UNFS

Upper North Farming Systems

2015

RESULTS

UPPER NORTH FARMING SYSTEMS ANNUAL RESEARCH AND EXTENSION COMPENDIUM

CONTENTS

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Collation and editing of this report was undertaken by Rufous and Co on behalf of the Upper North Farming Systems Group.

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, 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
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A Message from the Chair

We are pleased to provide this compendium of 2015 trial results and related issues relevant to farming in the Upper North.

Locally, the 2015 season was somewhat of a mixed bag, although results generally were quite reasonable and continued the run of better type seasons which have been experienced in the Upper North region in the past several years. Rainfall in the early and mid-parts of in the growing season in the majority of locations was at least Decile 5 and in some instances (particularly in the north east) was well above average. Generally, crops were sown early. With seasonal conditions remaining favourable during winter, yield potential was high, although the forecast of an El-nino weather pattern had concerns being expressed on its potential impact on spring rainfall. This subsequently manifested itself in a dry September which was followed by a very hot period in early October. Crops west of the ranges were generally sufficiently advanced prior to the hot spell to protect yield potential, whereas the slower development of crops east of the ranges saw them more exposed to this adverse weather and reduced yields and grain quality were commonplace.

The Upper North Farming Systems group has undergone significant change in recent times as it has evolved into a farmer driven autonomous body. We have continued to work on our strategic plan over the past year, following the holding of an initial workshop in Melrose in early 2015. 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.

The UNFS has also undertaken a change in structure in the past year by establishing an Operations Committee to overview project delivery with governance remaining under the control of the Strategic Board. As part of this change, we have re-implemented a hub model which sees groups of farmers in a district working collaboratively to address issues specific for their location. Many thanks go out to the farmers who have agreed to take up the leadership role for their local groups and be a part of the Operations Committee.

Part of the change in structure over the past 12 months also saw the appointment of a part time Finance and Administration Officer to handle the group's administration requirements. My thanks go to Sara Clark (initially) and now Mary Timms for their excellent work in this area.

Projects being undertaken by UNFS have continued to evolve during 2015/16. Our flagship project remains the GRDC funded "Stubble Initiative" with a number of key milestones being met through the year including the production of a range of important guidelines outlining key management requirements for profitable farming in stubble retained systems. A recent stop/go review of this project by GRDC saw confirmation of funding through to the completion date of 2018. GRDC remains a vital collaborator with UNFS and we were pleased to welcome the Southern Panel into our district in September, 2015 for a mutual discussion on key issues relevant for our region.

We have been successful in achieving funding for a number of other projects over the past 12 months. These include SA Grains Industry Trust funding for a Time of Sowing trial at Booleroo Centre to continue of important work of improving our understanding of the conflict between frost and spring heat as important yield drivers. Ongoing projects include work looking at reducing our dependence on chemicals to control weeds in our systems, and identifying benefits of controlled traffic systems.

I would like to take this opportunity to thank our sponsors for their support over the past year. These include Rabobank, Graingrowers, Emerald Grain, Suncorp, Northern Ag, David Hill (MGA Insurance Brokers), Centre State Grain, Flinders Machinery, National Australia Bank and PCT. We welcome new sponsorship proposals. As an example, we are pleased to welcome Graincorp and EPIC as sponsors for our Yield Prophet project in 2016.

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 and our hard working Executive Officer and Project Manager, Ruth Sommerville. 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 2015

(including projects undertaken in the 2014-2015 FY)

UNFS Project #	Other Names/ References	Full Name	Funding Source	Project Manager
201	Crop Sequencing	Profitable Crop sequencing in the low rainfall areas of South Eastern Australia	GRDC through SARDI	Micheal Moodie
204	Carbon Project/ UNFS Increase and Maintain Soil Carbon	Perennial Pasture Management Systems for Soil Carbon stocks in cereal zones, SA. Action on the Ground (AOTGR1-44)	DAFF	Jodie Reseigh
209	Yield Prophet	Yield Prophet in the Upper North	Emerald Grain / UNFS	Barry Mudge
210	Nitrous Oxide	Efficient Grain Production compared with N20 Emissions	Birchip	Micheal Wurst
211	GRDC Stubble Initiative	Maintaining Profitable farming systems with retained stubbles in Upper North SA	GRDC	Ruth Sommerville
212	2014 Low Rainfall Bus Trip	Eastern Low Rainfall Zone Bus Tour. Industry Development Award 2013 IDA10772	GRDC	Matt McCallum, Joe Koch
213	2014 Annual Field Day	GCS10778 - Conference Sponsorship - UNFS - Annual Field Day	GRDC	Ruth Sommerville
214	Overdependence on agrochemicals	Overdependence on agrochemicals	GRDC/CWFS	Barry Mudge/ Amanda Cook (SARDI)
215	Spot spray Weed Technology	More Effective weed control and reducing pesticide use in broadacre landscapes by using optical sensing devices to detect and "spot spray" weeds	NRM Board Community Grant Program 2014/2015	Matt McCallum
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

Upper North Farming Systems 2015

Event Summary

Date	Event	Location	Participants	Details/Topics
19-03-15	UNFS Precision Agriculture Field Day and Trade Show	Orroroo	70	15 trade exhibitors with a 15min time slot in the AM. Non-commercial presentations in the PM. Livestock and cropping focus. Case studies, technology and how to implement.
22-23/02/15	UNFS Strategic Planning	Melrose	18	
22-03-15	UNFS Members Dinner and WUE Project Windup	Melrose	22	
26-03-15	UNFS Farming Sustainably Field Day	Crystal Brook	28	Bees, pollination and insectides, Buffel Grass, Native Vegetation Legislation, Launch of Onion Weed Fact Sheet, Climate Variability/Challenge, Spot Spraying Technology, Native Grass Harvest and Seeding, Soil Carbon, Organic Matter and Productivity.
06-08-15	UNFS Annual Members Expo	Booleroo Centre	85	Harvest Height impacts - Sarah Noack, Hart FS. Crop Rotation - Michael Moody, MSFG. Models of Sheep Production Farmer Panel. Time of Sowing & N management, Barley - Kenton Porker, Adelaide UNI. Stubble Initiative Guidelines - Ruth Sommerville. Living Flinders Project - Danny Doyle, NYNRM. Livestock Nutrition and Grazing Stubbles - Hamish Dickson, AgriPartner Consulting (MMFS Funded), Controlled Traffic - Randall Wilksch and Matt McCallum.
10-09-15	UNFS Eastern Spring Crop Walk	Booleroo - Melrose - Orroroo	47	Seeding Systems: their set up and implications for stubble handling, management and plant establishment. Jack Desboilles, UNI SA. Post Pasture Sowing Demonstrations: Peter Baker for UNFS, Rust Outbreak Update: Matt Foulis for UNFS, Soil Parameters and Management: Mary-Anne Young. Crop Rotations - Vetch Varieties: Stuart Arbon, SARDI.
15-16/09/15	GRDC Southern Panel Tour of UNFS activities		16	
23-09-15	UNFS/Nelshaby Ag Bureau Western Crop Walk	Nelshaby, Baroota, Wanderah, Butlers Bridge	28	Barley Grass Overdependance on Agrochemicals Farm Trial, Pt Germein. Time of Sowing, CSIRO James Hunt, Baroota. Alternative grain legume choices- Baroota. New shearing shed at Butlers Bridge, New Barley Varieties, Sandy Soil issues at Wanderah,
02-10-15	MMFS/UNFS Sheep Nutrition Workshop	Appila	16	Follow on from Stubble Grazing Workshop at Annual Field Day. Investigating feed-lotting to prevent soil erosion and loss of condition over summer. Other nutrition basics.

UNFS 2014/2015 Financial Year Reports

UNFS 2014/2015 Unaudited Financial Year Report - General Operating

Audited Financial Statements for the 2014/2015 financial year were not available at the time of printing of the UNFS Annual Results Book. The unaudited financial information set forth below is preliminary and subject to adjustments and modifications. Adjustments and modifications to the financial statements may be identified during the course of the audit work, which could result in differences from this preliminary unaudited financial information**.**

DRAFT PROFIT AND LOSS STATEMENT
FOR THE YEAR ENDED 30 JUNE 2015

	2015	2014
	$	$
INCOME		
Project Administration Charges		
Carbon Account	3,000.00	3,000.00
Perenniels Account	4.06	0.00
Grazing Account	0.79	0.00
Low Rainfall Bus Trip	850.00	0.00
Fodder Account	7,230.00	1,605.00
Nitrous Oxide	0.00	1,000.00
	11,084.85	5,605.00
Project Income		
Group	2,061.89	0.00
Crop Sequencing	75,000.00	0.00
Better Surface Under Grazing	0.00	30,036.36
Lower Rainfall Bus Trip	2,727.26	10,890.00
Yield Prophet	1,200.00	3,500.00
Field Days	8,000.00	2,718.18
Zoning	9,000.00	13,000.00
Onion Weed	9,700.00	0.00
Spot Spray Weed Tech	9,500.00	0.00
Post Stubble Demo	18,700.00	0.00
Controlled Traffic	717.75	0.00
Nitrous Oxide	0.00	11,650.00
GRDC Stubble Initiative	130,200.00	130,643.24
	266,806.90	202,437.78
Hire of Plant	181.82	4,220.00
Interest Received	3,363.72	1,900.10
Sponsorship	7,000.00	136.36
Subscriptions	6,330.78	736.33
TOTAL INCOME	294,768.07	215,035.57

DRAFT PROFIT AND LOSS STATEMENT - CONTINUED
FOR THE YEAR ENDED 30 JUNE 2015

	2015	2014
EXPENSES		
Advertising & Promotion	0.00	0.00
Bank Charges	90.00	124.68
Finalise Projects		
Fodder Shrub Systems Project	0.00	130.60
Perennial Pasture Project	0.00	3,702.02
	0.00	3,832.62
Project Costs		
Group Management	32,903.65	0.00
Crop Sequencing	0.00	14,545.45
Field Days	11,473.51	0.00
GRDC Stubble Initiative	62,400.76	68,195.11
Lower Rainfall Bus Trip	17,414.53	0.00
Yield Prophet	6,200.00	2,465.00
Pasture Production Zoning	2,875.00	15,300.00
Overreliance on agrochemicals	240.00	0.00
Spot Spray Weed Tech	7500	0.00
Post Stubble Demo	4,596.90	0.00
Controlled Traffic	1,435.50	0.00
Nitrous Oxide	7,000.00	11,434.00
Onion Weed	3,145.00	3,050.00
	157,184.85	114,989.56
Management Fees		
Carbon Bank Account	6.00	12.00
Perrenials Bank Account	0.00	2.00
	6.00	14.00
Merchandise		1,831.37
Office Expenses	632.09	27.27
Publications	3,273.41	3,995.00
Minor Plant Purchases & Repair	0.00	4,148.95
Treasurer Expenses	3,452.73	3,520.91
TOTAL EXPENSES	164,639.08	132,484.36
OPERATING PROFIT & EXTRAORDINARY ITEMS	130,128.99	82,551.21
Retained Profits at July 1	103,917.10	21,365.86
PROFIT AVAILABLE FOR APPROPRIATION	234,046.09	103,917.07
RETAINED PROFITS	234,046.09	103,917.07

DRAFT STATEMENT OF FINANCIAL POSITION

AS OF 30 JUNE 2015

	2015	2014
CURRENT ASSETS		
CASH		
Bank SA Power Saver 443340	0.00	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	0.00	2,902.00
	240,434.09	98,599.07
OTHER		
GST Account	0.00	5,318.00
TOTAL CURRENT ASSETS	240,434.09	103,917.07
TOTAL ASSETS	240,434.09	103,917.07
CURRENT LIABILITIES		
GST Payable to ATO	6,388.00	0.00
TOTAL CURRENT LIABILITIES	6,388.00	0.00
TOTAL LIABILITIES	6,388.00	0.00
NET ASSETS	234,046.09	103,917.07
EQUITY		
Retained Profits	234,046.09	103,917.07
TOTAL EQUITY	234,046.09	103,917.07

The unaudited financial information set forth above is preliminary and subject to adjustments and modifications. Adjustments and modifications to the financial statements may be identified during the course of the audit work, which could result in significant differences from this preliminary unaudited financial information.

In the 2014/2015 Financial Year the Upper North Farming Systems Group operated one project outside of the general operating accounts; The Carbon Project (AOTGR1-44)(UNFS project #204). This is a requirement of the funding body. The unaudited financials showing the Income and Expenditure for the 2014/2015 and 2015/2016 financial years are provided below. The whole project was audited up to 31/12/2015 and these audited statements are provided on the following page.

CARBON ACCOUNT
DRAFT PROFIT AND LOSS STATEMENT
FOR THE YEARS ENDED 30 JUNE 2015 & 30 JUNE 2016

	2016	2015	2014
	$	$	$
INCOME			
Interest Received	496.28	1,471.11	5,800.96
Sundry Income	106.65	6.00	12.00
Grant Department of Agriculture, Fisheries & Forestry	19,999.55	79,955.45	174,727.00
	20,602.48	81,432.56	180,539.96
EXPENSES			
Bank Fees	0.00	0.00	30.00
Audit Fees	890.00	0.00	0.00
Administration Fee General Account	0.00	3,000.00	3,000.00
Project Expenses	44,673.00	256,008.56	142,716.50
	45,563.00	259,008.56	145,746.50
NET INCOME/(LOSS)	-24,960.52	-177,576.00	34,793.46

DRAFT BALANCE SHEET			
Opening Balance	26,472.65	204,048.65	169,255.19
NET INCOME/(LOSS)	-24,960.52	-177,576.00	34,793.46
EQUITY	1,512.13	26,472.65	204,048.65
ASSETS			
Bank SA	1,512.13	26,172.65	206,648.79
GST Adjustments (admin fee 2013)	0.00	300.00	300.00
GST Account	0.00	0.00	0.00
	1,512.13	26,472.65	206,948.79
LESS LIABILITIES			
GST Owed to General Account	0.00	0.00	2,900.14
	0.00	0.00	2,900.14
BALANCE	1,512.13	26,472.65	204,048.65
BALANCE AT CLOSE OF PROJECT	1,512.13		

Note: Project Balance of $1512.13 transferred to Freedom Account & Carbon Account closed on 05/07/2016.

The unaudited financial information set forth above is preliminary and subject to adjustments and modifications. Adjustments and modifications to the financial statements may be identified during the course of the audit work, which could result in significant differences from this preliminary unaudited financial information.

Audited Financial Statements for Carbon Project

Upper North Farming Systems

to end of Project 30/12/15

Perennial pasture management systems for soil carbon stocks in cereal zones, So

Income		
Interest Received	$	11,909
Sundry Income	$	28
Grant Department of Agriculture, Fisheries & Forestry	$	549,682
	$	561,619
Less Expenses		
Bank Fees	$	1,025
Administration Fee	$	10,300
Project Expenses	$	550,406
	$	561,731
Excess Expenditure over income	**-$**	**111**
Balance Sheet		
Opening Balance		0
Net Income/(Loss)	-$	111
Equity	**-$**	**111**
Liabilities		
BankSA	-$	111
Balance	**-$**	**111**

MID NORTH ACCOUNTING

INDEPENDENT AUDITOR'S REPORT

Project: Perennial Pasture Management Systems for Soil Carbon Stocks in Cereal Zones, South Australia

SCOPE

I have reviewed the Grantee's books, records and financial statements, including those relating to the receipt, holding, expenditure and commitment of the funding and other contributions.

AUDIT OPINION

In my opinion, the funding and other contributions were spent in accordance with the Budget & Funding Deed.

An income and expenditure statement and balance sheet for the period 15 June 2012 to completion of project in 2015 is attached

Vonnie Lea
Certified Practising Accountant
17 421 006 397

Date: November 5 2015

LIABILITY LIMITED BY A SCHEME APPROVED UNDER PROFESSIONAL STANDARDS LEGISLATION

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Income and Expenditure by Project

On the following page is a Draft Cashflow detailing inflows and outflows of income and expenditure for each of UNFS Projects (both current and historical). This information is preliminary and subject to adjustments and modifications. Adjustments and modifications to the financial statements may be identified during the course of the audit work, which could result in significant differences from this preliminary unaudited financial information.

