, grain yield and grain quality.

Data were analysed using Analysis of Variance in GENSTAT version 16 by Chris Dyson using a split plot design with a factorial (N treatment).

What happened?

Site characteristics

In 2014 soil characteristics in the 0-20 cm zone were, soil pH ($CaCl_2$) 7.9, Cowell P 28 mg/kg, phosphorus buffering index (PBI) 142 and salinity ECe 1.76 dS/m. Soil nitrogen measured in the stubble high treatment in April 2014 was 105 kg mineral N/ha in the 0-60 cm zone and in April 2015 was 134 kg/ha (0-60 cm).

At the start of 2016 soil characteristics in the 0-20 cm zone were (average of 16 treatments), soil pH ($CaCl_2$) 7.9, Cowell P 18.2 mg/kg, phosphorus buffering index (PBI) 150 and salinity ECe 1.63 dS/m. Available nitrogen (0-100 cm) without extra urea was 139 kg mineral N/ha. The additional N treatments increased mineral N/ha (0-100 cm) by 16 kg/ha to 155 kg mineral N/ha.

Predicta B tests prior to the 2016 crop predicted a high risk of Rhizoctonia disease (178 pg DNA/g soil), Yellow leaf spot inoculum was present and *Pratylenchus thornii* levels were medium risk (30 nematodes/g soil).

Yield and biomass production

Barley establishment was the same across all treatments in 2016 (average 86.1 plants/m^2), after good seeding conditions.

Table 1. Plant establishment and grain yield and quality of wheat as affected by stubble management, seeding alignment and initial stubble loads in 2014 and 2015

2013-15 stubble treatments	2014 stubble load (t/ha)	2014 plant establishment (plants/m^2)	2014 yield (t/ha)	2015 stubble load (t/ha)	2015 plant establishment (plants/m^2)	2015 yield (t/ha)
Stubble standing high	3.4	91	2.40	5.8	65	1.19
Stubble standing low	3.8	102	2.45	6.9	71	1.28
Stubble cultivated	3.4	94	2.58	4.3	45	1.26
Stubble removed	0	94	2.62	0	73	1.20
LSD (P=0.05)	*ns*	*ns*	*0.08*	*ns*	*14*	*Ns*
Inter row		98	2.55		65	1.24
On row		92	2.47		62	1.22
LSD (P=0.05)		*ns*	*0.06*		*ns*	*Ns*

Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.

In 2016 the retained stubble load was higher in low standing stubble compared to the other stubble treatments, which follows the trend which has occurred in the other seasons (Table1). Standing stubble yielded higher (between 0.15-0.33 t/ha) than cultivated or removed stubble in 2016 (Table 2). Grain yield averaged over the 2015 and 2016 seasons decreased where stubble had been removed (Table 2).

The extra nitrogen applied this season did not increase grain yield but increased grain protein from 10.0% to

10.9% (Table 2). Screenings were high in all treatments (average 22.8%) with the addition of extra nitrogen increasing screenings from 20.0% to 25.5% (data not presented).

In 2015 there were no differences in wheat yield or grain quality due to the treatments applied. In the 2014 season there was a 0.17 t/ha wheat yield advantage due to removing or cultivating the previous season's stubble (Table 1) which resulted in the decision to add extra nitrogen as a treatment. There was a 0.08 t/ha yield advantage in 2014 by inter row sowing rather than placing the seed on row (Table 1).

Agronomic factors

Weeds: Early grass weed numbers on 22 July were low (average 1.2 barley grass/m^2 and 0.5 ryegrass/m^2). Cultivation had slightly increased grass weed numbers (2.2 barley grass/m^2 and 1.2 ryegrass/m^2) but removing stubble reduced grassy weed numbers (0.3 barley grass/m^2 and no ryegrass) (data not presented).

Disease: In 2016 there were severe symptoms of Rhizoctonia as the trial was planted to a fourth cereal crop, and also barley shows greater visual symptoms of the disease. There were no differences detected between treatments for Rhizoctonia seminal root score. Rhizoctonia disease symptoms (Rh patch score) were greater with removed stubble, and this treatment also had the highest crown root infection. Cultivation had the lowest Rh patch score and lower crown root infection.

Table 2. Establishment, grain yield and quality of barley as affected by stubble management and seeding alignment in 2016

2013-15 stubble treatments	**2016 stubble load (t/ha)**	**Plant establishment (plants/m^2)**	**Early dry matter (kg/m^2)**	**Seminal root score**	**Crown root infection (%)**	**Rhizoctonia patch score (1-5)**	**2016 yield (t/ha)**	**Protein (%)**	**2015 and 2016 mean yield (t/ha)**
Stubble standing	4.28	88.1	0.56	3.19	67	0.89	2.14a	10.5	1.66 a
Stubble standing	5.07	85.0	0.52	3.19	65	1.19	2.24a	10.2	1.76 a
Stubble cultivated	3.95	82.1	0.50	3.27	55	1.15	1.99 b	10.6	1.62 ab
Stubble removed	(data removed from analysis)	89.1	0.47	3.19	70	1.65	1.91 b	10.5	1.56 b
LSD (P=0.05)	*ns*	*ns*	*ns*	*ns*	*6*	*0.37*	*0.14*	*0.40*	*0.10*
Inter row	4.29	84.1	0.52	3.19	64	1.22	2.11	10.3	1.68
On row	4.58	88.1	0.50	3.24	64	1.22	2.02	10.6	1.62
LSD (P=0.05)	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*0.28*	*Ns*
No extra N	4.24	86.9	0.49	3.22	64	1.35	2.06	10.0	1.64
*60 kg/ha	4.63	85.3	0.53	3.20	64	1.09	2.08	10.9	1.66
LSD (P=0.05)	*ns*	*ns*	*ns*	*ns*	*ns*	*0.20*	*ns*	*0.28*	*Ns*

Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments

**N treatment applied from 2015*

Pests: In 2014, there were no differences in snail numbers at harvest (average 1.7 snails/m^2). In 2015 snail numbers progressively decreased from 2.0 snails/m^2 in high standing stubble through low and cultivated stubble to only 0.5 snails/m^2 in removed stubble (data not presented).

What does this mean?

Standing stubble cut low (15-17 cm) resulted in the highest level of stubble being maintained into the following season. The standing stubble treatments (both high and low) yielded higher (between 0.15-0.33 t/ha) than the cultivated and removed stubble treatments this season. Maintaining standing stubbles may be the best option, but adequate nitrogen must be maintained as there was a 0.17 t/ha yield decline in 2014 with maintained stubbles compared to removal or cultivation.

The removal of stubble decreased the mean grain yield over the 2015 and 2016 seasons, however stubble removal may be considered in systems if pest levels like snails are high, or stubble borne disease carryover is an issue. The results this season have shown continuous cereal systems have a higher risk of not achieving potential yield due to issues with diseases or weeds. Cultivation may lower the impact of Rhizoctonia in systems, however rotations with grass-free break crops may be a better option to lower disease inoculum levels.

In previous seasons, stubble management and seeding position had little effect on grass weeds. In 2016 cultivation had more early grass weed geminate and stubble removal had the least.

Overall the results from this research at Minnipa indicate standing stubble may be the best option for maintaining stubble levels and have a slight yield advantage. Stubble management and seeding position have not impacted highly on weeds, disease and pests over three years with relatively high stubble loads in low rainfall farming systems.

Acknowledgements

Thank you to Sue Budarick, Tegan Watts and Katrina Brands for processing samples. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).
Registered products: see chemical trademark list.

Location
Minnipa Agricultural Centre, paddock S7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
Yield
Potential: 4.0 t/ha (B)
Actual: 2.1 t/ha
Paddock history
2016: Scope barley
2015: Grenade wheat
2014: Grenade wheat
2013: Mace wheat
Soil type
Red loam
Plot size
18 m x 2 m x 3 reps

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

EPARF
Eyre Peninsula Agricultural Research Foundation Inc.

Overdependence on Agrichemicals – UNFS 2016 Barley Grass Trial

Author: Barry Mudge

Funded By: GRDC CWF 00020

Project Title: Overdependence on Agrochemicals

Project Duration: 2015-2016

Project Delivery Organisation: Barry Mudge Consulting for Upper North Farming Systems

Key messages:

- **The 2016 trial results looking at cultural control techniques on barley grass largely confirmed the 2015 findings.**
- **Increasing the seeding rate of barley in the presence of barley grass can provide substantial benefits to both yield and reduced weed seed carry-over. This applies particularly to competitive varieties such as Fathom, but also to less competitive varieties such as Hindmarsh.**
- **In contrast, doubling the seeding rate of wheat had no beneficial effect on yield or weed carry-over.**
- **Doubling the district practice seeding rate in barley substantially reduced the competitive effect of barley grass to the stage where crop yields were similar to those check plots where herbicide was applied.**
- **During the trials, barley has consistently outperformed wheat in its ability to compete with barley grass, particularly when sown at high seeding rates.**

Why do the trial?

Barley grass is becoming an increasingly problematic weed in lower rainfall farming systems across South Australia and specifically in the Upper North. It has a very short growing season which allows it to set seed in even the driest of seasons. Control in the past has been relatively simple in non-cereal years with cheap and effective selective herbicides available. However, there is now widespread concern about the potential for herbicide resistance – Group A resistance is becoming increasingly common through the region.

There is the need to explore the effectiveness of cultural methods of grass suppression which do not involve the use of herbicides. An important requirement is to find practices which both maximise crop yield in the presence of background grass populations and also suppress weed seed carry-over.

This trial completed at Appila in the Upper North in 2016 represents a component of a coordinated approach across a number of low rainfall farming systems groups as part of a GRDC-funded 'Overdependence on Agrochemicals' project. The same trial was completed at Port Germein in 2015. This trial was reported in EPFS 2016, pp. 166-170.

The key messages from the 2015 trial results were:

- In the presence of a mixed stand of barley grass and ryegrass, the doubling of seeding rates in a competitive barley variety like Fathom resulted in useful yield benefits, which was likely to be as a result of the increased crop competition.
- A less competitive barley variety like Hindmarsh and Mace wheat did not achieve significant yield benefits from a doubling of seeding rates.
- Increasing the seeding rate of both barley varieties had a significant impact on reducing weed biomass and potentially reducing weed seed carry-over. This same effect was not evident in wheat.

At the high seeding rate, weed panicle counts at crop anthesis in barley were reduced significantly (56%) when compared with wheat.

The purpose of the trial in 2016 was to see if these results were repeated. One minor change to the trial protocol was the decision to increase the high seeding rate to double the normal district rate to explore crop competition effects under more extreme circumstances.

As part of a bigger picture, another purpose of the trial was to provide further background information for modelling barley grass carry-over, under differing management regimes.

How was it done?

A replicated field trial was established near Appila to study the interaction of cereal type and variety and seeding rate on crop yield and grass suppression on a known weedy site. The trial was direct drilled using knife points and press wheels on 12 May 2016 after receiving 19 mm of rainfall from 8-10 May. The site had a modest level of broadleaf weeds (medic and thistles) from an earlier germination and these were targeted with Sprayseed prior to sowing. There was very little grass evident at sowing. Soil conditions at seeding were damp on the seedbed, but drier at depth. PAW estimates taken on 3 May 2016 showed 21 mm in the soil profile prior to seasonal opening rains.

One wheat variety (Scepter) and two barley varieties (Fathom, a vigorous, more competitive variety and Hindmarsh which is considered less competitive) were sown with three treatments for each variety - this involved two seeding rates (60 and 120 kg/ha) and a further treatment which aimed at best practice weed control (high seeding rate of 120 kg/ha plus appropriate chemical weed control of Sakura @ 118 g/ha on wheat and TriflurX @ 2.5 L/ha on barley). The crop was established using 72 kg/ha 18:20:0:0 fertiliser with 70 kg/ha urea banded below the seed. Yield Prophet was used to monitor the site throughout the year, and this showed no need for further nitrogen applications.

Initial plant establishment counts were taken on 15 June followed by crop and weed early biomass assessments at crop tillering stage on 8 August. Anthesis crop and weed biomass and weed panicle assessments were completed on 13 October. For the purpose of the trial, it was assumed that panicle counts would provide a good indication of weed seed carry-over. Plot grain harvest was completed on 12 December with grain samples retained for subsequent quality analysis (this analysis was still to be completed at the time of writing this report).

Data were analysed using Analysis of Variance in GENSTAT version 16.

The site was selected due to the presence of a grass dominated medic pasture in 2015 giving the strong likelihood of good levels of barley grass recruitment for the 2016 season. This worked in practice with an excellent and reasonably even (for barley grass) establishment of grass after the trial was sown.

The Predicta B Root Disease Test results completed prior to seeding showed cereal cyst nematode was below detection levels, haydie/take-all and crown rot was at low risk level, and Rhizoctonia at moderate risk level.

What happened?

Crop establishment from seedbed moisture was reasonably good but was further consolidated by rainfall occurring 10 days after seeding. The remainder of the season saw above average rainfall culminating in a very wet September.