Jpper North Farming Systems: Cash Flow:6
19/02/2011 through 30/06/2016 (in Australian Dollars)

Category Description	101 Group Managment	103 Field Days & Tours	201 Crop Sequencing	202 Fodder Shrub Systems	203 Profit & Risk Management	204 Carbon	206 Better Surface Under Grazing	207 Zoning	208 Onion Weed	209 Yield Prophet	210 Nitrous Oxide	211 Stubble Initiative	212 Low Rainfall Bus Trip 2014	214 Overreliance on agrochemicals	215 Spot Spray Weed Tech	216 Controlled Traffic	217 Post Stubble Demo	219 Ladies on the Land Workshops	301 Perennials	302 Pasture Production Zoning	305 Grain & Graze 2	306 Retired Projects	OVERALL TOTAL
INFLOWS																						
EQUIPMENT HIRE	5,420.00	181.82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,601.82
EVENTS	0	13,600.00	0	0	0	0	0	0	0	0	0	0	0	0	0	500	0	0	0	0	0	0	14,100.00
FINANCIAL MANAGEM	438,153.88	1,000.00	0	19,605.58	4,800.00	25	400	0	0	0	0	0	0	0	0	0	0	0	3,048.87	379.55	0	1,072.38	468,485.26
INTEREST	8,573.68	0	0	2,341.14	0	12,130.13	0	0	0	0	0	0	0	0	0	0	0	0	1,394.81	0	0	0	24,439.76
MEMBERSHIP	19,781.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19,781.33
MERCHANDISE	45.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45.45
PROJECT ADMINISTRA	47,291.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600	0	0	0	47,891.29
PROJECT INCOME	75,513.88	17,668.19	164,800.00	297,000.00	20,000.00	549,682.00	86,000.00	32,000.00	9,700.00	4,700.00	22,550.00	260,400.00	17,247.26	10,000.00	9,500.00	1,317.75	18,700.00	6,600.00	157,270.00	0	20,727.27	16,314.42	1,797,690.77
SPONSORSHIP	1,272.72	4,568.18	0	0	0	0	0	0	0	15,500.00	0	443.24	0	0	0	0	0	0	0	0	0	0	21,784.14
Net GST	4,756.38	409.40	0.00	0.00	0.00	-1.06	0.00	1000	0.00	141.82	1,090.00	-272.61	363.00	0.00	0.00	30.38	0.00	660	0.00	0	0.00	0.00	8,177.31
TOTAL INFLOWS	600,808.61	37,427.59	164,800.00	318,946.72	24,800.00	561,836.07	86,400.00	33,000.00	9,700.00	20,341.82	23,640.00	260,570.63	17,610.26	10,000.00	9,500.00	1,848.13	18,700.00	7,260.00	162,313.68	379.55	20,727.27	17,386.80	2,407,997.13
OUTFLOWS																						
ADMINISTRATION	12,099.34	260	7,500.00	31,155.83	0	9,300.00	0	1,754.55	610	0	1,000.00	7,767.01	0	510	0	0	0	0	6,690.91	0	0	0	78,647.64
Advertising	0	152.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	152.95
ANNUAL FIELD DAY	0	0	0	0	0	0	0	0	0	0	0	221.82	0	0	0	750	0	0	0	0	0	0	971.82
BANK FEES	492.68	0	0	117.5	0	134.5	0	0	0	0	0	0	0	0	0	0	0	0	47.5	0	0	0	792.18
EQUIPMENT CAP PURC	4,745.75	570.34	0	0	0	0	0	0	0	0	0	633	0	0	0	0	0	0	0	0	0	0	5,949.09
Event Catering	0	942.18	0	0	0	0	0	0	0	0	0	43.8	0	0	0	0	0	0	0	0	0	0	985.98
Event Expense	0	0	10,000.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,000.00
FINANCIAL MANAGEM	456,255.96	0	0	-7,226.88	0	890	0	0	0	0	0	0	0	0	2,000.00	0	0	0	8.91	0	10,927.27	0	462,855.26
MACHINERY HIRE	0	0	0	4,220.00	0	0	0	0	0	0	0	0	0	0	5,000.00	0	0	0	0	0	0	0	9,220.00
MEMBERSHIP EXP	533.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	533.64
MERCHANDISE EXP	1,831.37	0	0	0	0	0	0	0	0	0	0	381.73	0	0	0	0	0	0	0	0	0	0	2,213.10
Presenter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	0	0	0	0	0	0	500.00
PROJECT EXPENSES	32,903.65	14,950.19	87,618.17	308,436.25	24,800.00	550,406.09	86,400.00	27,645.45	9,090.00	10,060.00	20,599.00	183,211.31	17,414.53	440	2,500.00	2,831.73	9,922.20	0	155,566.36	379.55	9,800.00	17,386.80	1,572,361.28
Project Management	0	0	59,681.83	0	0	0	0	3,600.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63,281.83
PUBLICATIONS	8,217.73	1,650.68	0	0	0	0	0	0	0	0	0	4,966.57	0	0	0	0	0	0	0	0	0	0	14,834.98
TREASURER	8,751.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,751.30
TOTAL OUTFLOWS	525,831.42	18,526.34	164,800.00	336,702.70	24,800.00	560,730.59	86,400.00	33,000.00	9,700.00	10,060.00	21,599.00	197,225.24	17,414.53	950.00	9,500.00	4,081.73	9,922.20	0.00	162,313.68	379.55	20,727.27	17,386.80	2,232,051.05
OVERALL TOTAL	74,977.19	18,901.25	0.00	-17,755.98	0.00	1,105.48	0.00	0.00	0.00	10,281.82	2,041.00	63,345.39	195.73	9,050.00	0.00	-2,233.60	8,777.80	7,260.00	0.00	0.00	0.00	0.00	175,946.08

The unaudited financial information set forth above is preliminary and subject to adjustments and modifications. Adjustments and modifications to the financial statements may be identified during the course of the audit work, which could result in significant differences from this preliminary unaudited financial information.

UNFS Yield Prophet in 2015

Author: Barry Mudge

Funded By: GRDC Stubble Initiative, Emerald Grain and participating land owners

Project Title: UNF S Yield Prophet

Project Duration: 2015 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 2015
In the majority of cases, Yield Prophet provided a good indication of yield prospects during the season. On some sites, yield predictions were compromised by the hot finish to the season

The information provided by Yield Prophet can be useful in adjusting inputs (mainly Nitrogen) as the season evolves

Project Report:

Background

Thanks to on-going sponsorship from Emerald Grain, Yield Prophet was run across the Upper North again in 2015. A total of 10 sites were selected with deep soil sampling undertaken at the start of May. Soils were 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). So it is 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.

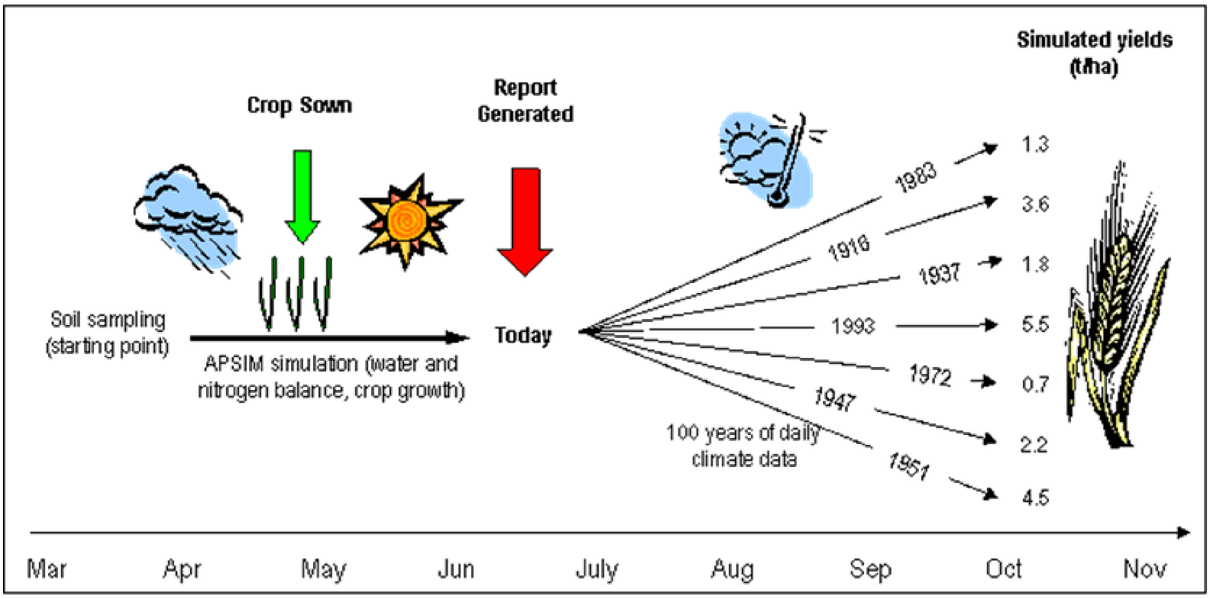


Figure 1. Diagrammatic representation of Yield Prophet

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 2015 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. In 2015, the UNFS Yield Prophet program was funded through generous sponsorship from Emerald Grain, plus a $200 contribution from growers whose paddocks were included in the program.

How did Yield Prophet perform in 2015

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

In 2015, starting soil moisture levels varied considerably across the region. Some properties had experienced excellent falls in April which had followed on some big rains (in parts) in January. Rainfall early in the growing season in all locations being tested was at least Decile 5 and in many instances (particularly in the north east) was well above average. Generally early sowing saw advanced crop stages. All this added up to the Yield Prophet model showing some impressive potential yields if good seasonal conditions were received for the rest of the season. However, there were two potential sleepers- The first was that on most sites, nitrogen levels were modest or low and the model showed that this would restrict crop yields in average or better seasons. In several cases, the N levels were so low that the model predicted that even a below average season would see yields restricted by N supply. The other sleeper was the potential impact that the El- nino weather pattern would have on winter and spring rainfall.

Seasonal conditions remained favourable through winter. By late August, all sites showed above average seasonal rainfall to date with some sites well above average. Then a dryish September followed by a very hot period early in October severely affected any crops which were not well advanced into grain fill. Generally, crops east of the ranges were most affected with crops west of the ranges sufficiently advanced prior to the hot spell to protect yield potential.

UNFS Yield Prophet site locations in 2015 are shown in Figure 12. Individual comments plus a review of the performance of YP at each site now follows- also included is a summary of the output from the model over the course of the season. 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 interprete these results, and as an example, the 90th percentile yield shows that yield which is expected to be equalled 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.

McCallum (7km south east of Morchard)- This was a paddock just east of Richards house. Emu Rock wheat back on pasture from last year. The paddock had good yield potential but model showed early on that additional Nitrogen would be required if the season was favourable. Additional 23kg/Ha of N was applied in early July which saw yield potential improve. The model suggested the final yield would be around 2.4 tonne/Ha- actual final yield of 1.64 tonne/Ha (AGP Quality- 6.9% screenings) was clearly affected by the poor finish to the season.

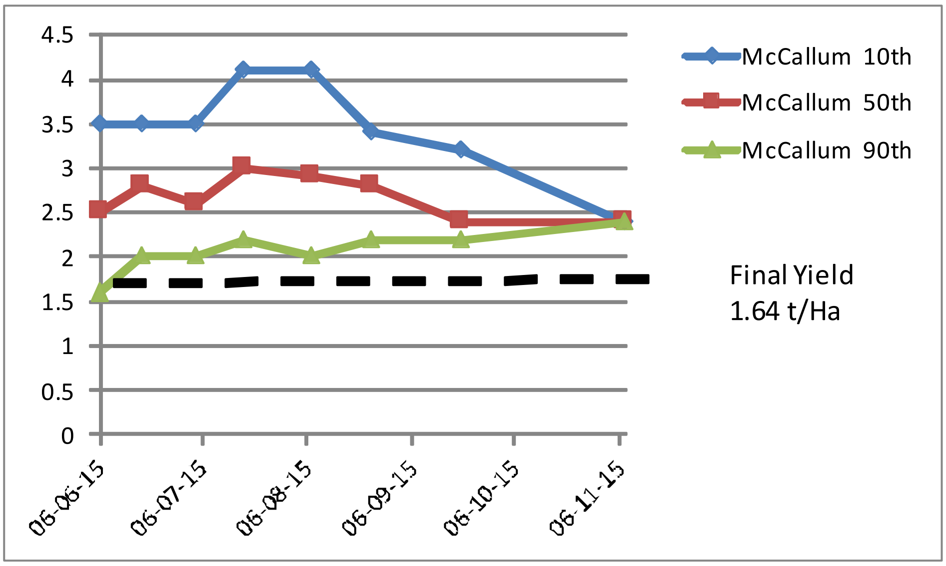


Figure 2. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the McCallum site 7 km south east of Morchard

Barrie (2 km north Willowie)- Katana wheat back on canola stubble. This is a highly variable paddock with soil constraints at depth which impact crop yields. Final crop yield in the area sampled for Yield Prophet was estimated by Peter at around 2.0 tonne /Ha which was in line with model predictions.

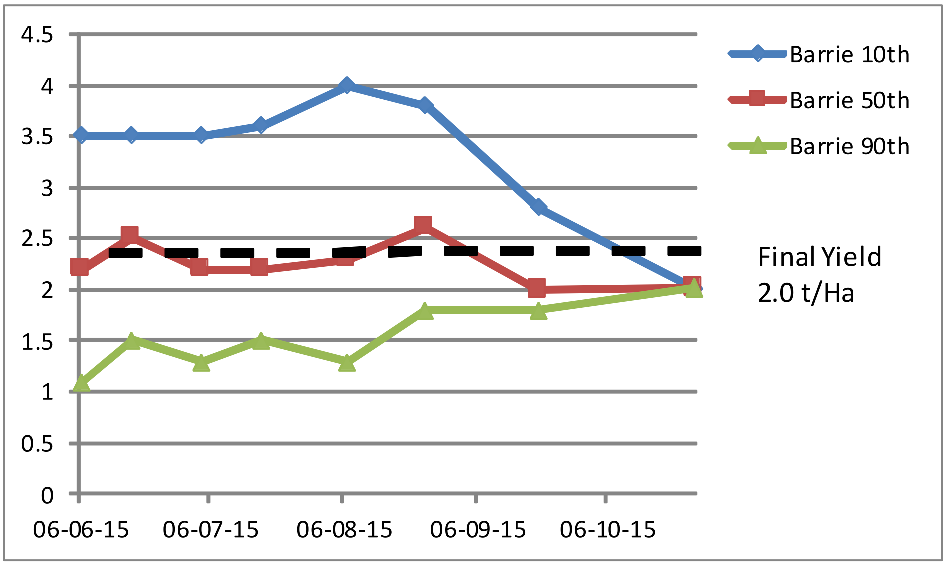


Figure 3. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Barrie site 2 km north of Willowie

Catford (10 km north of Morchard at Poverty Corner)- Katana wheat back on wheat stubble. This site showed very good levels of Plant Available Water (PAW) early in the season following very good January rains. Additional N was applied early in July which saw yield predictions improve. The model indicated that the final yield prediction of 1.89 t/Ha was still compromised by a lack of N. The actual final yield was 2.5 tonne/Ha of ASW quality which also suggests some yield compromise due to inadequate nutrition.

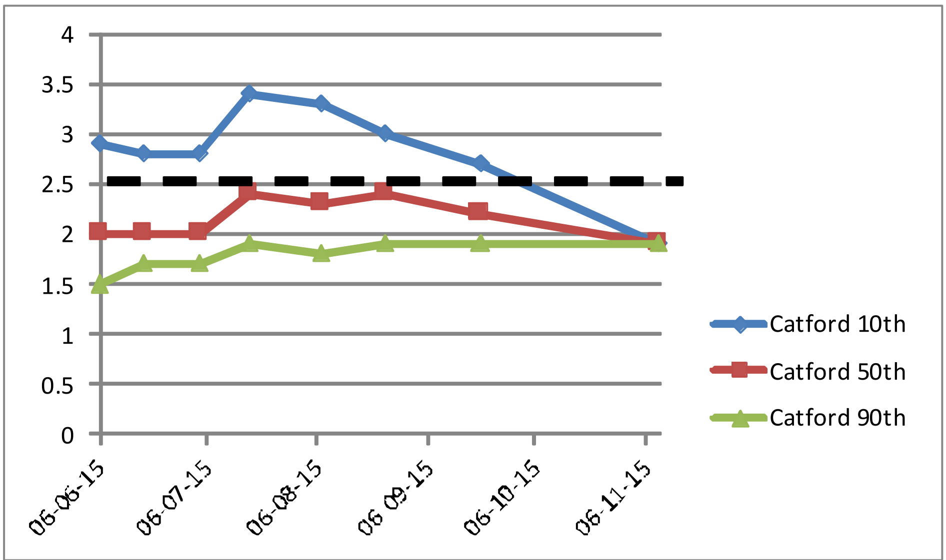


Figure 4. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Catford site 10 km north of Morchard

Crouch (25 km south of Port Pirie at Wandearah)- Kord wheat back on chickpea stubble. This area struggled for early season rainfall but had quite reasonable winter rains. Final growing season rainfall still was only around Decile 5. Chris and Graeme applied two applications of in-season N and predicted yield climbed steadily. The paddock showed a lot of variability in the final yield result- paddock average was 2.3 tonne/Ha but Chris indicated that the area sampled would have yielded much better- perhaps 3.0 to 3.2 tonne/Ha which is close to predictions.

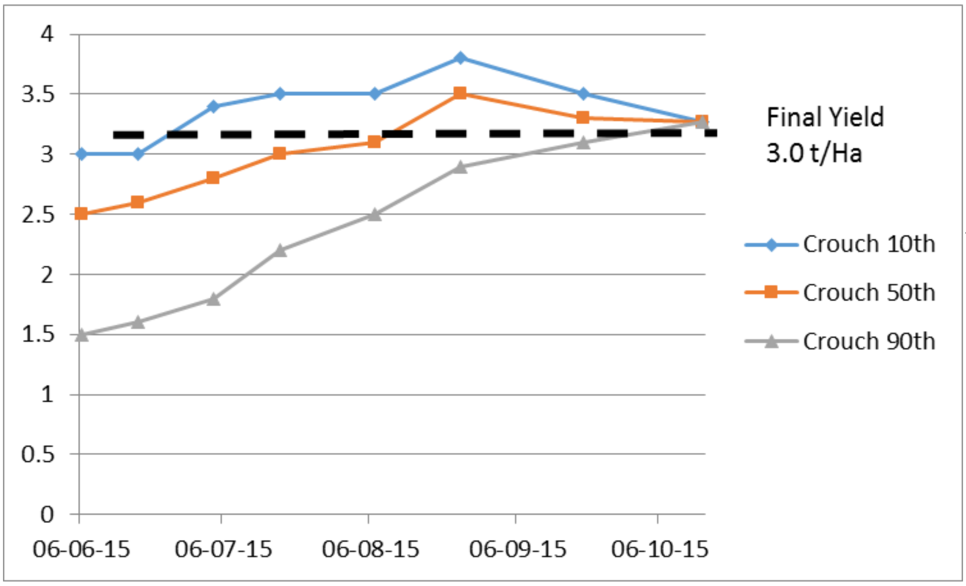


Figure 5. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Crouch site 25 Km south of Port Pirie

Heaslip (2 km north east of Appila on main Booleroo road)- Paddock showed good yield potential early but appeared to be lacking in N. Jim applied two additional N applications in July which lifted yield predictions considerably. However, yield predictions later in the season began to decline as the season closed off. The paddock final yield was 2.3 tonne/Ha of mainly ASW but with some AGP due to high screenings.