Table 1. Monthly and growing season rain at Appila in 2016 compared with historical mean

Month	April	May	June	July	August	Sept	October	April- Oct
2016 rainfall	9	40	69	34	59	136	28	375
Historical mean	28	37	42	41	43	43	37	232

Good levels of barley grass recruitment were observed during the early crop establishment phase. The control treatments which involved herbicide applications on the wheat plots (Sakura @ 118 g/ha) achieved good grass control, but the trifluralin treated barley plots only saw modest levels of grass control. There was moderate late-season development of broadleaf weeds (mainly saffron thistle and volunteer vetch).

A late frost at early grain fill devastated the wheat plots and grain yields were very poor. Barley was relatively unaffected by the frost with satisfactory yields being recorded.

Seeding rate impact of Scepter wheat

Table 2 compares results from the three sowing treatments for Scepter wheat. Crop establishment of Scepter at the lower seeding rate of 60 kg/ha was reasonably in line with district practice and resulted in plant populations of 161 plants/m^2. The high sowing rate of 120 kg/ha resulted in plant populations of around 280 plants/m^2, which would be regarded as very high, but necessary to explore the effect high plant populations have on weed development. Different seeding rates (with no herbicide treatments) had no influence on initial weed establishment levels. The herbicide treatment (Sakura @ 118 g/ha) resulted in a significant reduction in grass establishment.

Table 2. Impact of different seeding treatments of Scepter wheat on crop growth and weed infestation through the season

	Treatment and sowing rate			
	60 kg/ha (no herbicide)	120 kg/ha (no herbicide)	120 kg/ha (plus herbicide)	LSD (P= 0.05)
Early Crop Establishment Crop (plants/m^2)	161	275	288	*41*
Barley grass (plants/m^2)	118	142	21	*45*
Broadleaf (plants/m^2)	14	10	10	*n.s.*
Tillering Crop biomass (g/m^2)	123	154	149	*n.s.*
Weed biomass (g/m^2)	31.8	25.7	1.1	*11.5*
Total weed tillers (no/m^2)	415	333	24	*130*
Anthesis Crop biomass (g/m^2)	695	701	919	*115*
Grass biomass (g/m^2)	264	274	6	*129*
Total grass panicles (no/m^2)	341	326	16	*124*
Harvest Crop yield (t/ha)	1.21	1.24	1.50	*0.255*

At tillering and at anthesis, there were no significant differences between high and low seeding rates on the density of grass and other weeds where herbicides were not applied. There was also no observed influence of seeding rate on total weed panicles measured at crop anthesis. High seeding rate in Scepter wheat did not result in increased competition and did not influence weed density. At anthesis, there was no observed difference between the crop biomass in the high and low seeding rate plots, indicating that the wheat sown at low seeding rates had effectively compensated.

Although frost-affected, there was no difference in the final yield of the Scepter wheat sown at the two different seeding rates with no herbicide treatments. This means there was no benefit to yield from any crop competition effects from higher seeding rates.

The herbicide treatment resulted in significant reductions in grass levels at all crop stages. Crop biomass was also significantly greater at anthesis than the non-herbicide treated plots. As would be expected, the final crop yield of the herbicide treated plots was significantly higher although still substantially affected by the frost.

Seeding rate impact of Fathom barley

As with Scepter wheat, crop establishment of Fathom barley was good. As would be expected, barley plant numbers in the high seeding rate plots were about double that of the lower seeding rate ones. There was no influence of seeding rate on early grass establishment. The pre-sowing herbicide treatment of 2.5 L/ha of TriflurX (incorporated by sowing) was moderately effective at controlling grass with grass establishment levels at about one quarter of levels in non-herbicide applied plots.

Table 3. Impact of different seeding treatments of Fathom barley on crop growth and weed infestation through the season

	Treatment and sowing rate			
	60 kg/ha (no herbicide)	120 kg/ha (no herbicide)	120 kg/ha (plus herbicide)	LSD (P= 0.05)
Early Crop Establishment Crop (plants/m$^{2)}$	88	162	161	*17.3*
Barley grass (plants/m^2)	149	136	59	*36.6*
Broadleaf (plants/m^2)	14	15	11	*n.s.*
Tillering Crop biomass (g/m^2)	171.5	239.2	244.6	*n.s.*
Weed biomass (g/m^2)	31.6	13.1	12.8	*11.1*
Total weed tillers (no/m^2)	503	290	197	*132*
Anthesis Crop biomass (g/m^2)	920	1146	1029	*n.s.*
Grass biomass (g/m^2)	198.1	78.2	44.6	*86.7*
Total grass panicles (no/m^2)	246	115	68	*85.2*
Harvest Crop yield (t/ha)	2.70	3.53	3.64	*0.247*

By tillering, crop competition effects from the high seeding rate were evident. Both weed biomass and weed tillers under the high seeding rate (with no herbicide applied) were significantly lower than at the low rate. Interestingly, and although a trend was observed, statistically, there was no significant difference in weed measurements between the herbicide applied and non-herbicide applied plots at the high seeding rate. These observations continued to apply at anthesis.

Even though the herbicide application reduced weed recruitment levels substantially, the increased crop competition from the high seeding rate alone was still sufficient to reduce the impact from weeds down to similar levels achieved by the herbicide. In terms of weed seed carry-over, the high seeding rate reduced total grass panicles by about half that of the low seeding rate.

The final Fathom barley yield of the high seeding rate plots was significantly higher (by 0.8 t/ha) than the low rate plots. There was no significant difference between the yield of the herbicide treated and non-herbicide treated plots at the high seeding rate indicating the high level of effectiveness of the competition effect of just increased crop plant numbers in the absence of herbicide.

Seeding rate impact of Hindmarsh barley

As noted with earlier treatments, crop establishment in Hindmarsh barley was good and, as would be expected, differences in seeding rates (without herbicide) had no influence on the levels of early grass weed establishment. The herbicide application reduced grass weed levels by about two thirds.

Table 4. Impact of different seeding treatments of Hindmarsh barley on crop growth and weed infestation through the season

	Treatment and sowing rate			
	60 kg/ha (no herbicide)	120 kg/ha (no herbicide)	120 kg/ha (plus herbicide)	LSD (P= 0.05)
Early Crop Establishment	106	204	199	*24.1*
Barley grass (plants/m^2)	150	140	53	*56*
Broadleaf (plants/m^2)	14	13	8	*n.s.*
Tillering Crop biomass (g/m^2)	146.3	226.0	221.9	*67.4*
Weed biomass (g/m^2)	32.5	24.2	9.0	*18.2*
Total weed tillers (no/m^2)	434	408	152	*169*
Anthesis Crop biomass (g/m^2)	780	1062	1079	*167*
Grass biomass (g/m^2)	187.4	104.5	65.0	*79.2*
Total grass panicles (no/m^2)	229	143	83	*58*
Harvest	2.75	3.28	3.38	*0.41*

At crop tillering, there were no statistical differences showing in weed infestations at different seeding rates. However, by anthesis, weed biomass and total grass panicles were almost halved under the high seeding rates. Crop biomass at both tillering and anthesis was significantly higher under the high seeding rates. It is reasonable to assume this extra competition eventually affected weed growth. Hindmarsh crop biomass at the high seeding rate with no herbicide applied was *not* significantly different to the treatment with herbicide.

In contrast to the results seen in 2015, the final crop yield of Hindmarsh barley at the high seeding rate was about 0.5 t/ha higher than the low seeding rate treatment. Similar to the Fathom results, the application of herbicide at the high seeding rate did not achieve a further significant increase in yield.

Comparison of species and variety impact on weed infestation and seed set at different seeding rates

At the higher seeding rate of 120 kg/ha (refer Table 6), weed measurements taken at anthesis showed that both barley varieties had reduced grass weed panicles to well under half that observed in the wheat plots. At the low seeding rate, this reduction in grass seed carry-over was still evident, but not to the same extent. The analysis did not reveal any significant differences between the two barley varieties in terms of their impact on weed levels although the raw data tended to favour the more competitive variety, Fathom.

Table 5. Species and variety impact on weed infestation at 60 kg/ha seeding rate

	60 kg/ha Seeding Rate			
	Sceptre	Fathom	Hindmarsh	LSD (P=.05)
Tillering	31.8	31.6	32.5	*n.s.*
Total grass weed tillers (no/m^2)	416	434	503	*n.s*
Anthesis	264.3	198.1	187.4	*n.s.*
Total grass weed panicles (no/m^2)	341	246	229	*69*

Table 6. Species and variety impact on weed infestation at 120 kg/ha seeding rate

	120 kg/ha Seeding Rate			
	Sceptre	Fathom	Hindmarsh	LSD (P=.05)
Tillering	25.7	13.1	24.2	*12.1*
Total grass weed tillers (no/m^2)	333	290	408	*n.s.*
Anthesis	274.3	78.2	104.5	*104.9*
Total grass weed panicles (no/m^2)	326	115	143	*76*

What does this mean?

The aim of this 2016 trial was to build on the information obtained in 2015 on how crop yield and weed seed carry-over is affected by different cereal species and varieties under different sowing rates and under barley grass weed pressure.

The results obtained in 2016 strongly supported the findings from the previous year although with slight variations. Doubling the standard district seeding rate in both varieties of barley in the presence of barley grass had a significant benefit in terms of improved yield. In 2015, only the more competitive variety, Fathom, showed improved yield from higher seeding rates. The yield benefit (0.5 t/ha in Hindmarsh and 0.8 t/ha in Fathom) represented $75- $120/ha at a barley price of $150/tonne. This was a very good return on the extra seed cost (60kg/ha at a clean seed cost of $200/tonne) of $12/ha.

Similar to 2015, there was the additional benefit from high seeding rates in both varieties of reducing grass weed carry-over by about half as measured by panicles at anthesis.

In the presence of grass, wheat again performed poorly against both of the barley varieties. Wheat showed grass carry-over of 2-3 times that of barley. As in 2015, doubling of the wheat seeding rate provided no benefit. Yield data is questionable, given the level of frost impact, but also supports the fact that the Scepter wheat performed quite poorly as a competitor to barley grass, when compared with barley.

The trial has again demonstrated that increasing the seeding rate of barley in situations where barley grass is not controllable by herbicides, can have substantial benefits, both in terms of yield and reducing weed seed carry-over. Wheat would not be a preferred option in such circumstances and increasing seeding rate of wheat is unlikely to provide any benefit.

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Amanda Cook (SARDI) for statistical analysis.
GRDC for funding the trial under Project No CWF00020 ‘Overdependence on Agrochemicals’

Products used in trial:
Scepter is protected by Plant Breeders Rights. Licencee AGT Seeds.
Fathom is protected by Plant Breeders Rights. Licencee Seednet.
Hindmarsh is protected by Plant Breeders Rights. Licencee Seednet
Sakura is a registered trademark of Kumiai Chemical Industry Co. Ltd
TriflurX is a registered trademark of Nufarm Australia Limited

Location:
Appila, Upper North
Kevin and Ben Ritchie
Group: Upper North Farming Systems
Rainfall:
Av. Annual: 386mm
Av. GSR: 232mm
2016 Total: 605mm
2016 GSR: 375mm
Yield:
Potential: 6.2 t/ha according to Yield Prophet
Actual: Note frost affected. Highest barley yield was 3.64 t/ha
Paddock history:
2015: Medic Pasture
2014: Barley
2013: Wheat
Soil type:
Grey soil with surface and sub-surface lime
Plot size:
20 m x 1.8 m x 4 reps
Yield limiting factors:
Frost, weeds, possible root disease

Seeding rate by row spacing for barley grass management

Authors: Amanda Cook and Ian Richter (SARDI, Minnipa Agricultural Centre)

Funded by: GRDC

Project Title: Seeding rate by row spacing for barley grass management

Project duration: 2015-2016

Project Delivery Organisation: SARDI, Minnipa Agricultural Centre

Key messages:

- **Reducing row spacing to 18 cm from 30 cm increased grain yield of wheat by more than 0.5 t/ha in 2015 and 2016.**
- **Increasing seeding rate also increased grain yield in 2015 and 2016.**
- **Late grassy weed dry matter was 65% lower, and barley grass weed seed set was 57% lower, with a higher seeding rate.**
- **18 cm row spacing had 42% lower grass weed dry matter than 30 cm row spacing.**
- **Single row or spread row seeding boots showed little differences in plant establishment, grain yield and quality or grass weed competition.**

Why do the trial?

Controlling barley grass in upper EP low rainfall farming systems is becoming a major issue for growers, due to the development of herbicide resistance and changing ecology of the weeds, such as delayed emergence of barley grass populations.

There are reasonably effective but costly chemical options for grass weed control using pre-emergent and post emergent herbicides. However for long-term sustainability, a range of management techniques, not just reliance on herbicides, is required to address the issue. One of the potential non-chemical options for managing barley grass in a crop is increasing crop competition by reducing row spacing and increasing sowing rate. This research is funded as part of the GRDC 'Overdependence on Agrochemicals' project, which aims to find ways to reduce dependence on agrochemicals in our current farming systems.

How was it done?