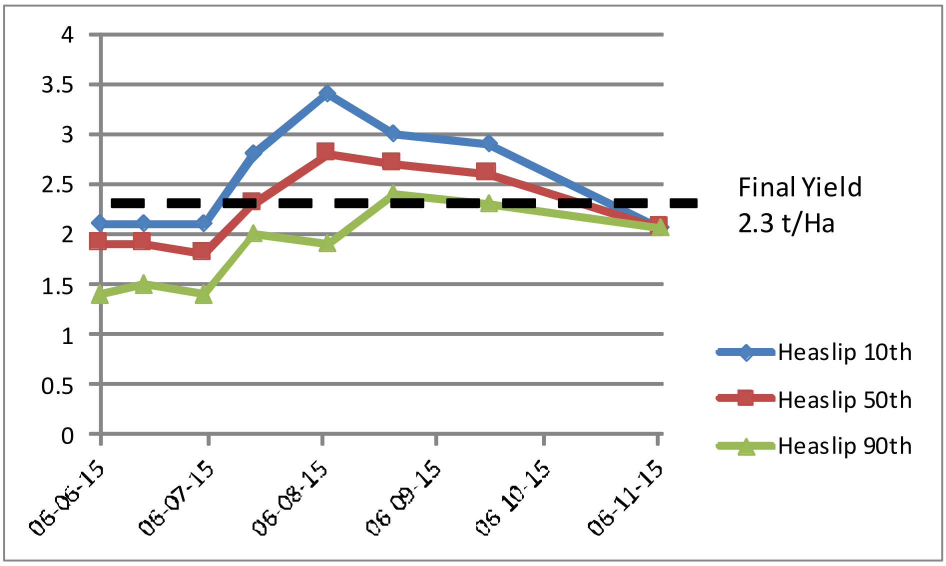
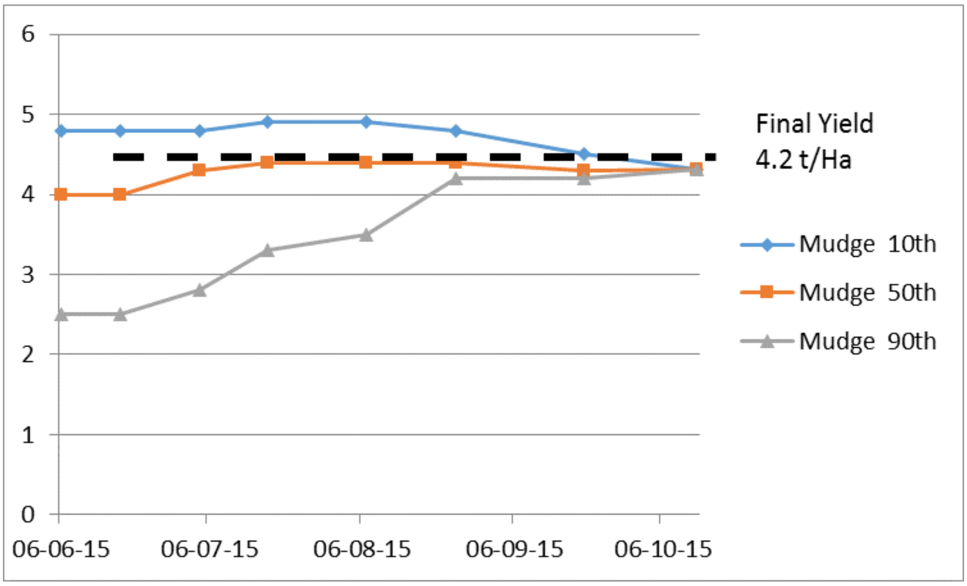


Figure 6 (left). Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Heaslip site 2 Km north-east of Appila

Figure 7 (below). Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Mudge site 9 Km north of Port Germein

Mudge (9 km north of Port Germein)- Mace wheat back on a spray fallowed medic crop in 2014. This was a paddock on the west side of the main highway which was reasonably favoured by early season rains and showed good PAW. It also showed reasonable good levels of available N, although the high yield potential indicated that additional N would be beneficial. No additional N was applied. Final crop yield of 4.2 tonne/Ha was close to the predicted yield of 4.3 tonne/Ha. Interestingly, the model predicted a final yield of 4.9 tonne/Ha if additional N had been applied.



Pole (5 km south east of Port Germein)- Mace wheat back on a grassy medic pasture in 2014. This was the site of the UNFS Barley Grass trial looking at the influence of crop competition on barley grass suppression. The site had reasonable growing season rainfall but showed quite low initial N which was not fully covered by additional applications. Final predicted yield based on N as applied was around 2.7 tonne/Ha- this was significantly lower than the prediction of 3.1 tonne/Ha if additional N had been applied. Actual final yield for wheat at this site was 2.1 tonne/Ha which may have been compromised due to possible presence of root disease (final yield of Fathom barley at the same site was 3.5 tonne/Ha).

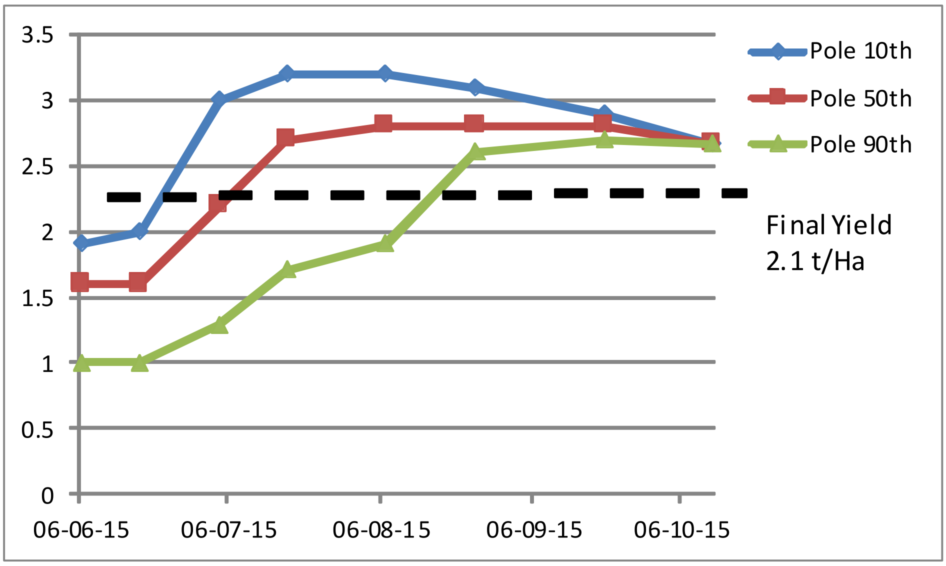


Figure 8. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Pole site 5 Km south-east of Port Germein

Berryman (7 km north east of Wirrabara)- Scout wheat on canola. This is high rainfall country which showed good yield potential during the season, but with the model showing a significant drop off in yield as the season finished poorly. The final predicted yield was (only) around 3.1 tonne/Ha- and while the paddock was quite variable, Dustin suggested that the predicted yield was 0.5-1.0 t/Ha below actual. This may have been due in part to the fact that the model used Booleroo Centre's (a drier location?) rainfall records for its calculations.

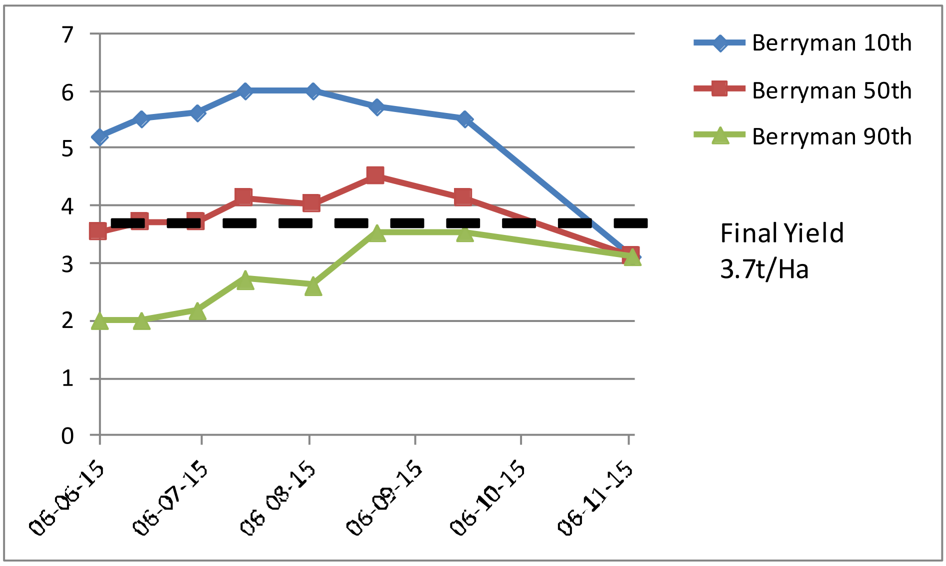


Figure 9. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Berryman site 7 Km north-east of Wirrabara

Foulis (3 km north of Wilmington)- Mace wheat back on wheat. This site had very good early and mid-season rainfall and showed high yield potential. Matt backed this up with some good levels of urea applications with yield predictions continuing to improve through the season. Unfortunately, the final yield was compromised by the hot and dry finish- final crop yield was 2.85 tonne/Ha of AGP against a predicted yield of 4.0 tonne/Ha. Interestingly, an adjoining wheat crop which had less urea applied went 1.0 tonne/Ha better.

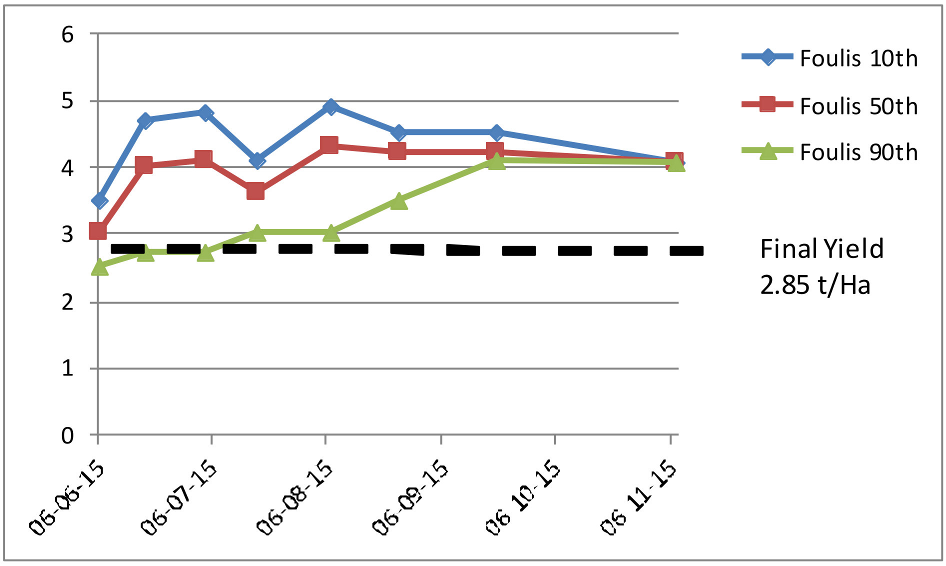


Figure 10. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Foulis site 3 Km north of Wilmington

Kuerschner (just east of Black Rock)- Katana wheat back on wheat stubble. Site received about 100 mm of rainfall in an April event and should have shown high levels of PAW when tested. However, the soil tests only showed wet soil down to about 40 cm, which was a mystery but may reflect variability across the paddock. In any event, predicted yields remained at moderate levels through the season, with additional N applied in late July lifting predicted yields considerably. Final predicted yield of 1.8 tonne/Ha was significantly lower than the actual achieved of 2.6 tonne/Ha which may have reflected the issue raised with the initial soil testing.

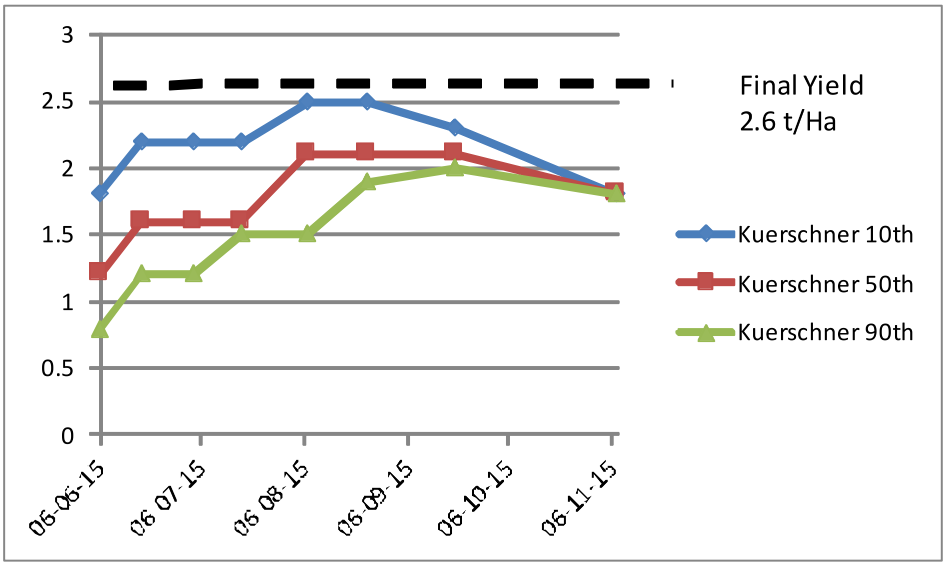


Figure 11. Yield potential (as measured by the 10th, 50th and 90th percentile) over the season and final yield for the Kuerschner site at Black Rock

Summary and Conclusions

In most cases in 2015, on the 10 sites used in the Upper North, Yield Prophet provided a reasonable estimate of yield potential as the season evolved. The less than favourable finish to the season compromised some sites, particularly those at a vulnerable crop stage during the extreme heat event in early October. However, Yield Prophet remains a useful tool to assist with in-crop input decision making particularly in-season Nitrogen applications.

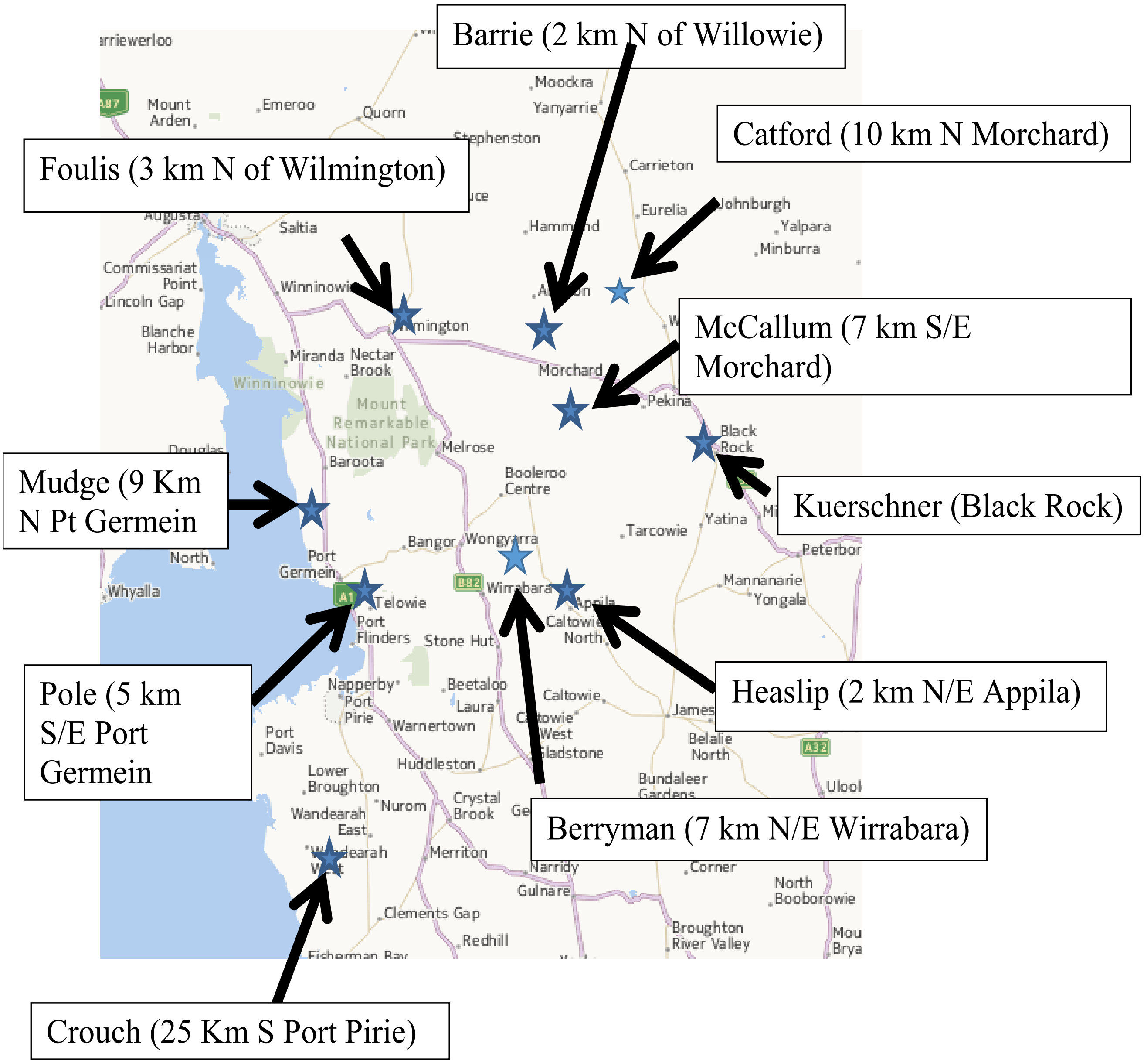


Figure 12. Yield Prophet- Site locations in 2015

Acknowledgements

Participating farmers- Richard McCallum, Peter Barrie, Gilmour Catford, Chris and Graeme Crouch, Jim Heaslip, Chris Pole, Dustin Berryman, Matt Foulis and Jim Kuerschner.

GRDC for funding the UNFS Stubble Initiative

Emerald Grain for Sponsorship of the UNFS Yield Prophet project in 2015

The value of break crops in low rainfall farming systems

Author: Michael Moodie - Mallee Sustainable Farming, Mildura & Nigel Wilhelm - SARDI, Minnipa Agricultural Centre

Funded By: GRDC - DAS00119

Project Title: Profitable Crop sequencing in the low rainfall areas of South Eastern Australia

Project Duration: *2011-2015*

Project Delivery Organisation: *Rural Solutions, Mallee Sustainable Farming, SARDI*

Key Messages:

The inclusion of two-year break phases in low rainfall crop sequences is a reliable management tool for increasing the yields of subsequent wheat crops in paddocks where agronomic constraints (e.g. grass weeds, declining soil fertility, root disease) are affecting yields of continuous cereals. These wheat yield benefits are commonly 1 – 2 t/ha over 2-3 seasons following the break phase.

Including one and two-year break phases in low rainfall paddock rotations can increase profitability by up to $100/ha/year over maintaining a continuous wheat cropping sequence. Key to increasing profitability is having at least one profitable break crop option that relieves the agronomic constraints for production of subsequent crops.

Project Report:

Why do the trial?

The agronomic benefits of including break phases in paddock rotations are well known: they can interrupt root disease cycles, fix nitrogen, conserve and provide management options to control grass weeds. However, over the past 15-20 years, the intensity of cereal crops in low rainfall zone paddock rotations has increased dramatically. The increased intensity of cereal crops has largely been at the expense of pastures and fallows and farmers have been reluctant to include broadleaved break crops in rotations due to the perceived higher risk of growing these crops in the low rainfall zone. Therefore, research was undertaken to quantify the yield benefits that break phases provide to subsequent cereal crops in the low rainfall zone and to quantify the impact of break phases on profitability of the long term rotation.

The Low Rainfall Crop Sequencing Project (LRCSP, funded by GRDC) commenced in 2011 with field trials at 5 sites across the low rainfall zone of south eastern Australia. At that point in time, paddock rotations in this region were dominated by intensive cereal cropping and broadleaved grain crops occupied less than 5% of the landscape. Moreover, these intensive cereal cropping sequences were declining in productivity due to agronomic constraints such as grassy weeds, declining soil nitrogen fertility and crop diseases. The aim of the project was to test if including one and two year well managed break phases in low rainfall crop sequences could successfully address agronomic constraints to increase the productivity of subsequent cereal crops and improve the profitability of the long term crop sequence when compared to maintaining continuous cereal.

How was it done?

The LRCSP is a collaboration between SARDI and five farming systems groups in the southern region:

Eyre Peninsula Agricultural Research Foundation (EPARF); Site location: Minnipa, SA
Upper North Farming Systems (UNFS); Site location: Appila, SA
Mallee Sustainable Farming (MSF); Site location: Mildura, Vic
Birchip Cropping Group (BCG); Site location: Chinkapook, Vic
Central West Farming Systems (CWFS); Site location: Condobolin, NSW

Replicated trials were established within paddocks which had had a long term history of intensive cereal cropping. Moreover, agronomic constraints such as grass weeds, soil borne disease and declining soil fertility were constraining cereal crops yields in these paddocks. Each trial included up to 19 unique crop sequences which included both one and two-year break phases in 2011 and/or 2012 followed by wheat in 2013, 2014 and 2015 (Table 1). These treatments were selected by the collaborating FS groups in consultation with local farmers and advisors. Each trial also maintained a continuous wheat treatment for the five years of the trial which was used to measure the impact of the 19 crop sequences trialed.

Table 1 Details of the four year rotations implemented at the Mildura, Appila and Minnipa sites.

Throughout the trials, agronomic management was varied for each individual rotation to help maximise the profitability of that rotation and to correct the agronomic constraints that emerged for that rotation. For example nitrogen inputs, varieties, sowing dates or herbicide applications were varied depending on the level and type of agronomic constraints in each rotation.

Mildura	Ident	Appila	Ident	Minnipa	Ident
canola-chickpea-w-w	C-CP	canola-field pea-w-w	C-FP	canola-field pea-w-w	C-FP
canola-field pea-w-w	C-FP	field pea-canola-w-w	FP-C	field pea-canola-w-w	FP-C
canola-[bm]vetch-w-w	C-V	[h]millet-[bm]vetch-w-w	MT-V	medic-[g]canola+pasture-w-w	M-C+P
chickpea-canola-w-w	CP-C	medic-[h]pasture-w-w	M-P	[h]medic-canola-w-w	M-C
fallow-canola-w-w	F-C	medic[(p)]-[h]pasture-w-w	M(P)-P	canola-[g]medic-w-w	C-M
fallow-fallow-w-w	F-F	pasture-[h]oats+vetch-w-w	P-O+V	[h]sulla-[g]sulla-w-w	S-S
fallow-field pea-w-w	F-FP	[c,h]mix1-[c,h]mix1-w-w	MX1-MX1	fallow-fallow-w-w	F-F
[a,g]medic-[g]pasture-w-w	M(H)-P	[h]canola+vetch-fieldpea-w-w	C+V-FP	canola-[g]oat-w-w	C-O
[b,g]medic-[g]pasture-w-w	M(L)-P	fallow-fallow-w-w	F-F	fieldpea-[g]oats-w-w	FP-O
field pea-canola-w-w	FP-C	fallow-canola-w-w	F-C	[h]medic-[g]oats-w-w	M-O
field pea-[bm]vetch-w-w	FP-V	fallow-lentil-w-w	F-L	[h]oats-canola-w-w	O-C
[bm]vetch-canola-w-w	V-C	[h]vetch-fallow-w-w	V-F	[h]oats-field pea-w-w	O-FP
[bm]vetch-field pea-w-w	V-FP	fallow-w-w-w	F-W	[h]oats-[g]medic-w-w	O-M
barley-wheat-w-w	B-W	lentil-w-w-w	L-W	[h]vetch+oats-canola-w-w	V+O-C
canola-w-w-w	C-W	w-barley-w-w	W-B	[h]canola+field pea-w-w-w	C+FP-W
canola+field pea-w-w-w	C+FP-W	w-[h]pasture-w-w	W-P	fieldpea-w-w-w	FP-W
[h]oat-w-w-w	O-W	w-[g]medic-w-w	W-M	[e]medic-w-w-w	M(J)-W
field pea-w-w-w	FP-W	[d]wheat[(p)]-[h]pasture-w-w	W(P)-P	[f]medic-w-w-w	M(A)-W
fallow-w-w-w	F-W	[h]oat-w-w-w	O-W	w-w-w-w	CONW
w-w-w-w	CONW	w-w-w-w	CONW		
[a]Low Sowing Rate (5 kg/ha) [b]High Sowing Rate (15 kg/ha) Note: Vetch were brown manured		[c]mix1:oats+vetch+medic [d]wheat undersown with medic pod [(p)]: Medic sown as pod		[e]Jaguar medic harvested for seed [f]Angel medic harvested for seed	

[h]Treatment cut for hay; [g]Treatment grazed; [bm]Treatment was brown manured
Note: Medic refers to sown medic pasture: Pasture refers to regenerating medic pasture
Fallow refers to chemical fallow

Each trial was intensively monitored for a range of agronomic parameters. Prior to sowing soil fertility and root disease inoculum was measured in the topsoil while soil nitrogen and soil water were measured throughout the soil profile. Grassy weeds populations were also monitored over the course of the trial by measuring weed seed banks and in-crop weed numbers.

Gross margins were calculated for each treatment in each season using the Rural Solutions 'Farm Gross Margin and Enterprise Planning Guide'. Costs were calculated using the actual inputs used in the trial and the values provided in the corresponding gross margin guide. Each year gross margins were calculated using the five-year average price stated in 2015 (Table 2). Treatment grain yields were used for calculating income and 85% of dry matter yield was used for calculating hay yield. For grazing livestock, income was calculated using the dry sheep equivalent (DSE) cereal zone gross margin for a prime lamb enterprise and a nominal stocking rate of 2 DSE per winter grazed hectare, irrespective of pasture production.

What happened?

This article reports on the first four years of data from three of the trial sites.

Impact of break crops on subsequent wheat yield

At the Mildura, Appila and Minnipa sites, including break phases in paddock rotations significantly increased yields of subsequent wheat crops in comparison to maintaining continuous wheat (Figures 1–3). At the Mildura site, including a double break phase in 2011 and 2012 resulted in increased wheat production of 0.6 – 1.6 t/ha in 2013 and 2014 (Figure 1). This is despite relatively low yields of the continuous wheat treatments of less than 1.4 and 1.3 t/ha in the corresponding seasons. At this site double breaks were more effective than single break phases which was largely due to the rapid re-establishment of brome grass in the second year following a single break.

Table 2 Enterprise prices used in the calculations of gross margins.

Enterprise	Price	Notes
Wheat grain	$271/t	All assumed APW quality
Barley grain	$225/t	All assumed feed quality
Lentils grain	$628/t	
Field Pea grain	$265/t	
Chickpea (Desi) grain	$414/t	Assumed $50/t below Kabuli chickpea price
Canola grain	$522/t	
Oaten hay	$148/t	
Legume hay	$198/t	Assumed $50/t above oaten hay
Mixed legume/non-legume hay	$173/t	Assumed $25/ above oaten hay
Livestock (grazing)	$66/ha	Cereal zone prime lamb: $33/DSE/ha x 2 DSE ha

At Appila and Minnipa, wheat yield benefits were of a similar magnitude those observed at Mildura despite much higher rainfall and yield potential at these sites. The continuous wheat treatments yielded 2.79 and 1.31 t/ha at Appila and 1.66 and 3.28 t/ha at Minnipa in 2013 and 2014 respectively. At Appila, two year break treatments increased subsequent wheat production by 1–2 t/ha and were also more effective than one year break phases with the exception of oaten hay – wheat and fallow – wheat (Figure 2). Wheat yield benefits at Minnipa were generally between of 1–1.4 t/ha over the course of the trial, however one year breaks were equally effective as two year breaks (Figure 3).

The choice of break phase appeared to have little effect on subsequent wheat production as long the break phase successfully addressed the constraints present. Analysis was undertaken to quantify the contribution of brome grass, soil nitrogen, rhizoctonia and soil water to the wheat yield benefits measured at the Mildura site in 2013 and 2014. In 2013, 39 percent of the yield improvement was due to less brome grass, 38 percent was due to more soil nitrogen, 19 percent was due to less rhizoctonia and four percent was due to more water. Brome grass was the dominant driver of positive break effects in 2014, accounting for an average of 80 percent of the differences in wheat yield. Higher soil nitrogen levels accounted for a further 18 percent of the positive break effects in 2014.

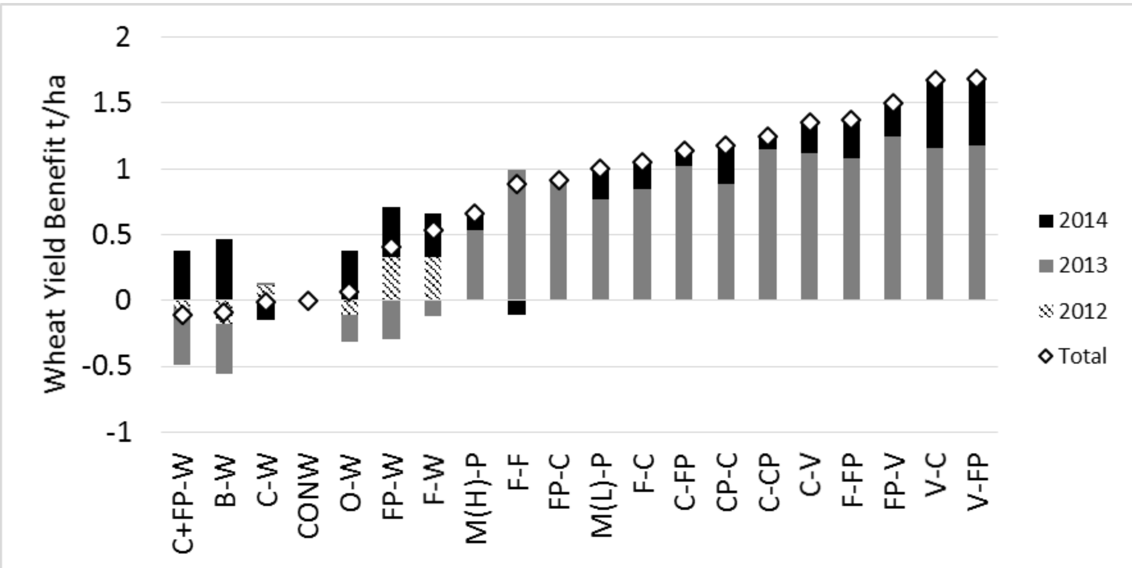


Figure 1 Wheat yield benefit (treatment wheat yield – continuous wheat yield) achieved at the Mildura site following one and two year break phase. Yields of the continuous wheat treatment (CONW) were 0.93, 1.42 and 1.31 t/ha in 2012, 2013 and 2014 respectively.

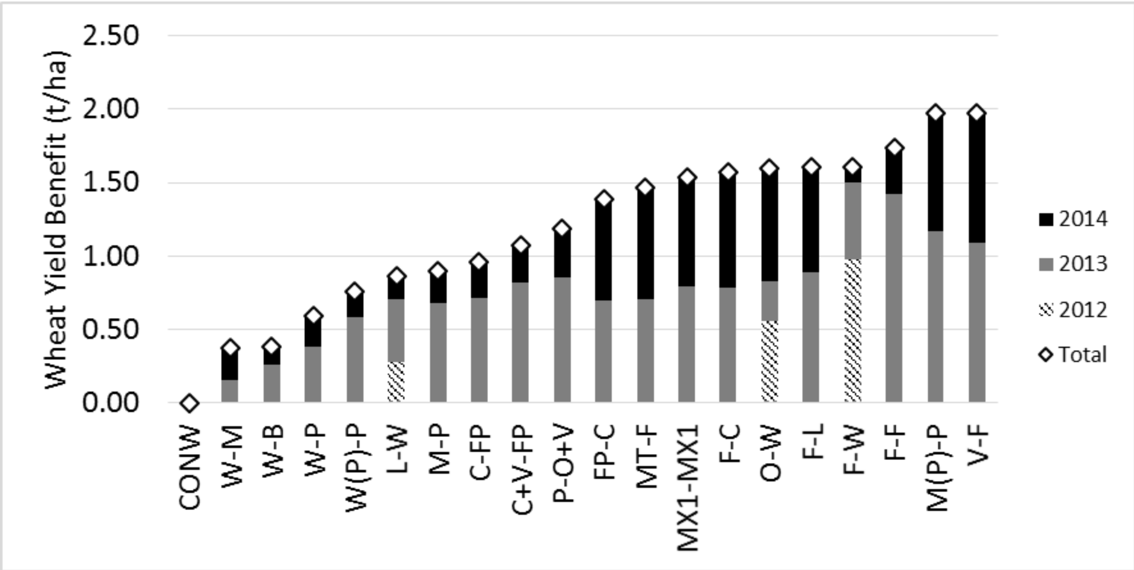


Figure 2 Wheat yield benefit (treatment wheat yield – continuous wheat yield) achieved at the Appila site following one and two year break phase. Yields of the continuous wheat treatment (CONW) were 1.65, 2.79 and 1.41 t/ha in 2012, 2013 and 2014 respectively.