A replicated trial was established at Minnipa Agricultural Centre (MAC) (paddock S3N) with Mace wheat sown at three seeding rates (targeting 60, 120 or 240 plants/m^2) on two different row spacings of 18 cm (7") and 30 cm (12") with two different seeding boots, a narrow row Harrington point and an Atom-Jet spread row seeding boot with press wheels.

The trial was sown on 18 May 2016 into good moisture. A base fertiliser rate of 60 kg/ha of 18:20:0:0 was applied to all treatments. The trial was sprayed on 16 May with a knockdown of 1.5 L/ha of glyphosate, 1.5 L/ha of trifluralin and 80 ml/ha of carfentrazone-ethyl. An insecticide was sprayed on 22 June and broad-leaved weeds were controlled on 24 August after sampling.

Trial measurements taken during the season included soil moisture, PreDicta B root disease test, soil nutrition, weed establishment, weed seedbank germination, crop and weed establishment, crop and weed biomass (early and late), light interception in crop rows (using AccuPAR PAR/LAI ceptometer), grain yield and quality.

Soil moisture and soil nutrition were sampled on 18 April. Plant establishment and weed counts were taken on 20 June. The Leaf Area Index (LAI) measurements were taken on 17 August at Zadoks growth stage Z49-51, aiming for maximum crop canopy. Late weed counts were taken on 12 October. The trial was harvested on 4 November. Post-harvest soil moisture in selected treatments was sampled on 29 November.

Grass weed seed set was calculated using the total panicle length and number of panicles/m^2 of individual plots. Weed seeds per panicle were counted from selected treatments and a regression was used to calculate weed seed set per plot.

Data were analysed using Analysis of Variance in GENSTAT version 16.

What happened?

The soil is an alkaline red sandy loam, with a pH ($CaCl_2$) of 7.8. Colwell P was 33 mg/kg (0-30 cm). Soil mineral N was 151 kg/ha in the top 90 cm in March. The soil has a moderate phosphorus buffering index of 143 (0-30 cm). Initial soil moisture was 107 mm to a depth of 90 cm.

There was a high risk of *Rhizoctonia* disease (332 pgDNA/g soil) but *Pratylenchus thornei* was a low risk. All other disease risks were low.

There were no significant statistical interactions for row spacing and seeding rate so the results are presented for the individual factors only.

Table 1. Wheat growth, yield and grain quality measurements taken in seeding rate and row spacing trial sown with Mace wheat at Minnipa, 2016.

Seeding rate target (plants/m^2)	Row spacing (cm)	Plant establish ment (plants/ m^2)	Early DM (t/ha)	Late DM (t/ha)	Yield (t/ ha)	Protein (%)	Screening s (%)
	18	108.4	0.21	3.87	2.87	10.3	1.8
	30	95.3	0.29	5.12	2.39	10.2	1.8
LSD (P=0.05) row spacing		*7.4*	*0.06*	*0.71*	*0.16*	*ns*	*Ns*
60		51.8	0.16	4.23	2.28	10.2	2.1
120 (district practice)		87.0	0.25	4.52	2.76	10.2	1.8
240		166.6	0.34	4.74	2.85	10.3	1.4
LSD (P=0.05)		*6.4*	*0.05*	*ns*	*0.14*	*ns*	*0.2*

This trial targeted barley grass weeds but there was also some ryegrass present. Seeding rate increased the number of wheat plants/m^2 however no rate achieved the targeted plant densities despite good seeding conditions. The 18 cm row spacing resulted in higher plant densities than the 30 cm row spacing (Table 1), but the seeding system boots had no impact on plant numbers (data not presented). There were no differences in early weed numbers for row spacing or seeding rates (Table 2).

Early crop dry matter was greater in the 30 cm row spacing than in the 18 cm, and this trend carried through to late dry matter. Seeding rate progressively increased dry matter early in the season but the effect had largely disappeared by late season dry matter cuts (Table 1).

Total late grass weed dry matter was lower in the higher seeding rate treatment. The 18 cm row spacing also had lower late grass weed dry matter compared to the 30 cm row spacing (Table 2).

The late barely grass and ryegrass weed seed set followed similar trends to the grassy weed dry matter. Barley grass seed production was lower with narrower 18 cm row spacing compared to 30 cm (Table 2). There was no difference in the ryegrass numbers or weed seed set with the narrow row spacing as ryegrass density was similar. The increase in seeding rate and plant density also decreased barley and ryegrass weed seed set (Table 2).

Table 2. Grass weed density and canopy measurements taken in seeding rate and row spacing trial sown with Mace wheat at Minnipa, 2016.

Seeding rate target (plants/m^2)	Row spacing (cm)	Early (plants/ m^2)		LAI (umols)	Late				
		Barley grass	Rye grass		Grass weeds DM (t/ha)	Barley grass (plants /m^2)	Barley grass seed production (m^2)	Ryegrass (plants /m^2)	Ryegrass seed production (m^2)
	18	29	12	381	0.24 (42% reduction)	12.3	582 (44% reduction)	6.0	193 (8% reduction)
	30	35	17	458	0.41	18.4	1037	5.4	209
LSD (P=0.05) row spacing		*ns*	*ns*	*73*	*0.14*	*5.6*	*322*	*ns*	*ns*
60		33	18	517	0.50 (47% increase)	16.3	1245 (50% increase)	7.3	328 (95% increase)
120 (district practice)		37	13	408	0.34	18.0	828	5.2	168
240		25	13	334	0.12 (65% reduction)	11.8	356 (57% reduction)	4.7	107 (36% reduction)
LSD (P=0.05) seeding rate		*ns*	*ns*	*63*	*0.12*	*4.8*	*279*	*3.7*	*58*

Grain yield increased with seeding rate (Table 1). The 18 cm row spacing also out-yielded the 30 cm row spacing for the second season, by 0.48 t/ha in 2016, but again there were no differences between the two seeding boots (data not presented).

There were no significant differences in grain protein in 2016 due to the unusually cool finish to the growing seasons, which reduces the protein level in the grain due to extra carbohydrates being formed. Screenings were very low in 2016 due to the cool finish to the season resulting in good grain filling conditions.

What does this mean?

The 18 cm row spacing achieved higher plant numbers than the 30 cm row spacing with the same seeding rate, but the seeding system (ribbon or narrow boots) had no significant impact on crop numbers. Row spacing did not significantly affect ryegrass seed set in this trial.

There were no differences in early weed numbers due to row spacing or seeding rates. The total late grass dry matter declined with the higher seeding rate, and also declined with narrower row spacing. The late barley grass showed similar trends decreasing weed seed set in the narrow row spacing, and also the higher seeding rate.

In the 2016 season the 18 cm again yielded higher (+0.48 t/ha) than the 30 cm system with no differences in grain quality this season due to the mild finish. In 2015 the higher seeding rates also resulted in higher grain yield, but grain quality differences were present due to the drier spring. Previous research from WA showed there is no difference in yield due to row spacing in crops less than 0.5 t/ha, but in crops greater than 3.0 t/ha there is a yield penalty with wider row spacing. The decrease in wheat crops (between 2.7 – 3.4 t/ha) was an 8% decrease in yield for every 9 cm increase in row spacing (GRDC, 2011).

A more recent review of row spacing of winter crops in broad scale agriculture in southern Australia, by Scott *et al*. in 2013, suggests the direct effect on yield of adopting wider rows (reduced yield at greater than 18 cm) has often been overlooked, due to the relative ease of stubble management in wider rows. At yields of 2.0 t/ha widening row spacing from 18 cm to 36 cm reduced yield by 1860 kg/ha (Scott, 2013). This review also noted crops sown on wider rows are less competitive with weeds, mainly ryegrass.

Research into using crop competition for weed control in barley and wheat in 2015 at Hart showed varying the seeding rates (increasing from 100 to 300 plants/m^2) reduced the yield loss due to weed competition (Goss, 2015). This research also showed there were differences in wheat and barley varieties' ability to compete with grass weeds, and it also found no difference between normal or spreader seeding boots (Goss, 2015). Spreader boots were used to try reduce the row spacing (by spreading the seed) and increase grass weed competition, however this effect has not occurred at Minnipa in the last two seasons.

Research in the Upper North of SA showed barley sown at higher seeding rates is more effective than wheat at reducing barley grass seed set, particularly with more vigorous varieties such as Fathom, compared to less vigorous varieties such as Hindmarsh (Mudge, EPFS Summary 2016). At Minnipa the seeding system boots showed little difference in either weed competition or crop yield.

Achieving 166 plants/m^2 instead of 87 plants /m^2 (targeted rate was district practice rate of 120 plants/m^2) has reduced barley grass seed set by 57% and ryegrass by 36%. Sowing to achieve a district practice seeding rate of 60 kg/ha (actually108 plants/m^2) at 18 cm spacing instead of 30 cm has led to a 44% decrease in barley grass seed production. Overall the reduction in barley grass numbers demonstrates using crop competition (either by using a narrow 18 cm row spacing, or by increasing plant density) are potentially effective non-chemical methods to reduce barley grass and ryegrass numbers in current farming systems. Using narrow row spacings of 18 cm in greater than 2 t/ha wheat crops have also shown a yield advantage in this environment.

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Location
Minnipa Agricultural Centre, paddock S3N
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
Yield
Potential: 3.6 t/ha (W)
Actual: 2.6 t/ha
Paddock history
2016: Mace wheat
2015: Grenade wheat
2014: Spray topped medic pasture
Soil type
Red loam
Plot size
20 m x 2 m x 4 reps

Row orientation, seeding system and weed competition

Authors: Amanda Cook[1], Ian Richter[1], Chris Dyson[2] and Nigel Wilhelm[1]

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

Funded by: GRDC

Project Title: Overdependence on Agrochemicals

Project Duration: 2015-2016

Project Delivery Organisation: SARDI

Key messages:

- **There was no detectable direct effect of sowing direction this season at Minnipa with a mild spring.**
- **Using a narrow row spacing of 18 cm instead of 30 cm resulted in wheat yield increasing from 3 t/ha to 3.6 t/ha (19% increase).**
- **Light interception was very sensitive to sowing direction, and not having 'weeds' resulted in higher light within the canopy in the north-south direction compared to east-west.**
- **Knife point and ribbon seeding systems achieved similar crop establishment and crop performance.**

Why do the trial?

Controlling barley grass in upper EP farming systems is becoming a major issue for growers, due to the development of herbicide resistance and delayed weed emergence. Management options other than herbicides need to be considered to address the issue for long-term sustainability. One of the best bets for cultural control of barley grass in-crop may be increased crop competition. The Australian Herbicide Resistance Initiative (ARHI) based at University of Western Australia has shown an increase in grain yield with wheat and barley sown in an east–west (E-W) orientation over crops sown in a north-south (N-S) orientation due to a decrease in ryegrass competition. This effect is due to lower light interception by the weed due to the crop row orientation resulting in a decrease in weed seed (Borger, 2015).

A trial was established at Minnipa Agricultural Centre to investigate the impact of row direction and row spacing on weed competition and cereal performance over two years. The previous season's research is reported in Eyre Peninsula Farming Systems Summary 2015, *Row orientation and weed competition,* p163.

How was it done?

In 2016 a replicated plot trial was sown in blocks with two row orientations; E-W and N-S into a pasture paddock. The ten treatments within the row orientation blocks included two row spacings, 18 cm (7") and 30 cm (12"), sown with two different seeding boots; a Harrington knife point and an Atom-Jet spread row ribbon seeding boot, both with and without 'oat weeds'. An 'oat' weed only treatment was also sown at both row spacings with the Harrington knife points. Plots were direct drilled with press wheels. Oats were spread at 70 plants/m^2 as a surrogate weed through the seeder on the 'weed' plots before the seeder pass.

The trial was sown 17-18 May. A base fertiliser rate of 60 kg/ha of 18:20:0:0 was applied for all treatments. The trial was sprayed on 16 May with a knockdown of 1.5 L/ha of glyphosate, and Broadside (MCPA; bromoxynil; dicamba) at 800 ml/ha on 22 June.

Trial measurements taken during the season included soil moisture, PreDictaB root disease test, soil nutrition, weed establishment, 'weed' germination, crop and weed establishment, crop and weed biomass (early and late), light interception in crop rows (using AccuPAR PAR/LAI ceptometer), grain yield and quality.

Soil samples for soil moisture and soil nutrition were taken on 18 April. Plant establishment and weed counts were taken on 22 June. The Leaf Area Index (LAI) measurements were taken on 17 August using an AccuPAR PAR/LAI Ceptometer (model LP-80), taking the average of 5 readings per plot placed at an angle across the crop rows as per the manufacturer's instruction manual. The measurements were taken at Zadoks growth stage Z49-51, aiming for maximum crop canopy. Late dry matter, weed counts and cuts were taken on 12 October. The trial was harvested on 4 November. Harvest soil moisture measurements of selected treatments were taken on 29 November. Design and analysis of this trial was undertaken by SARDI statistician Chris Dyson using GENSTAT 16.

What happened?

The 2016 row direction trial was sown into a medic pasture stubble so did not have previous crop stubble rows in the given orientations of 2015. Using oats as a surrogate grass weed resulted in an even weed pressure across the large area of the trial which was unlikely to be achieved by only relying on the background grass weed levels. Using oat 'weeds' gives a relative indication of the outcome that would be achieved with other grass weeds such as ryegrass and barley grass at high populations in the system.