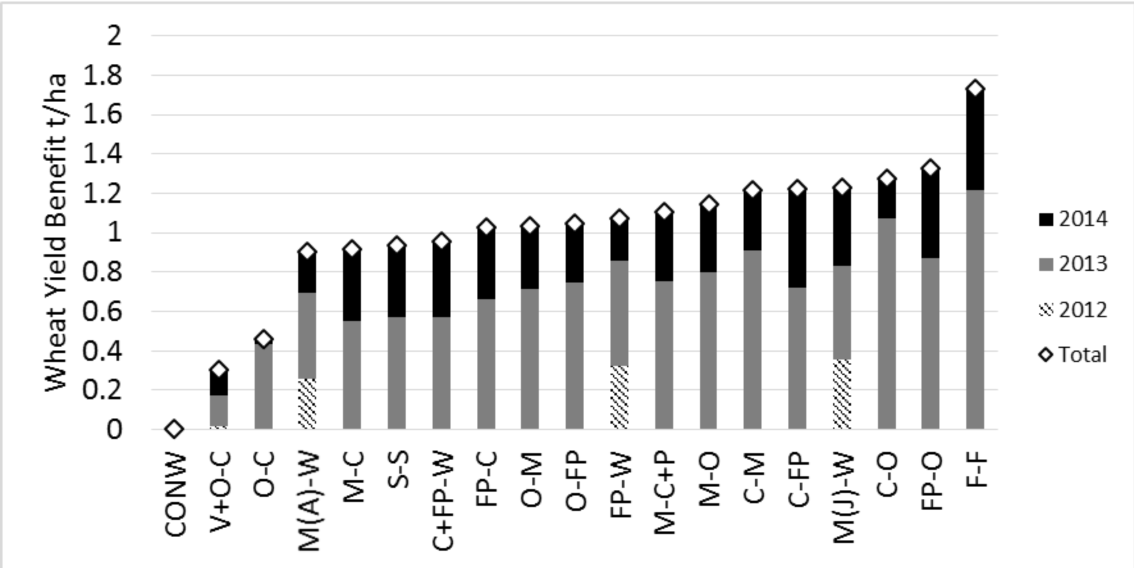


Figure 3 Wheat yield benefit (treatment wheat yield – continuous wheat yield) achieved at the Minnipa site following one and two year break phase. Yields of the continuous wheat treatment (CONW) were 1.70, 1.66 and 3.28 t/ha in 2012, 2013 and 2014 respectively.

Profitability of including break crop in low rainfall rotations

The inclusion of break phases was most profitable at the Mildura and Appila sites where over half of the rotations with break phases included were more profitable than maintaining continuous wheat at these sites (Table 3). At Mildura, the top five rotations increased gross margin by an average of $230/ha over the four years or approximately $60/ha/year. At Appila, the profit advantages were greater with the top five most profitable crop sequences delivering an average of $370 additional profit or approximately $60/ha/year.

Key attributes of the most profitable crop sequences at both Mildura and Appila were having at least one profitable break phase in the rotation (in comparison to the continuous wheat treatment) and that the rotation delivered large yield benefits to subsequent wheat crops. At Mildura, field peas, canola and chickpeas produced good yields and gross margins in the 2011 season. The yield of field pea was 1.8 t/ha, canola was 0.7 t/ha and chickpeas were 0.8 t/ha with corresponding gross margins of $258/ha, $185/ha and $138/ha. Seasonal conditions were poor at Mildura in 2012, however field pea treatments still averaged 1 t/ha while canola and chickpea both yielded below 0.4 t/ha. Field peas also out-yielded wheat in both seasons with the continuous wheat treatment yielding 1.5 t/ha and 0.9 t/ha in 2011 and 2012.

At Appila, profitable gross margins were achieved from crop sequences where crops and pastures were cut for hay. The top producing hay treatments in 2011 and 2012 produced of 4–7 t/ha of dry matter resulting in profitable gross margins of $350–500/ha. The continuous wheat treatment produced a profit of $285/ha and $240/ha in 2011 and 2012 seasons. At Appila, broadleaved break crops grown for grain generally performed poorly due to severe frost events impacting grain yield in both 2011 and 2012. The exceptions were canola and lentils producing excellent gross margins of $550/ha and $365/ha in 2012. Both of these treatments followed a chemical fallow in 2011 and both crops are high value grain crops where revenue is boosted by higher prices than other enterprises.

The continuous wheat treatment was the most profitable at Minnipa with a gross margin of $1608/ha over the four years of the trial (Table 4). The profitability of this treatment was boosted by a high wheat yield in 2011 (3.5 t/ha) resulting in an extremely profitable gross margin of $540/ha. Therefore, the opportunity cost of not having a wheat crop sown in 2011 was too much for the other rotations to claw back, even though continuous wheat was the least profitable treatment over the 2012-2013 timeframe. The top five most profitable rotations at Minnipa from 2013 – 2014 were $95/ha/year more profitable than the continuous wheat.

Table 3 Total gross margin (GM) for all years (2011-2014) and treatments included in the Mildura, Appila and Minnipa LRCSP. Total GM ($/ha) is provided for continuous wheat (CONW) with the differential GM ($/ha) (treatment - CONW treatment) shown.

Mildura		Appila		Minnipa	
Treatment	GM (2011-14)	Treatment	GM (2011-14)	Treatment	GM (2011-14)
CONW	**$692**	**CONW**	**$1,034**	**CONW**	$1,608
FP-V	+$284	M(P)-P	+$431	C-FP	$0
C-CP	+$240	MX1-MX1	+$417	FP-C	-$29
FP-W	+$228	F-C	+$373	O-M	-$59
C-FP	+$221	O-W	+$331	C-O	-$89
CP-C	+$180	F-L	+$303	C-M	-$133
F-FP	+$111	W(P)-P	+$173	O-FP	-$133
O-W	+$102	W-B	+$112	O-C	-$180
C-V	+$82	V-F	+$98	C+FP-W	-$184
B-W	+$55	W-P	+$84	FP-W	-$202
V-FP	+$27	F-W	+$77	FP-O	-$247
FP-C	+$13	MT-V	+$58	M-C	-$255
C-W	+$7	P-O+V	-$23	M-O	-$307
V-C	-$28	C+V-FP	-$45	V+O-C	-$371
M(L)-P	-$53	FP-C	-$87	M-C+P	-$394
F-C	-$84	F-F	-$101	M(J)-W	-$409
C+FP-W	-$95	L-W	-$101	S-S	-$440
M(H)-P	-$108	M-P	-$106	F-F	-$550
F-W	-$147	W-M	-$193	M(A)-W	-$576
F-F	-$169	C-FP	-$369		

What does this mean?
The inclusion of break phases in low rainfall crop sequences is a reliable management tool for increasing the yields of subsequent wheat crops in paddocks where agronomic constraints (e.g. grass weeds, declining soil fertility, root disease) are affecting yields of continuous cereals. These wheat yield benefits are commonly 1–2 t/ha over 2-3 seasons following the break phase.

Including continuous one and two-year break phases in low rainfall paddock rotations can increase profitability by up to $100/ha/year over maintaining a continuous wheat cropping sequence. Key to increasing profitability is having at least one profitable break crop option that manages agronomic constraints that increases the production of subsequent crops.

Acknowledgements
This paper draws on the excellent work by the five collaborating FS groups involved in the project: Eyre Peninsula Agricultural Research Foundation (EPARF) with SARDI Minnipa Agricultural Centre, Upper North Farming Systems (UNFS), Mallee Sustainable Farming (MSF); Birchip Cropping Group (BCG), Central West Farming Systems (CWFS). Thank you to the research and technical staff who have worked on the trials: Suzie Holberry, Ian Richter, Peter Telfer and Todd McDonald. Thank you to Roger Lawes (CSIRO) and Ray Carroll (Rho Environmetrics) who have undertaken data analysis of these trials. Thanks to GRDC, project code DAS00119.

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UNFS
Upper North Farming Systems

Mallee Sustainable Farming

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EPARF
Eyre Peninsula Agricultural Research Foundation Inc.

2015 Morchard Vetch Trials.

Authors: Stuart Nagel, Gregg Kirby and Rade Matic, SARDI, Waite Campus

Funded by: SAGIT, Project No S 914

Project Title: Common Vetch as a break crop for marginal cropping systems (2014-2017)

Project Delivery Organisation; SARDI

Key Points

- In 2015 the Morchard trial produced very good yields of both grain and hay with a site mean of 4.2t/ha of hay and 2.1t/ha of grain
- Several new variety lines showed good potential in dry matter production and grain yields and showed the potential of vetch in this area
- The new varieties Timok and Volga out yield Rasina in the trials in both hay and grain.

Background

In 2014 SAGIT funded a project with the National Vetch Breeding Program (NVBP) to investigate existing vetch germplasm that may be suited to the more marginal cropping areas in South Australia. It aims to provide a genuine legume break crop option for cereal and mixed farmers in the marginal cropping areas of South Australia, focusing on Western Eyre Peninsula, the Upper North and the Murray lands/ Mallee
The Upper North trials were conducted with Gilmore Catford at Morchard in 2014 and 2015.

Methods

Lines were selected from the 2014 trials based on early vigour, winter growth and dry matter/fodder yields.

In 2015 the trial was sown after good early rains on 23-April into good moisture with follow up rainfall.

Pre sowing Treflan was applied at 1.5l/ha and incorporated by sowing and post sowing pre emergence a tank mix of Simazine 500gm/ha and Metribuzine 250gm/ha was applied with an insecticide. There was no fertilizer or inoculation applied and no grass herbicide was applied.

The trial was cut for hay on the 10th of September and harvested for grain on the 28th of October.

Figure 1 Morchard July 23, SA 34876 centre front

Results

In 2015 the Morchard trial produced very good yields of both grain and hay with a site mean of 4.2t/ha of hay and 2.1t/ha of grain. The best lines producing over 5.0t/ha of hay and over 2.3t/ha grain (see Table 1)

Several lines showed good potential in dry matter production SA 34822, SA 34823-2 and SA 34876, with SA 34876 having the best early vigour and winter growth making it an attractive option in a mixed farming system. Other later lines took advantage of good moisture in spring to put on late growth. Grain yields were also excellent and showed the potential of vetch in this area.

The new varieties Timok and Volga out yield Rasina in the trials in both hay and grain. With Timok achieving the best results out of the varieties. This was due to the good moisture in spring which advantaged the later maturing varieties and saw all lines and varieties go on to produce good grain yields. This will not happen every year around Morchard as the seasons tend to finish earlier than in 2015 making earlier maturity preferable in most seasons.

Table 1: 2015 Grain and hay yields Morchard

Genotype	Hay t/ha	Grain t/ha
34559	4.03	1.82
34748	4.67	2.13
34822	5.15	2.24
34831	4.51	2.47
34842	4.93	2.12
34876	4.78	2.04
34883	4.23	2.3
34885	4.47	2.13
35019	4.25	1.92
35036	4.16	1.76
35122	4.54	2.13
37003	4.02	1.94
37058	4.67	2.25
37107	3.93	1.98
37457	4.14	2.05
34823-2	4.97	2.14
35427-1	4.34	2.22
Rasina	4.13	2.12
Timok	4.73	2.33
Volga	4.2	2.2
Site Mean	4.44	2.12

Acknowledgements

The National Vetch Breeding Program would like to thank SAGIT, GRDC, RIRDC and SARDI for funding this program and acknowledge the ongoing support and interest provided by Australian farmers. The feedback, advice, recommendations and wish lists for future varieties provided by farmers and agronomists to the program are gratefully received and appreciated.

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Images Below: UNFS 2015 Spring Crop Walk inspecting Morchard vetch trials with Stuart Nagel.

Maintaining Profitable Farming Systems with Retained Stubble "The Stubble Initiative"

Author: Naomi Scholz, SARDI

Funded By: GRDC

Project Title: Maintaining Profitable Farming Systems with Retained Stubble

Project Duration: 2013-2018

The GRDC initiative, Maintaining Profitable Farming Systems with Retained Stubble, or the "Stubble Initiative", is a five year program to address the issues encountered by growers when retaining stubbles from one year to the next.

Based in the southern cropping region, the initiative involves farming systems groups in Victoria, South Australia, southern and central New South Wales and Tasmania collaborating with research organisations and agribusiness to explore and address issues for growers that impact the profitability of cropping systems with stubble, including pests, diseases, weeds, nutrition and the physical aspects of sowing and establishing crops in heavy residues.

The initiative aims to address the issues with stubble retention, quantify the effects that these issues are having on yield and profitability, develop practical solutions and then extend the knowledge to grain growers and their advisers.

The farming systems groups involved are developing regional guidelines and recommendations that growers can implement on-farm to help them to consistently retain stubbles. The ultimate goal is to provide southern growers with practical information to guide their crop management, underpinned by results from local trials across the southern cropping region.

While each grower group is investigating their own locally relevant issues, there are common issues across the region that are also being addressed in a consistent manner by the groups, with the support of the CSIRO research team led by Dr John Kirkegaard.

The groups and organisations involved are BCG, on behalf of Southern Farming Systems, Victorian No Till Farming Association and Irrigated Cropping Council; Mallee Sustainable Farming Systems Inc; Riverine Plains Inc; Central West Farming Systems; Farmlink Research Limited; Eyre Peninsula Agricultural Research Foundation; Lower Eyre Agricultural Development Association; MacKillop Farm Management Group; Upper North Farming Systems; and Yeruga Crop Research, on behalf of the Mid North High Rainfall Farming Systems Group and the Yorke Peninsula Alkaline Soils Group. Hart Field Site group is also participating in the initiative, with South Australian Grains Industry Trust (SAGIT) funded trials (H0113 and H0114).

Research support is being provided by CSIRO, and SA Research and Development Institute's Naomi Scholz has been appointed to assist with co-ordination and communication.

For more information, contact your local grower group or Naomi Scholz, SARDI naomi.scholz@sa.gov.au (08) 8680 6233.

GRDC Project codes: BWD00024, CWF00018, EPF00001, CSP00174, LEA00002, MFM00006, MFS00003, RPI00009, UNF00002, YCR00003, DAN00170.

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Surface Cover Grazing Systems Trial

Author: Mary-Anne Young
Funded By: GRDC Stubble Initiative - UNF00002
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 is investigating the effects of rotational grazing versus set stocking of stubble residues on surface cover in arable paddocks.
To date, there is no clear difference in surface cover indicators between the two treatments.

Project Report:

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.

This year the trial on Don Bottrall's property at Appila was on 2.7 t/ha Hindmarsh barley crop stubble .

Figure 1: Paddock Layout.

The 17 ha paddock is split into approximately half, with an ungrazed or "control" strip (C) in the middle.

The western end is left for set stocking (S) while the rotationally grazed area (R) is further subdivided into 3 areas.

A mob of ewe hoggets was split into 2, with 97 in each group.

The sheep went into the trial areas on the 24th of January 2016 and remained for 27 days, during which time the ones in the rotationally grazed areas grazed each subdivided paddock 3 days 3 times.

All sheep were shorn on the 9th of February and 2 rams per mob were put in on the 16th of February.

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.

This year's results showed that there was no significant difference between the 2 treatments in changes in surface cover before and after grazing:

Table 1: Change in surface cover indicators after grazing * 1 = full cover; 8 = bare ground

	Dry Matter t/ha	Surface Cover %	Surface Cover Rating*
Rotational Grazing			
Before	2.5	96	2
After	2.1	90	4
Change	-0.4	-6	2
Set Stocking			
Before	2.3	93	2
After	1.9	84	4
Change	-0.4	-9	2

The changes in surface cover rating reflect that while a high amount of surface cover remained, the stubble had become flattened and detached to some extent, and this is quite apparent in photos. The percentage of the ground surface protected by cover remains high however the stubble is looser and more readily kicked, blown or washed around.

Much of the finer leaf and chaff components of the stubble had been grazed, leaving behind the bulkier straw.

Before the sheep went into the paddocks, Don had randomly selected 15 in each mob and weighed them. However, heavy rain washed the spray raddle markings off the selected sheep so they could not be identified for weighing after they came out.

Results for the 3 years to date indicate that overall there is no consistent difference between rotational grazing and set stocking on surface cover (Table 2).

Figure 2 & 3: Rotational grazing paddock before grazing (left) and after (right).

Table 2: Changes in surface cover factors after grazing

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

In 2014, set stocking appeared to result in more loss of dry matter but similar no change in % cover and a similar decline in surface cover rating to rotational grazing. In 2015, rotational grazing lost more dry matter and percentage surface cover but was on a par with set stocking for surface cover rating. It should be noted that the timing of sheep going into paddocks and length of stay has varied: in 2014, sheep went in on the 4th of June and remained for 18 days; 10th of March 2015 for 9 days; and 24th of January 2016 for 27 days.

Over the 3 years, surface cover levels after grazing have been regarded as adequate for protecting the soil against erosion. The highest erosion risk was in 2015 when the initial amount of stubble was low (1.6 t /ha) and after grazing, surface cover ratings were at the threshold of 5; at higher ratings than this (ie 6-8), the soil is regarded as having inadequate protection. Surface cover percentages have been maintained at over 75% on all areas.

Acknowledgements:

Don Bottrall's ongoing commitment and involvement is appreciated. Electric fencing and watering equipment used in this and other UNFS trials was donated to UNFS by PIRSA Rural Solutions SA.

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Primary Industries and Regions SA

Stubble efficiency – Stubble Grazing Condobolin 2015

Author: Ian Menz, Research and Development Agronomist, Condobolin, Nick Moody, Technical Officer, Condobolin, Daryl Reardon, Technical Officer, Condobolin

Funded By: GRDC Stubble Initiative CWF00018

Project Title: Maintaining Profitable Farming Systems with Retained Stubble

Project Duration: 2015

Project Delivery Organisation: Central West Farming Systems

Key Points:

- Treatment 1, Nil grazed, moderate stubble yielded the highest, (2.18 t/ha)
- No significant difference in Total Plant Available Water, majority of stored water was below the 50 cm depth.
- There was a significant difference between the eight treatments when comparing available soil nitrogen.
- There was a significant difference in grain quality attributes between the eight stubble treatments.

Project Report:

Trial aim

This trial is part of a series of trials aimed to investigate how differing summer farming practices influence stored water and how plant available water may influence grain yield potential and grain quality attributes in the low rainfall area in central NSW. The summer farming practices that were investigated included stubble and weed management.

Stubble was managed either through full or partial removal with sheep, other stubble treatments involved stubble left standing or stubble being burnt prior to sowing. In addition when stubble was retained the effect of weed control through sprays treatments was assessed.

As studied in previous year, the effect of stubble, grazing and spray management over the summer period was measured through its effect on plant available water at sowing and flow on effect in grain yield and quality parameters.

Trial details

Soil type:	Red Sandy Loam
Crop 2014:	Twilight field peas and Mannus oats, brown manured
Crop 2015:	Livingston wheat
Sowing rate:	30 kg/ha
Sowing Date:	20th May 2015
Fertiliser:	50 kg MAP
Seeder type:	DBS Parallelogram Hydraulic tyne seeder, with disc culters
Row spacing (cm):	25.4 cm
Harvest date:	9th November 2015

Treatments

1: Nil graze, as is moderate stubble retain
2: Nil graze, as is moderate stubble retain, burnt late
3: Nil graze, high stubble retain
4: Nil graze, mown stubble removed
5: Stubble moderate graze, stubble retention, sprayed for weeds
6: Stubble moderate graze, sprayed for weeds, burnt late
7: Stubble heavy graze stubble retention, sprayed for weeds
8: Stubble heavy graze, stubble retention, one missed spray

Grazing treatments were imposed on the 20th January 2015, when 330 merino ewes were placed on plots. Moderately grazed trial plots had a stocking rate of 727 sheep/ha for one day and were excluded on the 21st January 2015. The heavily grazed trial plots had a stocking rate of 727 sheep/ha for one day and 1455 sheep/ha for an additional day, the sheep were excluded on 22nd January 2015.

Seasonal review

The seasonal conditions experienced at Condobolin Research and Advisory Station, Condobolin during 2015 year had a profound influence on the trial results. The trial was sown into good moisture and established very quickly and evenly. Weed control was exceptional, and the trial was very even throughout the season.

The rainfall for the growing season (May to October) was just below average, with Condobolin Research and Advisory Station recording 198.7 mm during the growing season (Table 1), with the Long Term Average (LTA) during the growing season rainfall of 209 mm. Good rainfall fell in June, July, August and October. Rainfall during both May (11.6 mm) and September (6.2 mm) were well below the long term average of 34.4 mm and 29.1 mm, respectively. In addition to lower than expected rainfall in September, high daytime temperatures in the mid to high thirties were experienced, in conjunction with hot strong winds during the first week in October. Combination of high daytime temperatures, hot winds and low rainfall produced a hard finish for the crop.

Table 1. Monthly rainfall (mm) at Condobolin Research and Advisory Station, Condobolin during 2015.

Dec 14	Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sept 15	Oct 15	Nov 15	Dec 15	Total	In-crop
88.8	59.2	35.2	0.2	64.7	11.6	31.8	41.6	42.3	6.2	65.2	67.3	28.5	454.4	198.7

Trial results

Soil plant available water and nutrient tests

Soil tests were taken just prior to sowing at the soil depths of;

0-10cm
10-30cm
30-50cm
50-70cm
70-90cm

Plant available water

The application of the eight stubble treatments over the summer season did not result in any difference to total plant available water for the eight stubble treatments when soil was taken to a depth of 90 cm. The amount of plant available water to a depth of 90 cm was low and ranged from 43mm to 82 mm over the eight treatments. When plant available water was divided into depths there were increasing amounts of stored moisture at lower depths. The majority (69 %) of the little plant available water stored in the profile was below 50 cm in depth. This moisture was beyond the capacity of seedlings or moderately sized plants to exploit.

Soil Nitrogen

There was a significant difference, at the 5 % level, between the eight treatments when comparing the total available soil nitrogen (kgN/ha) as well as available soil N for soil depths of 0-10 cm, 10-30 cm prior to sowing the trial in 2015. There was no difference in soil N between the eight treatments at depths lower than 30 cm.

Total soil nitrogen levels varied significantly dependant on the stubble management treatment in the previous year. Highest total residual soil nitrogen level, prior to sowing, were recorded for stubble treatment 7 (146.5 kgN/ha), whilst treatment 5 (126.9 kgN/ha) and treatment 2 (121.7 kgN/ha) were similar. These three treatments had stubble retention with weed control through spraying or burning (Table 2.). The lowest total available soil nitrogen prior to sowing was treatment 8 with only 84.4 kgN/ha (Table 2.).

Soil nitrogen levels at the 0 to 10 cm depth ranged from 24.5 kgN/ha to 58.7 kgN/ha (Table 2.). The highest level of available N in the 0 to 10 cm depth was 58.7 kgN/ha for treatment 7, with 52.7 kgN/ha for treatment 5 and with 45.9 kgN/ha for treatment 2 similar in value (Table 2.).

*Table 2.:*Available soil nitrogen (kgN/ha) for soil depths of, 0 to 10 cm, 10 to 30 cm and total profile prior to sowing for eight stubble treatments at Condobolin in 2015.

Stubble treatment	0 to 10 (cm)	10 to 30 (cm)	Total N (cm)
1. Nil graze, moderate stubble retain	44.7	16.0	101.0
2. Nil graze, moderate stubble retain, burnt late	45.9	27.0	121.7
3. Nil graze, high stubble retain	30.1	18.8	91.8
4. Nil graze, mown stubble removed	37.6	19.0	114.9
5. Stubble moderate graze, stubble retained, sprayed	52.7	29.3	126.9
6. Stubble moderate graze, sprayed for weeds, burnt late	36.6	25.3	100.9
7. Stubble heavy graze, stubble retained, sprayed	58.7	29.0	146.5
8. Stubble heavy graze, stubble retained, one miss spray	24.5	19.8	84.4
l.s.d. $_{(p=0.05)}$	13.7	6.0	26.2

Soil nitrogen levels at the 10 to 30 cm depth ranged from 16.0 kgN/ha to 29.3 kgN/ha (Table 2.). The highest level of available N in the 10 to 30 cm depth was 29.3 kgN/ha for treatment 5, with 29.0 kgN/ha for treatment 7, with 27.0 kgN/ha for treatment 2 and with 25.3 kgN/ha for treatment 6 being similar (Table 2.).

Grain Yield and Quality

There was significant difference between the eight treatment grain yields of Livingston (Figure 1.). Treatment 1 (Nil grazed, as is moderate stubble retain) achieved the highest grain yield with 2.18 t/ha. Other treatments that also achieved similar yields were treatment 3 (2.13 t/ha), treatment 4 (2.11 t/ha), treatment 5 (2.07 t/ha) and treatment 6 (2.06 t/ha) (Figure 1. and Table 3.).

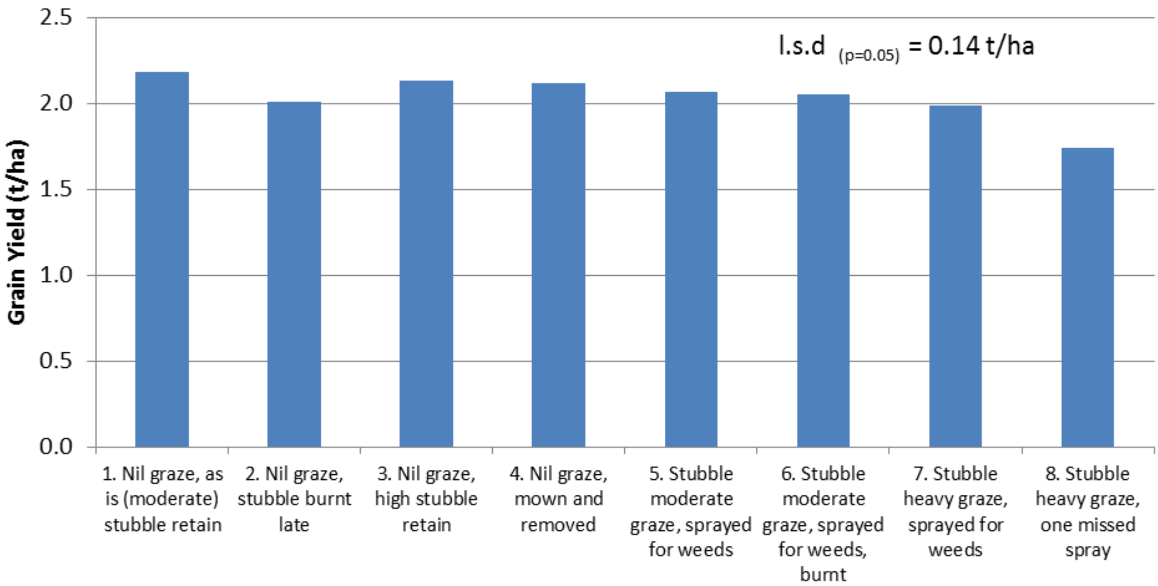

Figure 1: Grain yield (t/ha) for the eight stubble management treatments conducted on the stubble grazing trial at Condobolin in 2015.

The lowest achieved grain yield was achieved for treatment 8 (stubble heavy graze, one missed spray) at 1.74 t/ha (Figure 1. and Table 3.). This is a reduction in grain yield of approximately 20 % when compare to the highest achieved grain in treatment 1.

There were differences, at a 5% significance level, in grain quality attributes between the eight stubble treatments when comparing grain protein, test weight and screenings (Table 3).

The highest grain protein, was achieved in treatment 7, heavy grazed; stubble retained and weeds sprayed (11.7 %), this treatment had the highest total available soil nitrogen (146.5 kgN/ha) (Table 3.). Grain protein levels for treatment 4 (11.1 %), treatment 5 (10.9 %), treatment 8 (10.5 %) and treatment 6 (10.4 %) were similar to that achieved for treatment 7 (Table 3.). There was a significant difference between treatment 7 and treatment 1, treatment 2 and treatment 3, with 9.4 %, 10.3 % and 9.5% respectively (Table 3.).

The grain nitrogen removal ranged from 40.9 kgN/ha for treatment 4 to 31.6 kgN/ha for treatment 8 over the eight stubble treatments (Table 3.). There was no significant difference between the highest five grain nitrogen removal values. The top five rates of grain nitrogen removal were 40.9 kgN/ha, 40.3 kgN/ha, 38.9 kgN/ha, 37.7 kgN/ha, and 36.9 kgN/ha for treatment 4, treatment 7, treatment 5, treatment 6 and treatment 2, respectively (Table 3.).

Table 3: Grain yield (t/ha), grain nitrogen removal (kgN/ha), grain protein (%), test weight (kg/hl), screening (%), tiller number and total available soil nitrogen (kgN/ha) for the eight stubble management treatments conducted on the stubble grazing trial at Condobolin in 2015

Treatment	Grain Yield (t/ha)	Grain Nitrogen Removal	Protein (%)	Test Weight (kg/hl)	Screening (%)	Tiller number (m^2)	Available soil nitrogen (kgN/ ha)
1	2.18	35.6	9.4	75.3	23.1	181.9	101.0
2	2.01	36.9	10.3	73.9	28.2	229.4	121.7
3	2.13	35.4	9.5	75.7	28.5	201.9	91.8
4	2.11	40.9	11.1	72.8	42.8	234.4	114.9
5	2.07	38.9	10.9	73.1	36.9	265.6	126.9
6	2.06	37.7	10.4	73.6	36.6	221.6	100.9
7	1.98	40.3	11.7	72.4	52.6	234.9	146.5
8	1.74	31.6	10.5	73.7	43.4	227.1	84.5
l.s.d. $_{(p=0.05)}$	0.14	4.7	1.3	1.2	12.2	31.1	26.2

Variation between stubble treatments was evident when examining test weight, yet even with this difference none of the samples were in excess of the acceptable GTA standard of 76 kg/hl. The highest test weight was obtain from treatment 3, nil grazed high stubble retained (75.7 kg/hl), treatment 3 was similar to treatment 1, nil graze, moderate stubble retain (75.3 kg/hl) but greater than all other stubble treatments (Table 3.).

Differences in screening was observed between the eight stubble treatments, yet as with test weight all values were well over the acceptable GTA standard of 5 %. Screenings ranged from 23.1 % for treatment 1 to 52.6 % for treatment 7. Treatment 1 achieved the lowest screening with 23.1 %, with not statistically difference at the 5 % level between treatment 1 and treatment 2 (28.2 %) and treatment 3 (28.5 %). The nil grazed, retained stubble treatments (treatments 1, 2 and 3) achieved the lowest screenings (23.1 %, 28.2 % and 28.5 %, respectively), in conjunction these treatments also had the highest test weights (75.3 kg/hl, 73.9 kg/hl and 75.7 kg/hl, respectively) (Table 3.).

Stubble treatment 5 had the largest number of tillers with 265.6 tiller/m^2, whilst treatment 1 had the lowest with 181.9 tiller /m^2. Plant tillers for stubble treatment 7 were similar to that of treatment 5 (Table 3.).

Discussion

Seasonal conditions resulted in a short dry spring resulting in a fast, hot grain fill in and around the Condobolin region in 2015. These seasonal conditions resulted in high screenings and low test weights that fell below the GTA standard of 76 kg/hl and 5 % screenings for any grade ASW1 and above.

Nil grazing stubble treatments, did not affect overall plant available water but did on average improve grain yield to over 2 t/ha, screenings and test weight when compared broadly to stubble treatments that grazed the stubble treatments. The nil grazing treatment with exception of treatment 2, (nil graze, moderate stubble retain and burnt late), achieved the highest grain yields (Table 3. and Figure 1.). It appears that the effect of burning stubble on treatment 2 may have had an influence on the grain yield as this was the difference between treatment 1 and treatment 2.

Sheep grazing on stubble over the summer period in moderate intensity lead to similar grain yield than the nil graze stubble treatments yet the grain quality parameters of test weight were lower and screenings were higher (Table 3.). If grazing intensity was increased from moderately too heavy a reduction in grain yields were observed. In conjunction, increased grazing intensity reduced test weight and increased screening.

Removal of stubble, either by grazing, mowing or burning increased the number of tillers counted in a unit area. Under more normal conditions higher tiller numbers would in increase grain yield potential. The hot dry spring may have reduced productivity from each tiller causing many small pinched grains, resulting in low test weight and high screenings. Higher screenings and test weights in both moderately and heavily grazed may have resulted from increased tillers during the growing season.

In contrast, treatment 1, nil grazed, moderate stubble retained, had the highest ground cover over summer, the lowest number of tillers during the growing season. This caused the highest grain yield, high test weight and low screenings.

Under hot and dry spring conditions, highest grain yields and test weights in conjunction with the lowest protein and screenings were observed when paddocks were not grazed and at least a moderate level of stubble cover was maintained over summer.

Acknowledgement

The contributions of GRDC and CWFS in funding this trial are gratefully acknowledged.

The contribution of the Operational staff at Condobolin Agricultural Research and Advisory Station, Condobolin

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GOOD STUBBLE, BAD STUBBLE - MORE PROFIT, LESS PROFIT

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Funded By: GRDC Stubble Initiative CWF00018

Project Title: Maintaining Profitable Farming Systems with Retained Stubble

Project Duration: 2015

Project Delivery Organisation: Central West Farming Systems

Key Points:

- CWFS regional site trials during 2013 and 2014 suggest stubble loads greater than 3 t/ha can limit yield.
- "No till with no stubble is no good" on hard setting red brown soil types. The dilemma is that the annual incorporation of stubble just prior to sowing by cultivation or removal by burning would result in the loss of significant long term benefits to soil health.
- "If you do not measure it you cannot manage it!" Field measurements of stubble are the starting point for deciding what to do.
- Options to manage stubble loads above 3t/ha need to be made seasonally. Good planning may allow other agronomic and farm efficiency outcomes to be achieved at the same time.

Background

Stubble retention research is not new. The publication Scott et al "Stubble Retention in Cropping Systems in Southern Australia: Benefits and Challenges" (2010) cites research back to 1978. The focus of recent research is concentrating on maintaining profitable retained stubble systems rather than investigating agronomic and economic benefits of stubble retention.

The herbicide "glyphosate" was patented by Monsanto in the early 1970s as the active ingredient in the herbicide Roundup®. Roundup® was introduced to the consumer market in 1974 as a broad-spectrum herbicide and since 1980 has quickly become one of the best selling herbicides in Australia and worldwide. When its patent expired in 2000 the number of glyphosate based products grew dramatically and the cost of the product fell dramatically. The development and adoption of stubble retained farming systems has been and continues to be reliant on the development of glyphosate and different formulations of glyphosate based chemistry.

Major agronomic drivers for the adoption of stubble retained farming systems has beeen minimising soil erosion risk and within season benefits of soil moisture, particularly at sowing. Economic drivers for stubble retention have been lower input costs for machinery (less horsepower per hectare), improved efficiencies and timeliness of operations. Most research cited by Scott reports that the presence of stubble in-crop has a negative impact on yield as opposed to stubble removed farming systems. Cameron et al reports similar findings.

Looking to the future and based on a quick review of papers delivered at GRDC updates in recent years, it is reasonable to suggest that the decision to retain stubbles in a cropping business will continue to be driven by limiting soil erosion and degradation, maximising sowing soil moisture and improved machinery efficiencies and timeliness of operations. These overarching benefits may be tempered, however, as seasonally tactical stubble management approaches are required for managing herbicide resistance, lowering input costs or production risk and reliably improving yield under certain conditions.