In 2016 there were no interactions between row spacing, seed rate or seeding system in terms of the effect on weeds. There was no difference in crop establishment due to row direction with the average being 112 plants/m^2. There was a difference in plant numbers between the row spacing treatments, with 120 wheat plants/m^2 established in the 18 cm row spacing treatment and 105 plants/m^2 in the 30 cm row spacing (Table 1). The type of seeding point or the addition of weeds had no impact on wheat establishment. The oat-only treatment (no wheat sown) resulted in 72 plants/m^2, achieving the targeted plant density for weed pressure, unlike 2015 when the weed pressure was only 26 plants/m^2.

There were no differences in late crop dry matter due to sowing direction or seeding systems in the absence of weeds (Table 1). The late dry matter was greater in the narrow row spacing than in the wider row spacing (Table 1).

In 2016 there was no detectable difference in wheat yield due to sowing direction in the absence of weeds (Table 1). The narrow row spacing resulted in higher yields compared to wider (Table 1). There was no significant difference in grain quality, likely due to the mild finish (Table 1).

There was a significant difference in grain yield due to 'weeds' in the system with an average wheat grain yield decrease of 0.7 t/ha (Table 2). The 'oat' weed seed set averaged 0.23 t/ha and there was no effect on weed seed set due to sowing direction or row spacing in 2016 (data not presented).

Table 1. Mace wheat growth, yield and grain quality with different sowing direction, row spacing and seeding systems at Minnipa 2016.

		Crop establishment (plants/m^2)	Late DM (t/ha)	Yield (t/ha)	Protein (%)	Screenings (%)
Sowing direction	East-West	116	6.33	3.36	10.2	0.9
	North-South	108	6.40	3.30	10.3	0.9
		*	*	*	*	*
Row spacing (cm)**	18	120	7.05	3.64	10.3	1.0
	30	105	5.68	3.02	10.3	0.9
LSD (P=0.05)		*10.4*	*0.53*	*0.2*	*ns*	*Ns*
Seeding system	Knife points	114	6.13	4.03	10.3	0.9
	Knife points plus weed	115	-	2.58	-	-
	Ribbon	111	6.61	4.16	10.3	1.0
	Ribbon plus weed	110	-	2.52	-	-
LSD (P=0.05)		*ns*	*ns*	*0.20*	*ns*	*0.7*

**LSD not available due to lack of replication (>8 required for statistical comparison)*
*** in absence of weeds*
- Analysed data not provided

Table 2. Oat 'weed' growth, yield and grain quality with different sowing direction, row spacing and seeding systems trial at Minnipa 2016.

	Crop establishment (plants/m^2)	**Late DM**	**Yield (t/ha)**	**Protein (%)**
'Oats' weeds in wheat crop	60	2.41	2.56	10.4
'Oats' weeds only	72	7.43	4.10	10.2
LSD (P=0.05)		*0.59*	*0.14*	*0.15*

The light interception measured as leaf area index (LAI) showed greater shading in the E-W sowing direction compared to N-S, taken in August on a clear sunny day. Not having weeds in the system resulted in higher light within the canopy in the north-south direction compared to east-west. The narrow 18 cm row spacing also showed greater shading due to canopy cover compared to the 30 cm row spacing (Table 3). There was greater shading in the ribbon seeding system compared to the knife points and having weeds increased the shading in both systems (Table 3).

Table 3 Light interception measured as leaf area index (LAI) of Mace wheat with different sowing direction, row spacing and seeding systems at Minnipa 2016.

		Seeding system				
Sowing direction	**Row spacing (cm)**	**Knife points**	**Knife points plus weed**	**Ribbon**	**Ribbon plus weed**	**Weed only**
East-West	18	196.4	108.2	117.7	118.4	106.5
	30	160.2	120.5	176.4	127.3	174.8
LSD (P=0.05)	*62.3*					
North-South	18	237.0	118.5	215.1	133.0	147.3
	30	377.5	130.6	380.3	129.6	240.5
LSD (P=0.05)	*62.3*					
LSD (P=0.05)	*147.7 (between different orientations)*					

The volunteer weed numbers were low and the dry matter cuts taken at harvest showed no difference between seeding systems, but there was a decrease due to having oat weeds in the system (Table 4).

Table 4 Average weed dry matter at harvest with different sowing direction, row spacing and seeding systems at Minnipa 2016.

		Weed establishment	**Oat 'weed' dry matter (t/ha)**	**Volunteer grass weed dry matter (t/ha)**
Sowing direction	East-West	73	3.94	0.12
	North-South	71	4.23	0.09
		*	*	*
Row spacing (cm)	18	77	4.37	0.14
	30	67	3.79	0.19
		-	*ns*	-
Seeding system	Knife points	^	^	0.17
	Knife points plus weed	60	2.31	0.05
	Ribbon	^	^	0.14
	Ribbon plus weed	53	2.51	0.05
	Weed only	72	7.43	0.12

** LSD not available due to lack of replication (>8 required for statistical*

What does this mean?

Research from Western Australia showed an increase in grain yield with wheat and barley sown in an east-west orientation compared to north-south, due to a decrease in grass weed competition with high ryegrass populations (Borger 2015). The 2016 results showed no differences in grain yield, late dry matter or grain quality due to sowing direction at Minnipa Agricultural Centre in an above average season with a very mild spring with an average 69 plants/m^2 'oat' weed population.

The light interception showed greater shading in the E-W sowing direction compared to N-S and also the narrow 18 cm row spacing also showed greater shading; however there were no differences in weed dry matter measurement in 2016 due to light interception. The light interception differences show the potential benefits of E-W orientation, although it didn't affect weed dry matter this season. The higher than average rainfall season and very mild spring grain filling conditions may have allowed the crop and weeds to both achieve their potential this season rather than being competitive and resulting in yield differences between the treatments.

There was a difference in Mace wheat late dry matter and grain yield increase of 0.6 t/ha due to the 18 cm row spacing compared to the 30 cm in the absence of 'oat' weeds. Previous research from WA showed there is no difference in yield due to row spacing in crops less than 0.5 t/ha, but in crops greater than 3.0 t/ha there is a yield penalty with wider row spacing. The decrease in wheat crops (between 2.7 – 3.4 t/ha) was an 8% decrease in yield for every 9 cm increase in row spacing (GRDC, 2011).

A more recent review in 2013 of row spacing of winter crops in broad scale agriculture in southern Australia, by Scott *et al*, shows at yields of 2.0 t/ha widening row spacing from 18 cm to 36 cm reduced yield by 1.86 t/ha (Scott, 2013). This review also noted crops sown on wider rows are less competitive with weeds, mainly ryegrass.

Research into using crop competition for weed control in barley and wheat in 2015 at Hart showed varying the seeding rates, (increasing from 100 to 300 plants/m^2) reduced the yield loss due to weed competition (Goss, 2015). This research also showed there were differences in wheat and barley varieties' ability to compete with grass weeds, and it also found no difference between normal or spreader seeding boots (Goss, 2015). There was no difference at Minnipa due to seeding systems in these trials in 2015 or 2016.

Overall the 'Overdependence on Agrochemicals' research has shown the greatest benefit in low rainfall farming systems can be achieved by sowing on as narrow row spacing as possible, without compromising stubble handling, which will gain benefits in grain yield as well as weed competition.

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Location
Minnipa Agricultural Centre, paddock S5
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
Yield
Potential: 3.6 t/ha (W)
Actual: 3.3 t/ha
Paddock history
2016: Mace wheat
2015: Medic pasture
2014: Wyalkatchem wheat
Soil type
Red loam
Plot size
20 m x 2 m x 4 reps

2015-16 Weed control using narrow windrows vs EMAR chaff deck

Author: Helen McMillan (Central West Farming Systems)

GRDC project: CWF00020 – Overdependence on agrochemicals

Key Points:

- **Concentrating the header trash into rows prevents spreading of weed seeds across the paddock. Additionally, it allows for site specific weed management and weed seed destruction through strategic burning.**
- **A low cutting height (10cm) can allow greater than 95% weed seed capture and placement into rows. However this harvest height can impact harvest cost, speed and efficiency.**

Background

CWFS is undertaking a trial at Northparkes Mine that investigates the impact that two different harvest weed seed control (HWSC) methods - narrow windrowing of header trash and the Esperance Mobile Ag Repairs (EMAR) chaff deck - have on reducing the weed burden in the following crop.

Narrow windrow burning is the process where a chute is mounted to the rear of the harvester and concentrates the trash into a narrow windrow of approx. 500-600 mm wide (Walsh 2014) (Figure 2). The trash rows are then burnt when weather conditions are suitable to destroy the weed seeds.

EMAR chaff deck (designed in WA) is set-up to drop the chaff onto the tramlines of a controlled traffic farming system, where it is left to rot. The concept behind this process is that the compacted wheel tracks make a hostile growing environment for the germinating weeds. This is achieved by increased competition for light and nutrients, increased waterlogging, and in wet years an increase in trash decomposition rotting the weed seeds within the rows. It also allows for shielded spraying of the trash piles should the weeds germinate which is considered a saving in chemical compared to spraying the entire paddock.

Agronomic issues

Weeds cost Australian agriculture more than $4 billion per year in loss of income and cost of control (DAFF 2012). The overall cost of weeds to Australian grain growers is estimated to be $3,300 million p.a. attributing to 2.76 million tonnes of grain lost due to weeds (Llewellyn *et al* 2016). Herbicide resistant ryegrass (*Lolium rigidum*) has been ranked 1st nationally as the most costly to manage herbicide resistant weed with $103.2 million spent in extra herbicide (Llewellyn *et al* 2016). The rise of herbicide resistance to a number of modes of action mean that farmers are now required to use increasingly more expensive herbicides, or alternative methods such as HWSC to manage weeds.

The simultaneous maturity of crops and the weeds that infest them can result in effective harvest then redistribution of weed seeds across the paddock (Walsh and Powles 2014). Collection of these weed seeds and then their subsequent destruction has been identified as providing a cost effective means of controlling weeds by reducing the weed seed bank and addressing herbicide resistance, resulting in a reduction of grower reliance upon agrochemicals. Weeds such as annual ryegrass (ARG) (*Lolium rigidum*), wild radish (*Raphanus raphanistrum*), brome grass (*Bromus spp.*) and wild oats (*Avena spp.*) have been found to have high seed retention levels at time of crop harvest (Walsh and Powles 2014) which makes them suitable for HWSC. Options for HWSC include; windrow burning, chaff carts, bale direct, the Harrington Seed Destructor (Weedsmart 2013) and chaff tramlining with an EMAR chaff deck.

The GRDC undertook a national review in 2014 into weeds which was able to gauge the adoption of HWSC in Central NSW (Bogan, Cobar, Lachlan, Carrathool, Murray, Wakool, Balranald, Wentworth, Berrigan, Deniliquin and Jerilderie districts) (Llewellyn *et al* 2016). It found that technologies such as chaff tramlining, chaff carts, bale direct and Harrington Seed Destructor were very low in potential uptake in the next 5 years (2 -14%) (Llewellyn *et al* 2016). Windrow burning was identified as the highest potential HWSC adoption with 29% of growers feeling they would adopt the technology in the next 5 years (Llewellyn *et al* 2016). This response is lower than the Southern region average of 47% of growers looking to adopt windrow burning in the next 5 years, but similar in response to the other 4 technologies stated above (6-15%) (Llewellyn *et al* 2016).

Within the CWFS region of NSW, HWSC may be considered to be in its "infancy" with limited numbers of producers identified as using chaff carts or the Harrington Seed Destructor due to either their initial cost of purchase or the use of contractors who do not provide these options at harvest. In comparison, windrow burning has been widely adopted by growers in the Central West to manage herbicide resistant ARG. The EMAR chaff deck is an emerging product which has the potential to provide a similar HWSC to windrow burning but without the risk that fire holds. With HWSC being proven to be highly successful in Western Australia in reducing the weed pressure and reliance on herbicides (Walsh and Powles 2014) (Walsh, Newman and Powles 2013) these methods of weed control are becoming more common place in the Eastern states.

Figure 1. EMAR chaff deck in action harvest 2015

Figure 2. Setup for narrow windrows harvest

Figure 3. Narrow windrows post-harvest 2015

Figure 4. Narrow windrows pre-burn 2016

Trial design

Three paddocks were identified, one harvested with the EMAR chaff deck, one with narrow windrows and a control which was also narrow windrowed (2016 results not published).

Prior to harvest 2015, data was collected to determine the degree of weed seed capture at harvest and to gauge weed populations in the trial paddocks prior to treatment applications. This was measured by collecting weed seed above and below a low harvesting cutting height (10cm) and weed seeds already shed on the ground. Trash treatments were imposed during harvest in 2015. Post-harvest the narrow windrow and EMAR chaff deck trash lines were sampled at 15 random sites per paddock. This was to determine the bulk density of the trash and total crop residue (results not shown). Moisture under the trash lines and in the standing stubble was measured at 15 random points per paddock post-harvest (7/12/15), pre-trash line burning (23/2/16) and post trash burning pre-sowing (4/4/16). Trash lines were burnt by the farm manager when conditions were suitable in late March/early April. Due to very high stubble loads the fires got away and burnt most of the stubble within the paddocks. Weed counts were undertaken at 10 random points per paddock post-autumn rains in May and later on in the season in August.

Note: Due to previous work undertaken by Northparkes Mine, they identified that conventional trash management was increasing weed pressure in their paddocks. For this reason they no-longer use this method at harvest and all paddocks in 2015 were either harvested with the addition of narrow windrows or using the

EMAR chaff deck. The control paddock was narrow windrowed in 2015 and burnt 2016 and for this reason weed data will not be reported for 2016. For weed control Northparkes Mine include a field pea crop in their rotation that is brown manured prior to weed seed set. Trial paddocks were sown to Morgan field peas in 2016 preventing the collection of harvest data from those paddocks. Alternative paddocks that were harvested with the EMAR chaff deck and narrow windrowed in 2015 were identified as replacement paddocks and 2016 harvest data was collected from them. Sampling will continue in 2017 in the original trial paddocks to measure the success of HWSC and brown manuring on weed control.

Weed seed collection pre-harvest 2015

The degree of HWSC was measured by collecting weed seeds retained in the plant heads above 10cm harvest height (Table 1) and those still retained in the plant heads below 10cm harvest height plus those already shed on the ground (Table 2). These seed numbers represent the weed seed numbers in the trial paddocks prior to treatment application. Annual ryegrass (ARG) had the highest weed seed numbers across all paddocks, with phalaris and black oats having the second highest weed seed numbers. Whilst there were some ARG and black oat seeds escaping harvest (Table 2), more than 95% of weed seeds were being captured to allow destruction by burning or decomposition (Table 1).

Table 1. Weed seeds above 10cm harvest height (seeds/m^2)

Paddock treatments	*Weed*	*Count*
Control	ARG	1049
	Black Oats	225
	Wheat	807
EMAR chaff deck	ARG	653
	Barrel Medic	33
	Black Oats	277
	Phalaris	375
Narrow windrow	ARG	1374
	Black Oats	256

Table 2. ***Weed seeds below 10cm harvest height and on the ground (seeds/m^2)***

Paddock treatments	*Weed*	*Count*
Control	ARG	43
EMAR chaff deck	Black Oats	3
	ARG	33
Narrow windrow	Black Oats	3
	ARG	51

Soil moisture

Figure 5 shows the difference in moisture under the trash lines compared to the standing stubble of the control paddock post-harvest, pre-trash burning and post- trash burning. Any difference in soil moisture between the EMAR chaff deck and narrow windrows that were seen post-harvest and pre-burning are almost equal post-burn pre-sow. This difference in soil moisture has had an effect on the 2016 field pea crop with clear growth responses from the crop growing on stored moisture under the 2015 trash lines (Figure 6 and Figure 7).

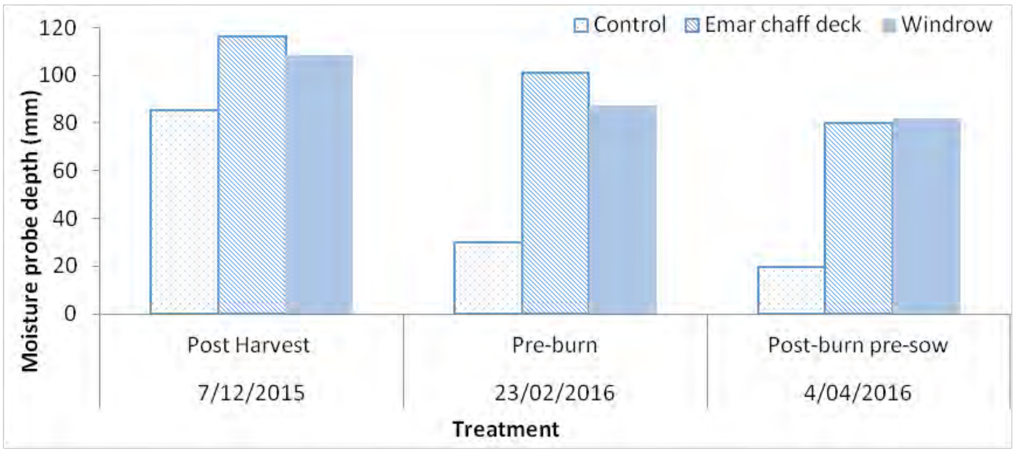

Figure 5. (Above) Moisture probe depth under trash lines and off trash lines (control) post-harvest, pre-trash burning and post-burning pre-sowing.

Figure 6. (Left) Field pea growth response to moisture 18/5/16

Figure 7. (lLeft) Field pea growth response to moisture 15/6/16

Weed counts 2016

Weed counts were undertaken in the trial paddocks in May (Figure 8) and August (Figure 9) to determine the effect of narrow windrows and EMAR chaff deck on weed populations. The sample points in the paddocks were random and included a mix of on and off the trash lines. The control paddock was sampled, however it had also been narrow windrowed at harvest 2015 and will not be reported at this time. Small broadleaf weeds and ARG were the most prominent weeds at the time of the May sampling with all weeds having a population of more than 50 plants/m^2 (Figure 8). At the second weed sampling in August, all weeds averaged fewer than 10 plants/m^2 (Figure 9).

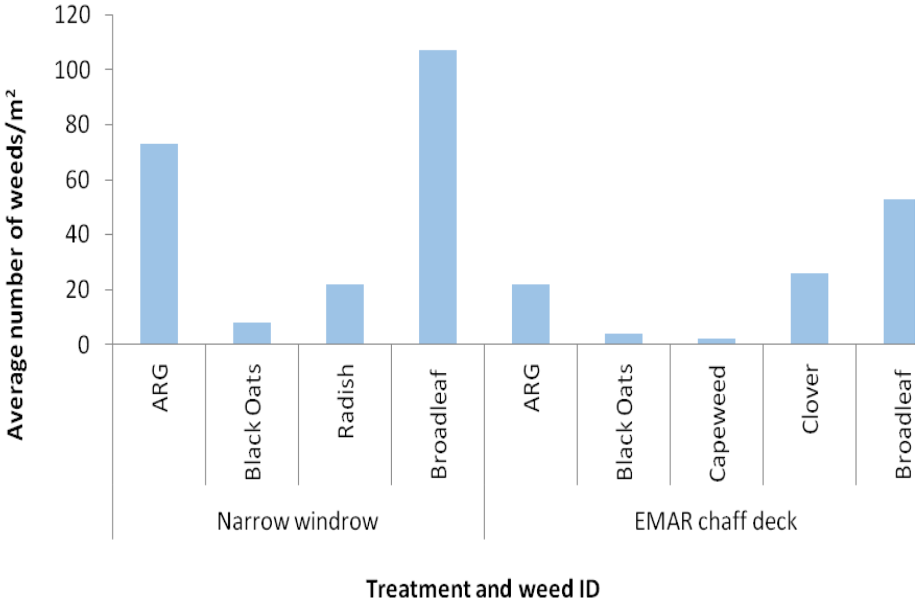

Figure 8. Weed counts 18/5/16

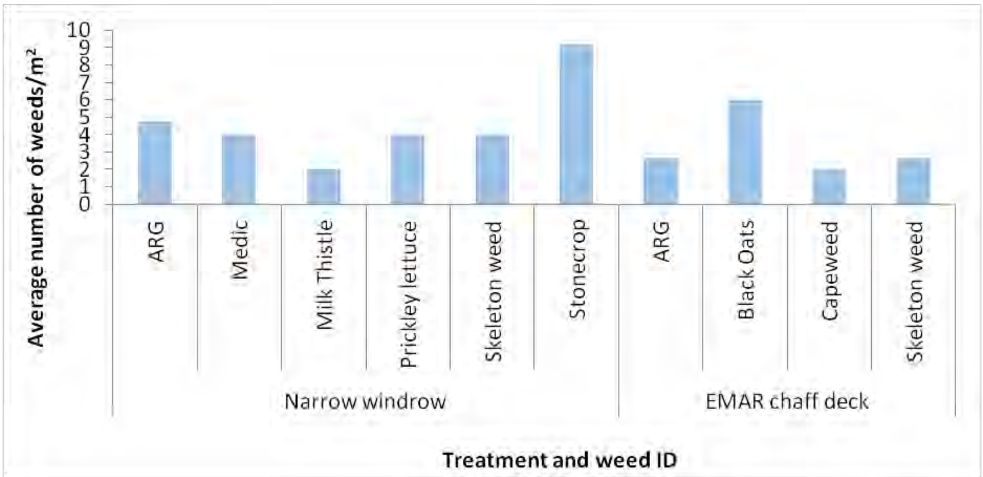

Figure 9. Weed counts 9/8/16

Weed seed collection prior to 2016 harvest

Due to the field pea crop being sown in the original trial paddocks two alternative paddocks were identified to enable the continuation of the data collection. Both alternative paddocks have had similar treatments with the only difference being the use of the EMAR chaff deck or narrow windrows at 2015 harvest. The most prominent weeds were toad rush (*Juncus bufonius*), phalaris (*Phalaris aquatic*), ARG and black oats and all were still green apart from the toadrush. Toad rush had the highest weed seed count with almost all of the seed existing below 10cm avoiding harvest capture (Table 4). The wet conditions that were experienced during 2016 would have favoured toad rush which thrive in waterlogged soils. In drier years this weed may not be a problem. Due to planned harvest of those paddocks approx. 1 week post our weed sampling it would be expected that weed seeds above 10cm would be captured by harvest to allow for subsequent destruction. The two paddocks used for 2016 harvest data were harvested with the aid of the EMAR chaff deck and will be sown to field peas 2017.

Table 3. Weed seeds above 10cm harvest height (seeds/m2)

Paddock treatments	*Weed*	*Count*
EMAR chaff deck	Phalaris	5 (seed heads)
	Toad Rush	64
Narrow windrow	Black Oats	116
	Toad Rush	222

Table 4. Weed seeds below 10cm harvest height and on the ground (seeds/m2)

Paddock treatments	*Weed*	*Count*
EMAR chaff deck	Toad Rush	410
Narrow windrow	Toad Rush	1001

Paddock assessment post brown-manuring

Use of double spraying in both directions and the use of a follow up spray has provided a good weed control to the paddock. Upon assessment of weed seed heads the herbicide has been well timed preventing the successful seed establishment of the ARG and black oats. Monitoring of these paddocks will commence post-autumn rains 2017.

Discussion

The trial demonstrated some key points regarding weed seed capture as a component of integrated weed management.

- HWSC methods are a useful strategy to reduce the spread of weeds across the paddock where weeds have escaped herbicide control during the growing season and have made it to maturity.
- A short harvesting height (10cm) allowed for greater than 95% weed seed capture during 2015 harvest. Other work undertaken by Walsh and Powles (2014) found that 80% or more ARG, wild radish, brome grass and black oats seeds were retained at 15cm harvest height at time of wheat crop maturity.
- The strong growth response in the field peas, thought to be a response to higher soil moisture under the trash lines, led to greater crop competition and increased weed suppression, resulting in fewer than 10 ARG and black oat plants/m^2 at the August 2016 assessment.
- Implementing an HWSC method such as placing the chaff into the wheel tracks using a chaff deck allows for the benefits of weed seed capture without the risk of fire that narrow windrow burning can cause.
- Care must be taken so that one weed control tool is not relied on too heavily, allowing weeds to form a resistance to control. Effective weed management revolves around using multiple control tools that have different modes of action such as rotating herbicide groups, using strategic cultivation or stubble burning, seed removal such as bailing or seed destruction such as the Integrated Harrington Seed Destructor (iHSD) and narrow windrow burning etc. that slow the weeds ability to form resistance to control.
- 2016 harvest for Northparkes Mine was planned to include both narrow windrow burning in the canola and chaff tramlining in most of the cereal crops to reduce the fire risk.

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Application of Controlled Traffic Farming (CTF) to the Upper North

Author: Matt McCallum

Funded by: GRDC project ACT00004 – Application of CTF in the low rainfall zone

Project Title: Application of Controlled Traffic Farming in the Low Rainfall Zone

Project Duration: 2015-2018

Project Delivery Organisation: UNFS

Key messages

- **Heavy vehicles cause compaction of our agricultural soils across Australia, including the Upper North.**
- **Results to date have revealed that compaction can have a negative, positive or no impact on crop yield.**

Background

The UNFS is involved in a 5 year project, funded by GRDC, looking into the application of CTF in the low rainfall zone (LRZ) of the Southern Region. Details of this project can be found in the other two CTF articles in this compendium. Briefly, the ultimate question is whether soil compaction caused by heavy vehicles is having sufficient negative impact on yield to justify more growers moving towards a CTF system.