Stubble retention reduces yield but not profit

In a GRDC update paper presented at West Wyalong (29.07.2014) "Lifting productivity in retained stubble farming systems" by James Hunt, et al, a review of local research demonstrated that most of the benefits of stubble retention (no erosion or run-off) are achieved at stubble loads of 2-3 t/ha. The paper proposed that retaining cereal stubble above 2-3t/ha past sowing is unlikely to provide any yield benefits and in favourable seasons (>250 mm growing season rainfall) can reduce yield (Figure 1). The dilemma is that the annual incorporation of stubble prior to sowing by cultivation or removal by burning would result in the loss of significant long term benefits to soil health. Many would question whether this approach to stubble management maintains a stubble retained farming system.

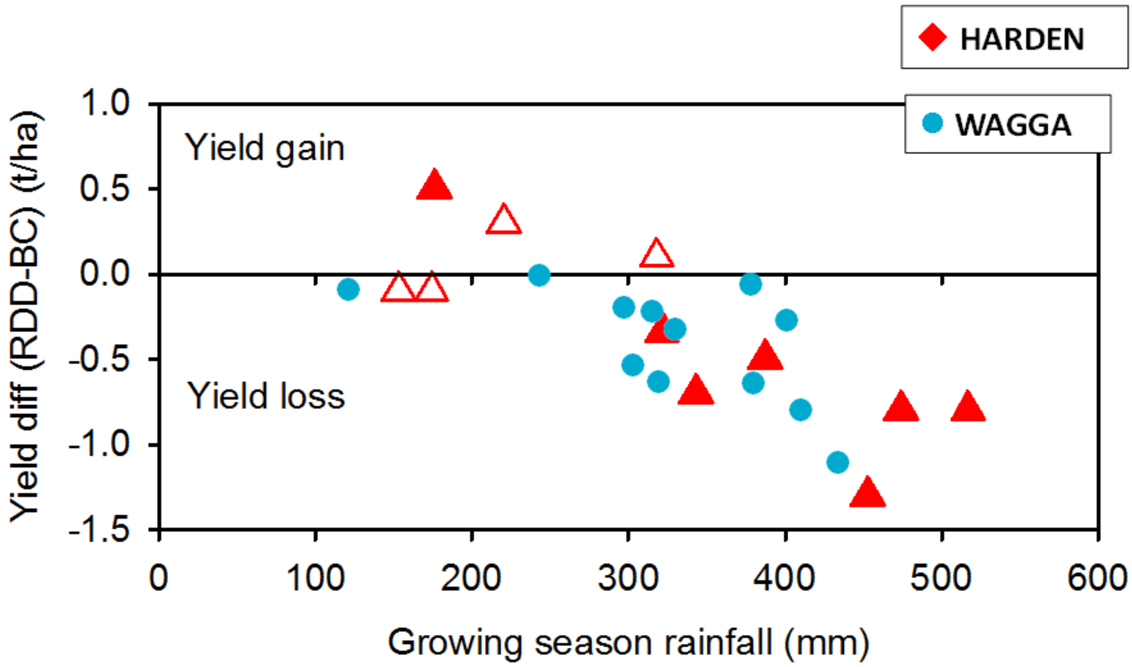

Figure 1. The relationship between growing season rainfall and the yield difference between stubble retained direct drill (RDD) treatments vs. burn and cultivate (BC) treatments form long term sites at Wagga (NSW DPI) and Harden (CSIRO). Figure courtesy of John Kirkegaard, CSIRO

The Merrriwagga tillage and rotation trial was established in 1999 and is currently managed by AgGrow Agronomy and Research on behalf of Merriwagga growers and research partners Central West Farming Systems. Since 1999 continuous stubble retention has been more profitable than annual cultivation in all unaltered rotations. Long term stubble loads have not been collected at Merriwagga but given the environment and yields achieved at Merriwagga a 2-3 t/ha stubble load was unlikely to be present at sowing in the great majority of years. Growing season rainfall would also have been less than 250 mm in most years, meaning yield penalties from retaining stubble are unlikely (Figure 1). It cannot be determined whether active stubble management in the high stubble years would have resulted in higher yields or profits. It is observed that in the Merriwagga environment stubble retention is more profitable than the alternate annual tillage system.

CWFS trials to date

CWFS has conducted eighteen trials at its regional sites that investigate the impact of different stubble treatments (burning, cultivation or standing stubble) have on the yield of wheat, barley and canola, refer figure 3 for a summary impact of stubble loading on yield. The trials with wheat and barley have also evaluated any varietal responses within crop species to the impact of the different stubble treatments.

During 2013 CWFS conducted trials at six locations - Tottenham, Euabalong, Weethalle, Rankins Springs, Wirrinya and Tullamore. During 2014 CWFS again conducted trials at six locations - Nyngan, Alectown, Gunning Gap, Lake Cargelligo, Ungarie and Tullamore. In 2015 similar trials are currently established at Weethalle, Tottenham, Wirrinya, Mumbil Tank and Tullamore; stubble treatments tested are standing, burnt, cultivated and harrowed (knocked over not incorporated into soil).

Of the eighteen trials, eight have been established in commercial paddocks with stubble loading of less than 3 t/ha and six have shown no yield response to cultivation or burning stubble late in fallow. Two sites, Tullamore (2013) and Lake Cargelligo (2014) both showed a yield response to cultivation. Both sites suffered compacted soil, at Tullamore due to heavy grazing and Lake Cargelligo due to soil type and lack of ground cover over fallow. A yield response was also observed at Tullamore to burning, most likely related to its effect on the established windmill grass present.

Of the 10 trials with stubble loading greater than 3 t/ha an improvement in yield in either the burnt or cultivated treatment has been observed at six trials. It should be noted that a yield improvement in both

Merriwagga Tillage and Rotation Trial

The Merrriwagga tillage and rotation trial established in 1999 aimed to compare five different cropping rotations using no-till farming techniques and conventional farming methods. The trial is situated 10km west of Merriwagga, NSW. Soils are red sandy loams with an underlying calcareous clay with a pH of 5.5-6.5 and have a tendency to erode with wind and water. Each plot is 1 ha, each treatment is replicated three times and the total trial area is 30 ha. The 2014 Merriwagga trial report highlighted some clear trends after 16 years:

When using contract rates growing crops with no-till techniques has been on average 15% cheaper. In every rotation tested the no-till system has resulted in a higher cumulative gross margin than the conventional rotation. Contract rates are different to the costs a typical farmer would apply but it does allow for a very good comparison of real costs associated with each farming system.

The most profitable rotation has been two cereals followed by a break crop of either peas, lupins or canola under a no-till system (Refer figure 2). Interestingly, a continuous wheat rotation no-till is a close second. It is an interesting discussion and beyond the scope of this paper as to why, despite the agronomic risks, the continuous wheat rotation performs so well in the drier Merriwagga environment.

Generally no-till farming methods compared to cultivation have maintained or increased yields in continuous cropping rotations. The exception is where a fallow exists in the rotation and in this case cultivation has increased yield in most but not all years.

Rotation 1 and rotation 2 are two cereals followed by a break crop such as peas but are not in years. Rotation 1 was in lupins in 2014, rotation 2 is due for a break crop 2015.

WFW is wheat-fallow-wheat.

WLFW has been wheat-fallow-wheat since 2005 but alternates with the wheat-fallow-wheat rotation above. Therefore the years when this rotation is sown to wheat the WFW is fallow.

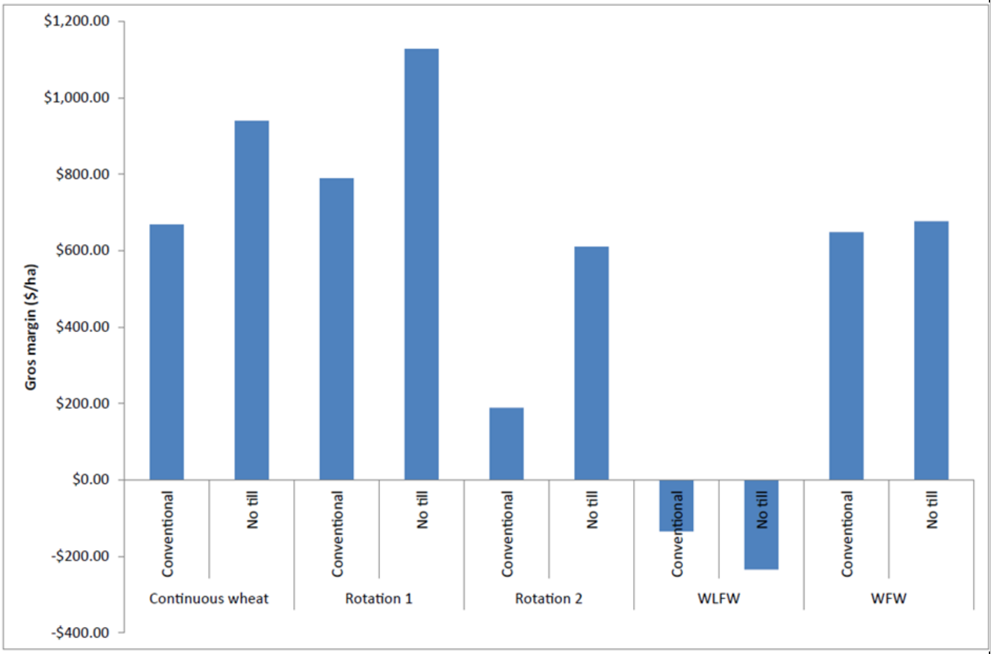

Figure 2. Cumulative gross margin results from Merriwagga long term trial 1999-2014.

treatments was only observed at two trials. The four trials where no response to either treatment was observed were the 2014 Alectown and Ungarie cereal trials and the 2014 Rankins Springs and Wirrinya canola trials, all of which suffered moderate to severe frost damage.

An important issue highlighted by the cereal trials is that no treatment changed the variety yield ranking. Stubble modification did not improve a poor variety's performance. The best option in terms of yield was to simply grow the variety with the highest yield potential for the sowing window. (*Figure 3 removed)*

How can stubble loads greater than 3 t/ha be managed?

There are seven options to reduce stubble load between harvest and sowing. The decision will be impacted by many interactive factors that produce a range of potential risks or rewards as shown in Figure 4.

1. At harvest with the header.
2. Left undisturbed during the fallow, the do nothing option.
3. Cultivated into the soil during the fallow.

4. Mechanically managed but retained on the surface during the fallow (e.g. flail mulched, slashed, harrowed, crushed, rolled).
5. Burnt.
6. Removed (e.g. baled).
7. Grazed during the fallow.

CAUTION: Do not place stubble management in front of fallow management i.e. control of summer fallow weeds.

Subsoil moisture trumps stubble loading as a driver for future yields!

Also important are those paddocks which for some reason end up with no ground cover and are compacted (e.g. end of pasture phase, during drought periods or other natural disasters). Local farmer experience (particularly on red brown earths), CANFA experience and Neville Gould's summary "No-till with no stubble, no good" (this summary is also supported by Pittelkow et al) show in these instances cultivation is the best option to return the system to production.

Golden rules for CWFS districts for fallow stubble:

Ground cover minimises soil erosion. Summer rainfall stored as soil moisture during the fallow is a major driver of subsequent crop yield.

The presence and architecture of stubble may impact weed germination and spraying results, mice populations, fire risk and in a mixed farming business feed budgets for livestock during the fallow. These impacts need to be actively managed to minimise impact on profit. The seasonal timing and distribution of fallow rainfall will call for different annual management response.

The presence and architecture of stubble at the end of fallow will affect sowing conditions. Target and manage what characteristics you desire.

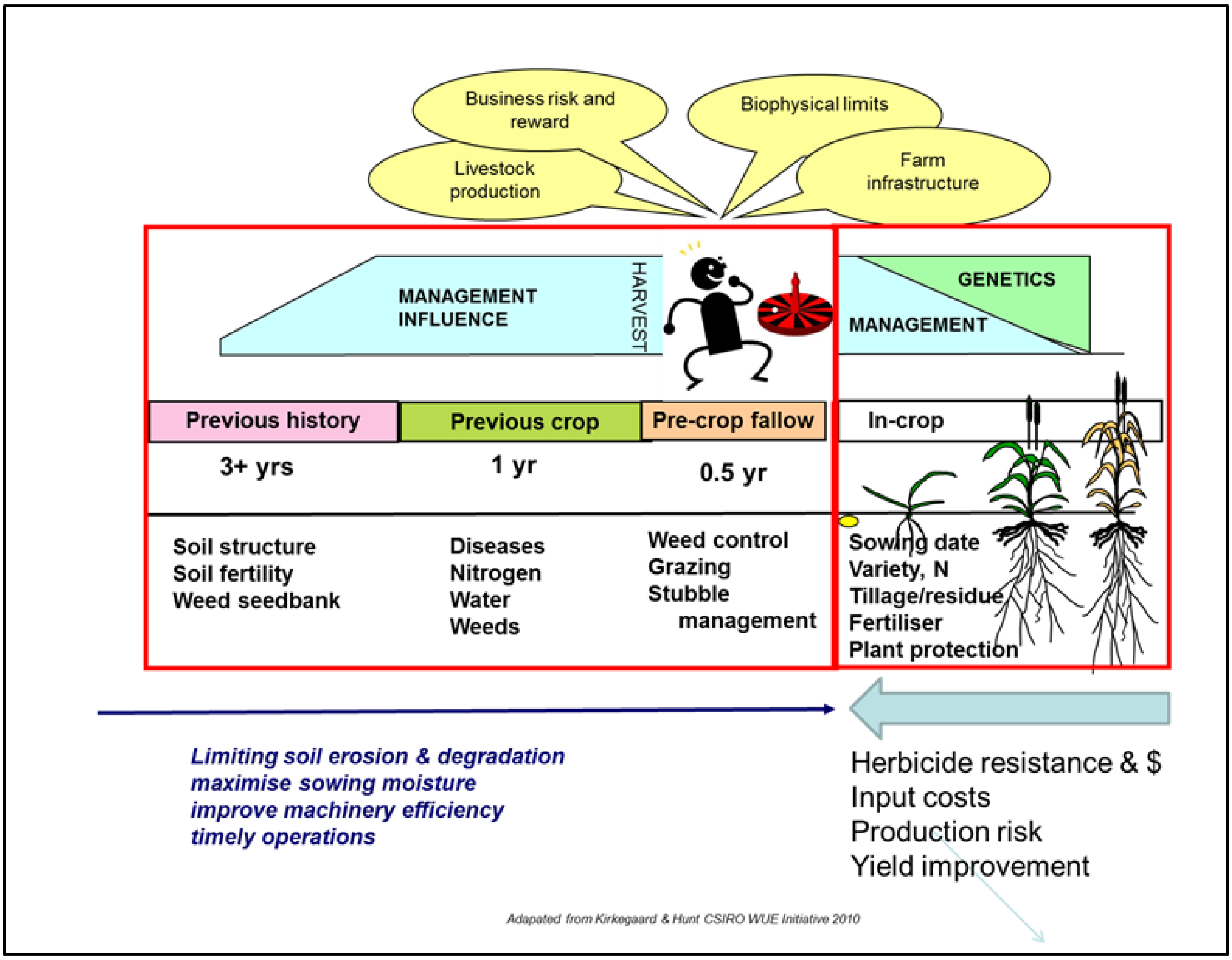

Figure 4: Management considerations in deciding how to manage stubble.

Summarising available options for managing stubbles

1. At harvest with the header

Golden rules for CWFS districts at harvest: *Ensure harvest is completed ASAP to avoid weather damage. Harvesting costs vary considerably from farm to farm but generally a header at harvest is an expensive option to "groom or mulch" crop residue. "Groom" only for an economic or agronomic outcome that cannot be achieved once harvest is complete such as weed seed management.*

Recent Stubble Initiative trial results;

a. CWFS harvest height trial at Weethalle 2013, 2014. - A replicated trial concluded that stubble height did not influence fallow efficiency in dry seasons.

b. CWFS windrow burning trial at West Wyalong in 2013 that compared the impact on paddock performance of windrowing and burning to manage rye grass seed bank in comparison to harvesting at a traditional harvest height. Key outcomes of this trial were:

- Well managed windrow burning effectively reduces the ryegrass seed bank.
- To effectively establish windrows requires forward planning and potentially slows harvest and increases harvest cost.
- Burn as early as conditions allow. Make it a priority job.
- Small rainfall events may germinate weeds in burnt areas that require attention before the whole paddock area.
- More work needs to be done over a number of seasons to quantify any impact on fallow efficiency.

c. Farmlink "The cost of harvesting low" data compiled by Paul Breust for wheat cv. Suntop in 2014 at different harvest heights.

Table 1: Values are means of three replicates taken from John Deere 9770 STS yield monitor and all differences are significant ($P<0.05$)."The cost of harvesting low" Farmlink, Breust 2014.

Cut height	Efficiency (ha/h)	Speed (km/h)	Fuel (l/hr)	Fuel (l/ha)	Efficiency (t/h)	Yield (t/ha)
Short (15 cm)	5.7	6.2	54.3	9.6	14.0	2.05
Tall (60 cm)	9.5	10.6	51.2	5.4	28.8	2.19
% decrease harvesting short	41%	42%	-6%	-78%	51%	6%

d. CWFS stubble trials at Weethalle and West Wyalong 2013. At both sites plots with taller stubble required spraying for weeds prior to plots with shorter stubbles. Effectively this resulted in an extra spray during the fallow in a dry summer.

2. The do nothing option

To date this is the business as usual for many farmers and they are balancing the short term loss of potential yield against the long term benefits of organic matter in their farming business. Such decisions are extremely valid despite being extremely difficult to ever accurately quantify long term benefit of short term losses. Every business is different and in the end the decision relates more to the aspirations and attitudes of the individual.