Research results

There are four research sites in this project, covering a range of soil types and different climates;

- Lake Cargelligo (NSW) - deep red earth
- Minnipa (SA) - red calcareous sandy loam
- Loxton (SA) - deep sand
- Swan Hill (Vic) - brown loam

The following treatments were imposed at the start of the trial in 2015, and the impact of this compaction is to be measured over four years (2015 to 2018)

1. Control (no heavy vehicle trafficking).
2. One pass of a 20 tonne vehicle prior to seeding when soil was dry.
3. One pass of a 20 tonne vehicle prior to seeding when soil was moist.
4. Three passes of a 20 tonne vehicle prior to seeding when soil was moist.
5. Deep ripping (to loosen any historical trafficking) - some sites only.

To date the research results have been mixed. Compaction has caused a negative (up to 1t/ha in wheat), positive (up to 0.8t/ha in wheat and barley) and nil effect on crop yield in trials. Given these early results, there is no consistent message for growers in the low rainfall zone (LRZ) of the Southern Region in regard to the impact of compaction on crop yield.

Local results

In 2015 the UNFS has access to a soil penetrometer to measure compaction within the region. The penetrometer measures the amount of pressure (kPa) required to push a steel rod into the soil. The more compact the soil, the more pressure is required to push the rod into the soil. The penetrometer was used in one of Joe Koch's paddocks at Booleroo. The results indicated that repeated wheel traffic from heavy vehicles is causing increased soil compaction at 20-35cm down the soil profile, compared to where no repeated traffic had been for at least 4 years (Table 1).

Table 1. Penetrometer results (kPa) measured in one of Joe Koch's paddocks at Booleroo. Measurements were conducted in July 2015. Traffic results included the soil under the seeding tractor, spray tractor and harvester.

Soil depth (mm)	No traffic	Traffic
25	1250	1298
50	1820	1764
75	2190	2234
100	2507	2485
125	2595	2607
150	2641	2602
175	2677	2689
200	2696	2812
225	2729	3021
250	2878	3240
275	3092	3418
300	3350	3637
325	3483	3877
350	3478	4007

0 to 2000 kPa roots are not restricted
2000 to 3000 kPa roots can start to struggle
Above 3000 kPa root growth will be restricted

Learning about CTF
Members of the UNFS continue to gain an understanding of soil compaction and CTF systems adopted by growers across Australia. Interstate bus tours, local field trips and guest speakers at UNFS events have been a great way to learn about CTF. These activities will continue in 2017.

Further information
ACTFA website
http://actfa.net/projects/
Further information: Chris Bluett –
chris.bluett@hrzconsulting.com

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Heavy trafficking gives rhizoctonia a head-ache

Author: Nigel Wilhelm (SARDI, Minnipa Agricultural Centre)

Funded by: GRDC project ACT00004 – Application of CTF in the low rainfall zone

Project Title: Application of Controlled Traffic Farming in the Low Rainfall Zone

Project Duration: 2015-2018

Project Delivery Organisation: SARDI

Key messages

- **Trafficking on wet soil in 2015 resulted in substantially less rhizoctonia in barley in 2016.**
- **After two years of cereal production, there is little evidence that heavy vehicle trafficking is severely depressing grain yield on a Minnipa soil.**

Why do the trial?
Adoption of Controlled Traffic Farming (CTF) in the low rainfall zone (LRZ) of the Southern Region is very low.

The GRDC-funded project 'Application of controlled traffic in the low rainfall zone' is evaluating whether or not this skepticism is justified. To help LRZ growers answer the questions and uncertainties they face when thinking about CTF adoption, the project is conducting research on four sites (R sites) across dominant soil types and agro-ecological zones in the Southern Region LRZ. These trials focus on the impact of trafficking (by heavy vehicles) on crop production and soil condition as well as monitoring how quickly LRZ soils will "self- repair" if heavy trafficking is stopped. Issues of implementing CTF and managing permanent wheel tracks are being addressed in other components of the project.

This article summarises the first two years of crop performance after trafficking was imposed on a red calcareous sandy loam at Minnipa Ag Centre (a detailed summary of 2015 results can be found in the 2015 Harvest Report). Three other trials similar in design and monitoring have also been implemented across the LRZ – on a deep sand at Loxton (SA), a brown loam near Swan Hill (Vic) and on a deep red earth at Lake Cargellico (NSW). All these trials will be maintained for at least the five year life of the project.

How was it done?
The R trials were designed and implemented to be the same at all four sites. Each trial consists of 5 treatments replicated 4 times:

1. Control (no heavy vehicle trafficking).
2. One pass of a 20 tonne vehicle prior to seeding when soil was dry.
3. One pass of a 20 tonne vehicle prior to seeding when soil was moist.
4. Three passes of a 20 tonne vehicle prior to seeding when soil was moist.
5. Deep ripping (to loosen any historical trafficking).

These passes were conducted with 50% overlap of the load bearing wheels to ensure even coverage and will not be re-imposed.

The trafficking treatments simulate the effect of compaction caused by trafficking of heavy vehicles, with three passes when the soil is moist as an extreme (soil is always softer when wet so compacts more for the same vehicle weight). A deep ripping treatment was included because we cannot be sure if there is still compaction from previous trafficking in our control areas and the ripping was designed to disrupt any of this historical compaction. Trials were located on farms with soils typical for their district and where wheel track patterns for the previous five years (at least) were the same and were identifiable. The trials are being seeded and managed with the farmers' equipment.

At Minnipa, trafficking treatments were imposed in April 2015, the wet passes and deep ripping following 30 mm of rainfall. Scepter wheat was grown in 2015. In 2016, Fathom barley was seeded on 19 May at 65 kg/ha and with 60 kg/ha of DAP without prior cultivation into good seeding conditions. The farm's Horwood

Bagshaw precision seeder (knife points) was used and 40 kg/ha of urea was top-dressed on all plots mid-season.

Crop performance was monitored at establishment, for early and late dry matter production and at maturity (grain yield, quality and yield components). Grain harvest was conducted by hand to avoid trafficking from a header on treated plots. Crops will continue to be seeded and managed with farm equipment for the next two years, rotation options to be the same as the rest of the paddock. Trafficking treatments will not be re-applied.

What happened?
Trafficking on dry soil in 2015 had little visual impact on the soil but three passes on wet soil depressed the soil surface by at least 5 cm. Ripping left the surface more cloddy than the control with the surface raised by at least 10 cm.

In 2015, performance of wheat was confounded by establishment issues: seeding depth after three trafficking passes on wet soil reduced seeding depth from 54 mm in the control to only 25 mm. Ripping resulted in seeding depth averaging 103 mm because the profile was so loose and the variability in placement was also higher.

Establishment of barley was much more even and consistent across all treatments in 2016. Ripping caused seed to be placed a little deeper than the control (56 mm vs 42 mm) and multi trafficking wet a little shallower at 34 mm (table 1). Plant populations were the same in all treatments and averaged 99 plants per sq m.

Dry matter production was similar across all treatments for most of the season in 2016 with the exception of ripping, where dry matter was 30-40% better than the control up until flowering. As the season progressed, rhizoctonia appeared in the trial as frequent and severe patches. Trafficking on moist soil had a marked impact on rhizoctonia severity with multi trafficking on moist soil (in 2015) reducing rhizoctonia from a score of 3.8 in the control to almost 1 (table 1). A single trafficking pass on moist soil (also in 2015) also reduced rhizoctonia substantially but trafficking on dry soil had similar disease to the control. Ripping appeared to cause a small reduction in rhizoctonia severity.

Trafficking on wet soil in the previous year substantially increased the yield of barley in 2016 (table 1), by more than 0.7 t/ha. Ripping and trafficking on dry soil resulted in grain yields similar to the control of 2.9 t/ha. Barley produced more grain after trafficking due to more fertile heads in the crop (table 1). The size of heads and grain were similar for all treatments. Grain proteins in 2016 were all high in the trial and similar to the control except for deep ripping which was more than 2% higher than the control (13.2%), suggesting that the crop after ripping had accessed N reserves which the control had not.

Grain yields of wheat in 2015 were similar for all treatments, except ripping which was lower.

Table 1. Performance of Fathom barley in 2016 after trafficking and ripping at Minnipa in 2015.

	Grain yield (kg/ha)	**Depth of seeding (mm)**	**Rhizoctonia severity (0: none, 5: severe)**	**Heads per sq m**	**No of grains per head**	**1000 grain weight (g)**	**Grain protein (%)**
Control	2923	42	3.8	353	21	39	13.2
Single trafficking on dry soil	3366	45	4.0	438	20	39	12.9
Single trafficking on wet soil	3773	42	1.8	458	21	39	12.8
Multi trafficking on wet soil	3696	34	1.3	459	21	39	13.1
Ripping	3284	56	2.3	449	19	39	15.4
LSD (5%)	*562*	*9*	*1.7*	*51*	*ns*	*ns*	*1.0*

What does this mean?
We have imposed three increasing levels of trafficking in all four R sites to investigate the sensitivity of crop production to compaction caused by heavy vehicles in typical LRZ situations. The deep ripping treatment is an attempt to remove any compaction already existing in our control areas due to historical traffic.

In this trial, in the first year of crop production following implementation of these trafficking treatments, wheat produced similar yields to the untrafficked control, despite seeding depth being shallower after the most extreme trafficking which also resulted in a lower plant population. These early results suggest that wheat is relatively insensitive to the compaction caused by heavy vehicles on this red calcareous sandy loam in a low rainfall environment, compared to the existing conditions in the paddock.

In the second crop after trafficking had been imposed, growth of barley was poorest in the control and rhizoctonia the most severe. Both forms of soil "conditioning", trafficking on wet soil and ripping, improved growth during the season and reduced rhizoctonia. The exception was trafficking on dry soil which has been very similar to the control throughout the two years of the trial so far. Wet trafficking finished very well in 2016, producing 30% more heads than the control and more than 0.7 t/ha of extra grain. Only part of this yield increase with wet trafficking was due to reduced rhizoctonia. Ripping and dry trafficking produced grain yields not very different to the control but protein levels in ripping were substantially higher than in any other treatment.

Of the other three trials, the two on lighter soils (typical of mallee environments) are also showing that little crop production is being lost with all but the most extreme trafficking treatment. However, on the heavy and deep red soil of southern NSW, crop production has been severely depressed by any trafficking.

This trial will be continued for the next two years at least and we will continue to monitor the impact of trafficking imposed in 2015 on subsequent crop production and soil condition. So far, there is little direct evidence that relieving current levels of compaction by ripping treatment will improve crop production on Minnipa soil.

Acknowledgements
Thanks to MAC farm staff for the implementation and management of the R site and to Ian Richter and Naomi Scholz for undertaking the monitoring of crop performance and soil condition. GRDC is the major funder of this project, which is managed by the Australian Controlled Traffic Farming Assocation.

Location: Minnipa Agricultural Centre
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
Yield
Potential: 6.0 t/ha (B)
Actual: 3.7 t/ha
Paddock History
2013: Medic pasture
2014: Medic pasture
2015: Scepter wheat
Soil Type
Calcareous Red sandy loam
Plot Size
50 m x 3 m x 4 reps

Controlled traffic – two contrasting seasons

Author: Helen McMillan (Central West Trials Agronomist)

Funded by: GRDC project ACT00004

Project title: Application of CTF in the low rainfall zone

Project duration: 2015-2018

Project delivery organisation: CWFS

Key points from R-Sites:

- **New research is exploring whether CTF has merit when practiced under low rainfall conditions.**
- **At the CWFS R-site, data after year 1 showed significant decline in yield, increased protein and screening with increased trafficking**
- **After its 2nd season, yield differences were less notable, but may have been non-responsive due to increased rainfall events.**

Background

In the Southern Region low rainfall zone (LRZ), the practice of controlled traffic farming (CTF) is very low. To investigate the merits of CT farming in our environment has led to our participation in a GRDC funded project administered by the Australian Control Traffic Farming Association (ACTFA). CWFS has partnered with Agriculture Victoria, SARDI, and SPAA to host a research site that explores whether there are any significant crop and soil changes that might be caused by trafficking. The results of this project will provide growers with greater economic data to evaluate the value of adopting CTF.

As well as the Lake Cargelligo site managed by CWFS, the project is collaborating with other farmer groups to obtain research results that are representative of the dominant soil types and agro-ecological zones in the Southern Region LRZ including: a red calcareous sandy loam at Minnipa (SA), a deep sand at Loxton (SA) and a brown loam near Swan Hill (Vic).

Issues of implementing CTF and managing permanent wheel tracks are being addressed in other components of the project.

Co-operator:
Derek Davis

Soil type:
Deep red earth

Crop:
2015 Gladius wheat
2016 Gladius wheat
2017 Field peas

Treatments

Across all the project R-sites, four treatments, including a control, were imposed to represent light, medium, and heavy trafficking. This was undertaken using a tractor towing a fully laden trailer (8 tonne) with 50% overlapping of tyre tracks to ensure even coverage:

1. Light trafficking – one pass when soil was dry
2. Medium trafficking – one pass when soil was moist
3. Heavy trafficking – three passes when soil was moist
4. Control – nil traffic

The treatments were replicated 4 times and the trafficking was imposed only once, prior to sowing in 2015.

Results

The effectiveness of the treatments was assessed with estimates of bulk density. These appear to show that the "High" trafficking treatment compacted the soil but this effect was only shallow, while the other treatments only made small increases in bulk density (Fig. 1). More precise measurements are being analysed.

The 2015 rainfall season followed long-term trends, whereas 2016 recorded one of the wettest years for Lake Cargelligo, with an annual rainfall almost double the long-term average (Fig. 2).

In 2015 trafficking treatments reduced yields and increased screenings (Table 1). These lower yields were also associated with higher protein levels.

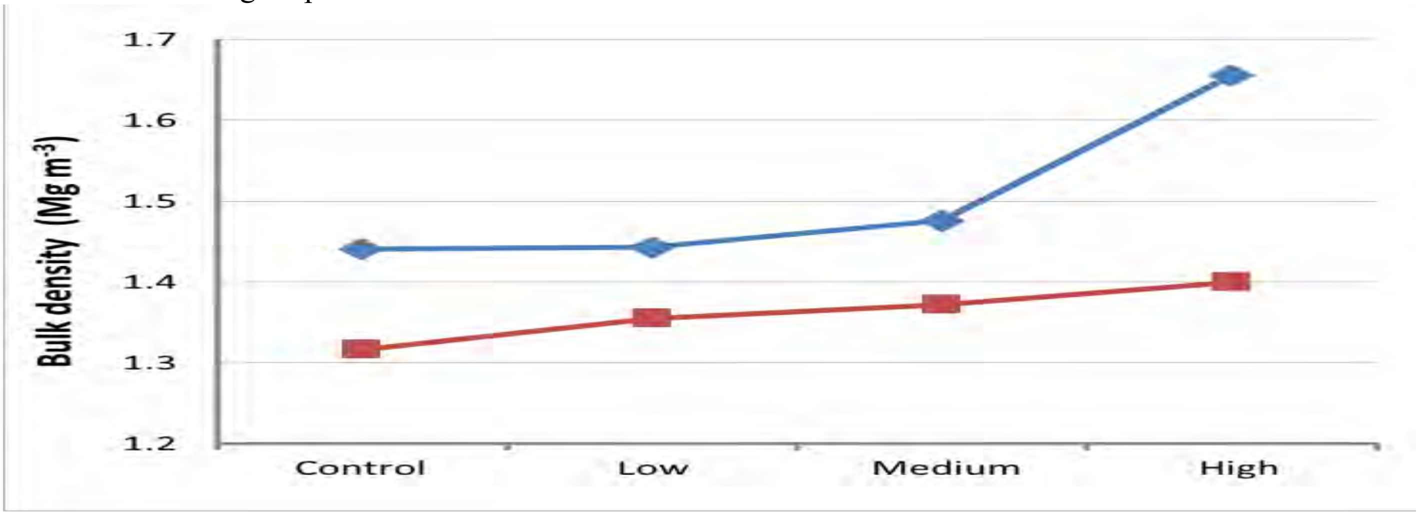

Figure 1. Bulk density at Lake Cargelligo for 0-10 cm (blue diamonds) and 20-30 cm (red squares) for the treatments: Control. Low trafficking, Medium trafficking, and High trafficking.

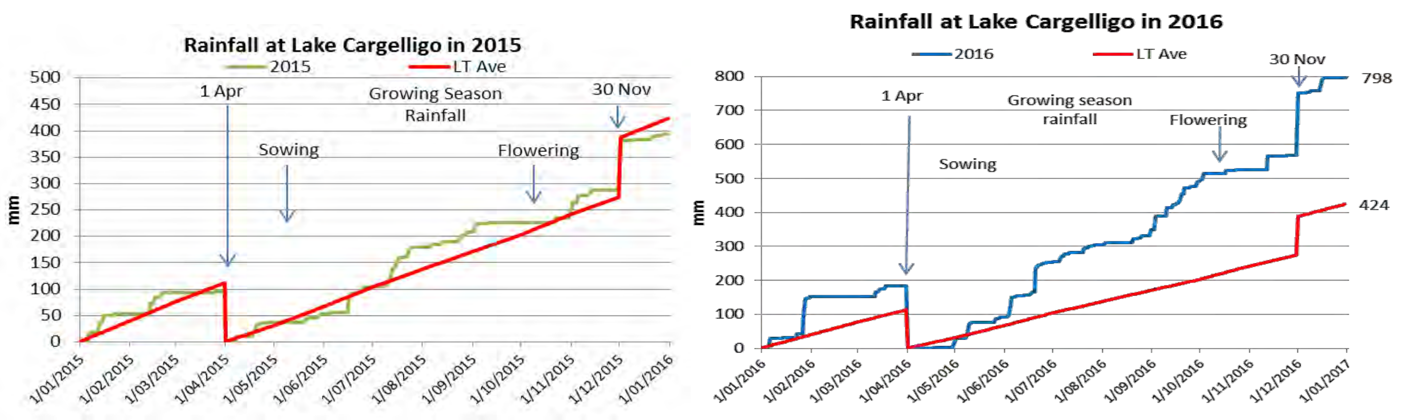

Figure 2. Cumulative rainfall for year and long-term average (red). The cumulative values have been adjusted to zero at the start of the growing season (1 April), and adjusted back to whole of year amount at the end of the growing season (30 Nov).

The increased rainfall in 2016 led to a 32% yield rise in the Control treatment compared to 2015. In contrast to 2015, trafficking treatments did not decrease yields but appeared to have increased yields, although this yield increase was only statistically significant for the "Low" and "Medium" trafficking treatments. Screenings were low across all treatments in 2016.

	2015 Gladius wheat			
Trafficking	Dry matter (t/ ha)	Yield (t/ha)	Protein (%)	Screenings (%)
None	6.96 [a]	2.53 [a]	10.5 [a]	4.0 [a]
Low	6.84 [a]	2.28 [ab]	10.6 [a]	4.8 [ab]
Medium	6.39 [a]	1.77 [bc]	11.8 [b]	7.0 [ab]
High	4.52 [b]	1.50 [c]	14.5 [c]	10.9 [b]

Numbers with different letters denote significant difference (P=0.05)

	2016 Gladius wheat			
Trafficking	Dry matter (t/ ha)	Yield (t/ha)	Protein (%)	Screenings (%)
None	8.15 [a]	3.35 [a]	8.6 [a]	0.6 [a]
Low	9.80 [b]	4.13 [b]	8.6 [a]	0.6 [a]
Medium	9.12 [ab]	4.00 [bc]	9.0 [a]	0.6 [a]
High	8.61 [ab]	3.65 [ac]	8.9 [a]	0.7 [a]

Numbers with different letters denote significant difference (P=0.05)

Discussion

Lake Cargelligo

The trafficking treatments were imposed prior to seeding in 2015 and appear to have a big impact on the following season's yields.

The three trafficking treatments were developed to reproduce the key conditions that affect the amount of compaction for a specific axle load. These are: i) the soil water content during trafficking, and ii) the number of trafficking passes.

The "Low" trafficking treatment may represent minimum soil damage caused by a heavy vehicle as it used only a single pass when the soil is dry and therefore most rigid. This might represent conditions at harvest time.

The "Medium" treatment also involved only a single pass but when the soil was moist and therefore of lower strength. In 2015, the region saw a mere 23mm in the three days prior to treatment which may not have been enough to cause significant compaction down the soil profile. Even so this treatment may still be representative of soil conditions at sowing time for this region.

The "High" treatment was also under the same moist conditions (imposed on the same day) but had three passes of overlapping tyre tracks instead of one. This was intended to represent severe trafficking that might occur after several years of random traffic. It is only this treatment that made large differences to the observed bulk density measurements, albeit only at a shallow depth. Greater soil damage may have occurred if the treatments had been imposed during wetter conditions.

Dry matter production in 2015 reflected the observed change in shallow bulk density measurements, with small decreases in dry matter for the "Low" single pass treatments but a large decrease for the "High" trafficking treatment. Grain yield in 2015 was impacted by the treatments, with a 40% (1 t/ha) yield difference recorded between the control and "High" trafficking. This yield trend combined with the pattern of increased screenings would have a large financial impact.

Season 2016 saw no yield decline, but rather the one-pass treatments ("Low" and "Medium") had a statistically significant increase in yields compared to the "Control" treatment. No change in yields due to the trafficking treatments could be due to: i) the very wet conditions in 2016 removed any soil constraints, particularly plant available water, or ii) that the constraints caused by the treatments that were applied before sowing in 2015 had been removed by natural or machinery processes. The paddock has been sown to field peas for 2017 and will be sown to wheat in 2018. The variation in results from 2015 to 2016 demonstrates the importance of repeating such experiments over a few years to have confidence in the results and recommendations.

Other R-sites summaries

Three other research sites have been established to provide greater clarification to the practice of CTF in the low rainfall zone, with each site on a different soil type. All sites have had identical trafficking treatments to the CWFS site, although the machinery used was different in every case. The long-term average rainfall at the other sites (270 – 340 mm) is less than Lake Cargelligo and the sites have sandier soils which have responded differently to the trafficking treatments.

In 2015, the growing season rainfall was average at Minnipa but below average at Loxton and Swan Hill. The trafficking treatments had no effects on yield at Minnipa, but the yields in the “High” trafficking treatment were reduced by over 28% at Loxton and Swan Hill.

In 2016 growing season rainfall was slightly above average at all Loxton, Minnipa and Swan Hill. The “High” trafficking treatment reduced yields by 20% at Loxton. The Minnipa site was badly affected by *Rhizoctonia* which affected the wet trafficking treatments less than the other treatments. Grain yields were not affected by trafficking treatments at Swan Hill.

Conclusions

Large, and economically important, yield declines were found at Lake Cargelligo in the first year following imposed trafficking treatments, with up to 1 t/ha decline recorded for the “High” trafficking treatments. Over 28% yield declines were also found for this treatment at 2 of the other 3 sites although due to generally low yields this was less than a quarter of a tonne per hectare. At all sites the “Low” trafficking treatment had no effect on yields. In the second year, a yield decline was only found at the Loxton site for the High trafficking treatment (20%). At some sites the trafficking treatments resulted in an unexplained yield increase which requires further research and validation.

Acknowledgments

The project team would like to thank the support of the co-operating farmers for their in kind contributions, support and enthusiasm to undertake these trials.

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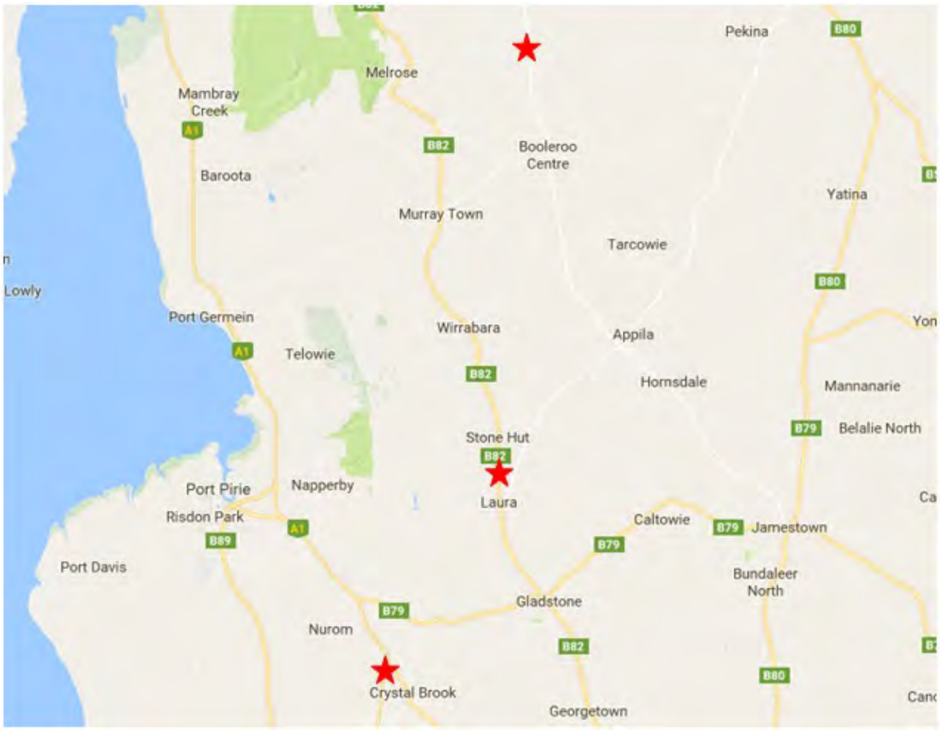
CWFS
Central West Farming Systems Inc.

2016 National Variety Trials

In 2016 a series of National Variety Trials were conducted in the Upper North region at Booleroo Centre (wheat), Laura (lentil, faba bean, field pea) and Crystal Brook (barley, oats).



Crop varieties were analysed for their predicted yield and receival standards. Some of the highest yielding varieties are highlighted in the following table.

To view the full results of the trials, please visit http://www.nvtonline.com.au/

Crop	Variety	Predicted
Wheat	Trojan	5.32
	Cobra	5.19
	LRPB Arrow	5.16
	Beckom	5.14
	Scepter	5.13
Lentil	Nugget	3.46
	PBA Hurricane XT	3.37
	PBA Flash	3.35
	PBA Bolt	3.27
Faba Bean	PBA Zahra	6.32
	Fiesta VF	6.07
	PBA Samira	5.95
	Farah	5.87
	Nura	5.8

Crop	Variety	Predicted
Field Pea	PBA Percy	3.72
	PBA Oura	3.41
	PBA Pearl	3.4
	Parafield	3.27
	PBA Wharton	3.18
Barley	RGT Planet	6.85
	Maltstar	6.32
	Alestar	6
	Explorer	5.87
	Rosalind	5.86
Oats	Bannister	6.44
	Echidna	6.3
	Potoroo	5.87
	Williams	5.86
	Wombat	5.54

UNFS Membership List 2016-2017.

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Appendix : UNFS Stubble Initiative Guideline Produced in 2016

Images from our events and activities in 2016

Upper North Farming Systems

Stubble Management Guidelines

Flaxleaf fleabane

Flaxleaf fleabane is emerging as a challenging weed in no-till stubble retention cropping systems. Photo: Ruth Sommerville, UNFS

Key facts

- Recent changes to farming systems, primarily the widespread use of chemicals for summer weed control, has seen Flaxleaf fleabane (*Conyza bonariensis*) become more prolific in no-till stubble retention (NTSR) systems across South Australia.
- Young (one month or less) plants can be easily controlled with herbicides but when plants have developed strong root systems, chemical control becomes more difficult.
- Effective broadacre control of fleabane requires an integrated weed management (IWM) approach, using chemical and non-chemical control techniques such as grazing or strategic cultivation.

Flaxleaf fleabane (*Conyza bonariensis*) has been a problem weed across Queensland and northern New South Wales cropping regions for many years, but has only recently emerged as a difficult-to-control weed in South Australia and Victoria.

Fleabane is a surface-germinating weed previously controlled by a combination of cultivation, sulfonylurea (SU) herbicides and grazing, but is emerging as a major challenge in no-till stubble retention (NTSR) farming systems. It has been present in many areas of SA as a summer weed along roadsides and around yards, but has not caused problems in cropping paddocks until recently.

Individual fleabane plants can produce up to 120,000 small, light-weight seeds, which can be dispersed by strong winds with about one per cent of seed travelling 10km or more. Managing seed levels can be difficult as neighbouring paddocks, roadsides and non-arable areas can be a continual source of new infestation.

Fleabane thrives in NTSR farming systems as the seeds are not deeply incorporated, with most seeds germinating from the top 1cm of soil. Fleabane emerges when air temperatures are between 10–30ºC, with optimal temperatures between 20–25ºC. Provided there is adequate moisture, plants will germinate in crops and pastures from late August through to November.

Controlling fleabane during the summer fallow is important for conserving soil moisture. Research in SA has proven that effective fleabane control during summer can result in significant soil moisture being retained for following crops (Figure 1).

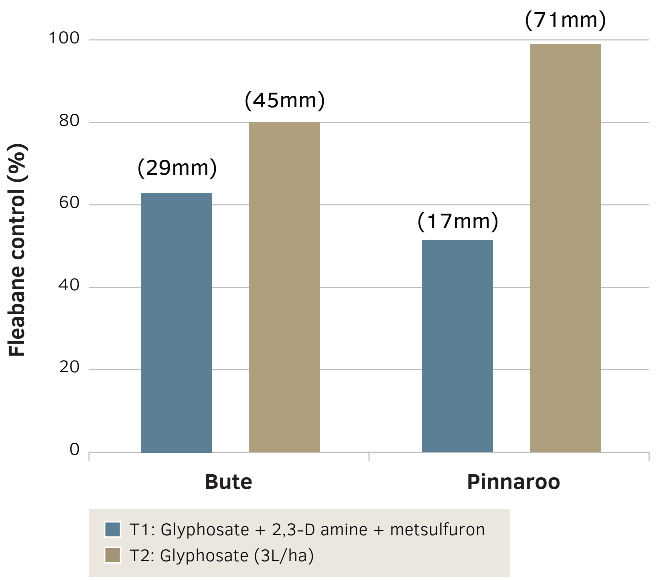
Project information

This Flaxleaf fleabane management guideline has been developed for the Upper North Farming Systems Group (UNFS) as part of the Maintaining Profitable Farming Systems with Retained Stubble Initiative, funded by the Grains Research and Development Corporation (GRDC UNF00002).

The Stubble Initiative involves farming systems groups in Victoria, South Australia and southern and central New South Wales, collaborating with research organisations and agribusiness, to address challenges associated with stubble retention.

The GRDC, on behalf of growers and the Australian Government, is investing $17.5 million in the initiative that has been instigated by the GRDC Southern Regional Panel and the four Regional Cropping Solutions Networks that support the panel.

Figure 1. The effect of fleabane control on residual soil moisture



Note: *Fleabane control as a percentage at each site (Bute and Pinnaroo) is displayed in the columns, with saved soil moisture shown in brackets at the top of each column. Soil moisture was measured to a depth of 1.2m.*

Source: Fleet B and Gill G, (2013) Fleabane ecology and control in cropping systems of southern Australia, University of Adelaide, GRDC Adviser Update

Integrated approach critical to control

While fleabane presents a serious and costly weed challenge, GRDC-funded research has shown that a strategic approach using integrated weed management (IWM) can significantly reduce the weed's impact on crop production.

Fleabane has a natural tolerance to the uptake of herbicides due to fine, dense hairs on the leaf surface and a thick cuticle (leaf surface). Populations of fleabane resistant to glyphosate have been found in SA, NSW and Queensland, earning fleabane the title of Australia's first glyphosate-resistant broadleaf weed.

When treated early (one month old or younger) glyphosate can control susceptible fleabane plants. When mature however, the weed is difficult to control with glyphosate, regardless of its resistance status (Figure 2).

Individual fleabane plants can produce up to 120,000 small, lightweight seeds. Photo: Ruth Sommerville, UNFS

Control is often made more difficult as plants are sprayed post-harvest during summer, when they are well established and spray conditions are often sub-optimal.

University of Queensland researcher Dr Steve Walker says the key to getting on top of fleabane is to attack all parts of the weed's life cycle to keep the seedbank low. Adopting an IWM strategy, which includes chemical and non-chemical tactics, will result in substantially fewer fleabane problems and dwindling resistant populations in subsequent seasons.

Pre-harvest chemical control options

A range of pre-emergent and in-crop products can help control earlier-emerging fleabane plants. Based on experience from Northern NSW, pre-emergent herbicides such as trisulfuron (e.g. Logran®), metribuzin, simazine, terbuthylazine (Terbyne®), and isoxaflutole (Balance®) all have some activity on fleabane. In-crop applications of 2,4-D amine, metsulfuron (e.g. Ally®) and clopyralid (e.g. Lontrel®) are effective in controlling newly-emerged and younger fleabane plants.

Post-harvest chemical control options

Most research to date has focussed on fleabane control during summer, after the crop has been harvested and fleabane plants have started to elongate. At this stage fleabane has a well-developed root system and as it progresses towards maturity it becomes more difficult to control with herbicides.

Figure 2. Fleabane becomes increasingly difficult to control with herbicides as the plant matures

First seedling leaves almost round and hairy.

Best control stage

Later leaves are oval with toothed margins.

Best control stage

Flowers in a terminal pyramid-shaped cluster with white to pale pink hairs.

Difficult stage to control

Mature plants hairy, often branched at the base and up to 70cm high

Difficult stage to control

A range of herbicide options for fleabane control during summer are shown in Table 1.

In this study, high rates of glyphosate (3–4L/ha) provided excellent control even when a second knock was not implemented. However, using glyphosate alone may be a short-lived strategy, as resistant populations of fleabane continue to emerge.

TABLE 1. Herbicide efficacy on fleabane at Bute and Pinnaroo, summer 2012

Herbicide treatment	Fleabane control (%)	
	First knock	Second knock
Untreated	0	36
Glyphosate (570g/L) @ 1L/ha	30	54
Glyphosate (570g/L) @ 2L/ha	55	82
Glyphosate (570g/L) @ 3L/ha	89	95
Glyphosate (570g/L) @ 4L/ha*	93	97
Glyphosate (570g/L) @ 1L/ha + 2,4-D amine (700g/L) @ 1.1L/ha	50	87
Glyphosate (570g/L) @ 1L/ha + 2,4-D amine (700g/L) @ 1.1L/ha	50	84**
Glyphosate (570g/L) @ 1L/ha + metsulfuron (600g/kg) @ 5g/ha	50	73
Glyphosate (570g/L) @ 1L/ha + 2,4-D amine (700g/L) @ 1.1L/ha + metsulfuron (600g/kg) @ 5g/ha	57	91
Glyphosate (570g/L) @ 1L/ha + 2,4-D amitrol (250g/L) @ 2.8L/ha	63	80
Glyphosate (570g/L) @ 1L/ha + 2,4-D dicamba (500g/L) @ 0.5L/ha	46	69
Glyphosate (570g/L) @ 1L/ha + 2,4-D dicamba (500g/L) @ 1L/ha	58	91
Glyphosate (570g/L) @ 1L/ha + 2,4-D carfentrazone (400g/L) @ 45mL/ha	32	53
Glyphosate (570g/L) @ 1L/ha + 2,4-D saflufenacil (700g/L) @ 18g/ha***	29	45
Glyphosate (570g/L) @ 1L/ha + 2,4-D amine & picloram (300g/L & 75g/L) @ 0.7L/ha	50	97
Glyphosate (570g/L) @ 1L/ha + clopyralid (300g/L) @ 0.3L/ha	42	69
P<0.001 LSD = 10.934		

Second knock herbicide application was paraquat (250g/L) @ 2.4L/ha. The surfactant LI700 @ 300mL/ha was used with all herbicide treatments except where indicated.

** Only at Bute site*

*** Second knock was fluroxypyr (400g) @ 400mL/ha*

**** Bonza surfactant used instead of LI700.*

The above treatments are for research purposes and some may not be registered.

Final assessments (April 2012) on % control for main herbicide treatment alone (first knock), and with the addition of a subsequent paraquat application (plus second knock). Data was pooled from the sites. Bute site: knife roller 11 January 2012, first knock 12 January 2012, second knock 9 February 2012. Pinaroo sites: knife roller and first knock 1 February 2012, second knock 1 February 2012.

Source: Fleet B and Gill G, (2013) Fleabane ecology and control in cropping systems of southern Australia, University of Adelaide, GRDC Adviser Update

***Note:** Some common product names for chemistry used in these trials.*

Metsulfuron	e.g. Ally™
Amitrole	e.g. Amitrole®
Carfentrazone	e.g. Hammer®
Saflufenacil	e.g. Sharpen®
Clopyralid	e.g. Lontrel®
Picloram	e.g. Tordon™ 75-D
Fluroxypyr	e.g. Starane®

These trials showed that fleabane control was significantly better where a second knock of paraquat was applied, particularly when the first herbicide application provided at least 50 per cent control or better.

Achieving 100 per cent control with herbicides during summer can be expensive. Spray grazing or the use of precision spray technologies (i.e. WeedSeeker™ or WEEDit™ systems) will help reduce herbicide costs.

Non-chemical control options

Crop competition

» As a seedling, fleabane is a poor competitor. Increased crop competition from cereals using higher sowing rates and narrow row spacings can suppress growth and weed seed production.

Strategic tillage

» Strategic soil disturbance is an effective option to control fleabane in areas of high infestation or going into a crop with limited in-crop control options.

Grazing

» Grazing and spray grazing are effective tools to control fleabane as the plant is palatable to both sheep and cattle.

Integrated approach offers effective fleabane control

Barry Mudge, Port Germein

Fleabane has become an important summer weed on the sandy-loam cropping soils north of Port Pirie, where the storage of out-of season-moisture through effective summer weed control is given the highest priority.

According to Barry, fleabane is one of a number of weeds that are becoming increasingly difficult to control by conventional (chemical) means alone.

The Mudge Family has found a combination of grazing (fleabane is quite palatable to stock), chemical control and, as a last resort, the use of low-disturbance chisel sweeps or a blade plough will give effective control.

Barry has found glyphosate-based sprays, even at rates of up to 4L/ha to be fairly ineffective against fleabane. He also suggests it is essential to follow-up with a second knock of paraquat, one week to 10 days after the initial glyphosate application, which can become an expensive exercise.

In fleabane-susceptible paddocks, Barry recommends maintaining high levels of surface cover to allow integrated weed control measures to be implemented without risking soil erosion.

Fleabane infestations on roadsides have contributed to the burgeoning weed seedbank across much of SA's cropping areas. Photo: GRDC

Further information

» **GRDC website: https://grdc.com.au/Resources/IWMhub/Section-8-Profiles-of-common-weeds-of-cropping/Flaxleaf-Fleabane**

» **Barry Haskins on fleabane: https://www.youtube.com/watch?v=YYgZKzNeOIc**

» **www.qaafi.uq.edu.au/content/Documents/weeds/IWM-Fleabane-guide.pdf**

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