From an agronomic viewpoint this option requires careful consideration of how high stubble loads impact on the efficacy of fallow herbicide sprays and pre-emergent in-crop herbicide. Herbicide options will become more limiting and potentially expensive. Higher water rates which add to the expense of spraying should also be considered. The use of "stubble movers" on sowing rigs maybe needed to produce ideal sowing conditions.

3. Cultivated into the soil during the fallow

Advantages of cultivation:

- Weed seed burial of difficult to control or herbicide resistant surface germinating weeds e.g. fleabane.
- Renovation of tram tracks.
- Management of a fallow weed blow out where early summer rain has germinated weeds and subsequent hot conditions made herbicide control difficult and expensive, such as in the 2014-2015 summer.

- Reduction of fire risk. The wide spread adoption of stubble retention during the summer fallow has increased the fire risk across the landscape as well as allowing fires that start the opportunity to spread rapidly. During the 2015 CWFS survey of fallow management practice, the cultivation of heavy stubble paddocks along public roadways where fires may start was a consideration. Also on mixed farming operations the cultivation of strategic paddocks to provide a livestock refuge was also practiced.
- Incorporation of lime and other soil ameliorants.
- Reduction in some pest and disease populations. Careful consideration to the biology of the specific pest or disease is required to ensure a positive outcome is achieved.
- Accumulation of immobile nutrients such as phosphorus on the surface layers in paddocks with a long history of no-till has been widely reported. Soil tests from some CWFS regional sites support these reports. During 2015 CWFS is conducting initial trials to investigate if cultivation effectively redistributes immobile nutrients back through the profile for crop use.

Disadvantages of cultivation:

- Most likely the most expensive in terms of cash cost, impact of soil structure and potential for wind or water soil erosion.
- Seasonal conditions, either dry or wet, may reduce the number of days with optimum seed bed moisture.
- Potential for increasing the spread of weed seeds, soil borne pests and diseases within paddocks and between paddocks. This is an important consideration when contractors are used for one-off tillage operations. A strict biosecurity plan may reduce the risk.
- Reduction in population of soil based predators such as Carabid beetles, spiders and ants.
- Likely to encourage weeds that require burial to trigger germination e.g. black oats. Burial of weed seeds which reduces natural attrition and efficacy of pre-emergent herbicides such as trifluralin, Sakura and Boxer Gold.

For further information refer to GRDC projects DAN152 and ERM00003.

<u>4. Mechanically managed but retained on the surface during the fallow </u>(e.g. Flail mulched, slashed, harrowed, crushed and rolled)

During the 2015 CWFS survey of fallow management practice the idea of mechanical stubble management with no soil disturbance was observed amongst growers, particularly in the eastern CWFS districts.

Advantages:

- Potentially the cheapest in terms of cash cost if the motivation is to physically keep the stubble in the paddock.
- Limited impact on soil structure.
- Maintain ground cover.
- Can easily be adopted in controlled traffic farming systems.
- May encourage quicker biological decomposition.

Disadvantages:

- Laying stubble over may lower the efficacy of pre-emergent herbicides.
- Laying stubble over may lead to "hair pinning" issues with disc seeders.
- The use of "stubble movers" on sowing rigs maybe needed to produce ideal sowing conditions.
- Depending on machinery choice may leave "lumps" of stubble or windrows in the paddock.

Bill Long from Ag Consulting Co. (www. agex.org.au/.../innovative-stubble-management-seeding-begins-harvest/) promotes the idea of double cut stubble using the header a second time after harvest is complete, resulting in a greater chaff fraction and less straw and allowing faster breakdown of stubble residues following harvest. The concept is that it is best to keep as much stubble standing rather than laying over to increase herbicide efficacy during crop establishment. Standing stubbles also act as a barrier to soil throw between rows, reducing the chance of crop damage from high herbicide concentrations.

5. Burning

Often seen as the cheap option but the cost of burning stubble needs to be considered both in terms of dollar labour cost and lost nutrients. Costs of compliance with burning regulations, WHS and insurance should not be underestimated. It is also a good last minute option where despite good planning stubble is still interfering with sowing. Burning potentially may lower populations of pests such as mice particularly if a baiting program is used immediately post-burn.

6. Removal (e.g. baled)

Baling straw post harvest can be profitable in some seasons. Unfortunately if drought conditions are driving straw demand the benfits of baling to remove stubble loads above 3 t/ha may not be needed. The impact of machinery used for baling on soil conditions and compaction needs to be carefully considered. Unless carefully planned, opportunistic baling to reduce stubble loads may create as many long term problems as it solves.

7. Grazed during the fallow

In mixed farming operations summer stubble is an important feed resource. CWFS and Farmlink research during both the Water Use Efficiency project and this project confirms that when correctly managed, sheep grazing stubbles during the fallow have no significant impact on subsequent crops.

Critical success factors for stubble grazing are:

- Sheep's mouths removing ground cover damage soil rather than soil compaction by feet.
- Ensuring at least 2 tonnes per hectare of stubble cover remains (70% cover). The cost and risk of going below this threshold in periods of drought will be different for each business. Therefore general rules of thumb are unsuitable.
- Do not let grazing compromise summer weed control. Spray weeds before grazing.
- Closely monitoring condition of sheep. Once split grain, husks and palatable weeds are eaten the feed value of standing straw alone maybe not sufficient.

If you do not measure it you cannot manage it!

If different stubble loadings, for example above 3 t/ha at sowing and below 3 t/ha at sowing, are going to be managed differently in an attempt to improve yield then stubble loads need to be accurately known at a paddock scale. Growers need to quantify stubble loads to improve seasonal management. The idea is no different to the management of soil nutrients and soil testing, if the amount of soil N or P is not reliably known the most profitable programs cannot be reliably developed.

Bowman, 2006, suggests stubble present after harvest is about 1.5 times the grain yield for yields between 0.5 to 4 t/ha in drier areas. This rule of thumb does not account for stubble still present from crops prior to the crop just harvested. Also the amount of stubble decomposition over summer is dependent on seasonal conditions.

Mallee Sustainable Farming, Mildura, have produced a series of reference photographs that are useful in estimating ground cover percentage after different stubble management operations. The stubble management guide is available from their website (put the URL here).

At the end of the day the most reliable method of monitoring stubble loads is to representatively collect and weigh samples from across the paddock. Same as collecting soil samples, ensure the samples taken represent the paddock by taking multiple samples and avoid unrepresentative areas such as headlands, trees and small areas of distinctly different soil types, all of which will have a greater impact on crop performance than stubble load at sowing.

To take samples you will need:

- A metre square quadrant.
- Rake.
- A chaff bag or something similar to put stubble in.
- Battery powered digital scales (e.g. for calibrating air-seeder, weighing granular herbicides) or pocket spring scale (e.g. scales used for checking fish weights when fishing) that can measure in the 0 to 1 kg range.

Method:

1. When stubble in paddock is dry randomly throw quadrant. If stubble is wet samples will need to be dried.
2. Rake up all stubble (standing and lying on ground) inside quadrant, put in bag and weigh. Do not collect soil as it will quickly cause inaccurate weights.
3. Every 100 grams of stubble per square metre equals 1 tonne of stubble per hectare. i.e., 200g stubble equates to 2 t/ha, 250g equates to 2.5 t/ha, 300g equates to 3 t/ha.
4. It is reasonable to think that after some time the operator will gain an ability to know by feel and volume whether the stubble collected is above or below any pre-determined threshold weight but they should "recalibrate" themselves when conditions change.

Conclusion

In CWFS districts it appears that most of the benefits of stubble retention are achieved by retaining 3 t/ha and more than this can potentially limit yields, particularly in favourable seasons. Options exist to strategically lower stubble loads. Monitoring how much stubble is present is the starting point in deciding if action is required. Seasonal conditions and individual farm business's aspirations will dictate which option is best. If stubble removal is to be undertaken other non-agronomic advantages such as paddock layout, reduction in business risk and soil improvement opportunities may also be achieved at the same time.

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PERENNIAL PASTURE MANAGEMENT SYSTEMS FOR SOIL CARBON STOCKS IN CEREAL ZONES

Author: Jodie Reseigh,

Funded By: Australian Government Department of Agriculture – Action on the Ground. **AOTGR1-0044**

Project Title: Perennial pasture management systems for soil carbon stocks in cereal zones

Project Duration: *2011-2015*

Project Delivery Organisation: *Rural Solutions*

Key Points:

- The project has established 13 demonstration sites in the upper north and eastern Eyre Peninsula of South Australia that provide opportunities to determine the value of short-term measures of management change (e.g. ground cover) to inform longer-term impacts on soil carbon
- In the short-term (2 years) measures of plant productivity (ground cover, cover rating, perennial plant number) were more sensitive to management change compared to soil carbon stocks and may represent valuable short-term monitoring tools to inform longer-term modelling of likely soil carbon outcomes
- Changes in Soil Organic Carbon stocks may take many years to see change, let along significant change.
- Trials such as these have an important role in establishing the most likely management practices which will lead to improvements in landscape attributes (ground cover, cover rating, perennial plant number) and ultimately Soil Organic Carbon stocks
- Soil Organic Carbon monitoring methods need to be able to detect small but real changes in Soil Organic Carbon as a result of a change in management
- Improvements in plant productivity were observed for all management practices, implying an increase in carbon inputs to the soil, and a reduced risk of carbon losses from the soil, providing the theoretical potential to increases Soil Organic Carbon stocks over time. Longer-term monitoring (>2 years) is required to measure the Soil Organic Carbon changes that may result from rotational grazing, management of unviable or degraded land, and approaches to increase perennials

Project Report:

Below is a summary of the final report on this project. For the full reports please visit our website. Case Studies will be released in 2016 from the sites used in this project.

The project investigated four management practices that have been proposed to increase the sequestration of carbon in soils: rotational grazing; management of unviable cropping land; management of degraded land and management for increased perennials; at 13 sites in the cropping and grazing region of the upper north and eastern Eyre Peninsula, South Australia. The trial found that no one management practice conclusively led to improved soil organic carbon (SOC) stocks, increases in production and reduction in erosion risk (Table 1), however cover rating and ground cover measurements were more sensitive to management change over the two year trial, compared to SOC stocks and erosion risk attributes. Overall the SOC stocks declined in 6 of the trial sites, remained constant in 5 of the sites, and increased in 2 sites. The changes in SOC stocks were inconsistent with management which may be attributed to a wide range of site specific parameters (e.g. soil type, climate), the way in which management change was implemented, and the lack of time to reach a new equilibrium state.

Despite the lack of consistent evidence for the effectiveness of different management practices on SOC stocks, production and erosion risk attributes, important trends have emerged. With increases in some production and landscape attributes: rotational grazing led to increases in perennial plant numbers; management of unviable cropping land led to increase in ground cover; management of degraded land led to improvements in cover (decreased cover rating); and management for increased perennials led to improvements in ground cover.

Table 1. Summary of the impact of management on the change (2012-2014) in measured landscape attributes where each site is represented by a symbol indicating non-significance (0), or a significant ($P<0.05$) increases (□) or decreases (□), NA = not applicable.

Management practice	Number of sites	Landscape attributes				
		SOC stocks	Erosion risk	Cover rating#	Ground cover	Perennial plants
rotational grazing	3	0 ↓* ↓	0 0 0	0 0 ↓	↑ ↑ ↓	↑ NA ↑
unviable cropping land	3	0 0 ↓	0 0 0	↓ ↓ 0	↑ ↑ ↑	↑ 0 ↑
degraded land	4	↑ 0 ↓* ↓	0 0 0 0	↓ ↓ ↓ ↓	↑ ↑ 0 ↑	NA ↑ ↓ ↑
increased perennials	3	↓ 0 ↑	0 0 0	0 ↓ ↓	↑ ↑ ↑	↑ ↑ 0

* Changes of < 2.0 Mg C ha-1 are expected within natural variability (pers. comm. L Macdonald April 2015); # Cover rating is a 1-8 scale, with 1 = highest cover rating and 8 = lowest cover rating. Therefore a decrease in cover rating is an improvement in condition.

The project has identified a number of questions which arose and remain unanswered:

- Are there more appropriate simple and inexpensive short-term monitoring tools (e.g. remote sensing of landscape attributes) that can inform the likely longer-term outcomes of management change on SOC stocks?
- How to engage farmers and the community in managing for SOC in the future? Managing for carbon is seen by many as low priority due to:
- lack of information about how best to manage for SOC
- how to measure SOC
- concern about implications of offsetting, particularly commitment to long timeframes
- mixed policy
- Management and complementarity of above and below ground carbon on farm, needs to further explored and defined.
- How to account for the effect of microbial activity on SOC balance.

Methodology

Twelve landholders (a total of 13 sites) were identified in the Upper North and on eastern Eyre Peninsula (Figure 1) based on their (i) interest in participating in a trial to increase soil organic carbon on their property through implementation of one of the four management practices; (ii) commitment to undertake management actions aimed at increasing soil organic carbon; (iii) willingness to record and provide details of management actions undertaken; (iv) proven management history (e.g. cropping, grazing, fertiliser application) of their paddocks and farm; and (v) preparedness to share their learnings about management actions aimed at increasing soil organic carbon (SOC) undertaken on their property.

All landholders in the trial are mixed farmers, with cereal (predominately wheat and barley) and livestock (sheep, cattle) enterprises. Annual rainfall varies across the study area from 278 to 422 mm (winter dominant). Demonstration site soils were classified using Australian Soil Classification as Calcarosols (7 sites), Chromosols (3 sites) and Sodosol (3 sites).

Management histories were collected for all demonstration sites and included details of livestock grazing, cropping and fertiliser management. The management history for each demonstration site is based on landholder records, observations and discussions about their current and previous management where possible. Rainfall records from each landholder were obtained including average annual rainfall (from long term farm records) and annual rainfall during the period of the trial (2011-2014).

Landholder records of dates and types of management actions undertaken at each demonstration site were collected including building of infrastructure (fencing, watering points); grazing management (type and number of stock, grazing period, grazing/rest interval); rates of application of fertiliser; rates of application of amendments (hay, gypsum); pasture preparation techniques (spraying, cultivation); and types and amounts of seed planted. For further details refer to next section.

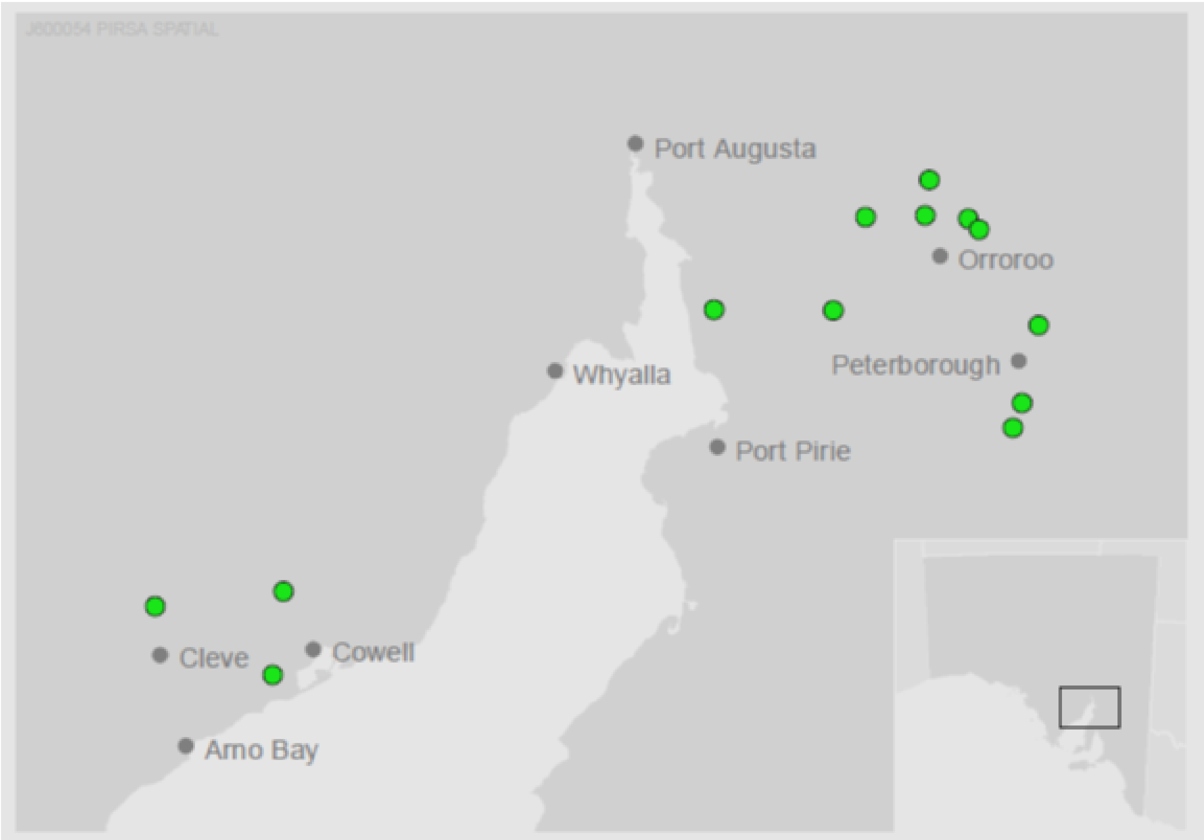

***Figure 1**. Trial site locations in the upper north and eastern Eyre Peninsula of South Australia*

Management Actions

The trial demonstrated a number and range of management practices including:

- rotational grazing – intensive grazing (5-14 days) followed by long rest periods (90-120 days)
- management of unviable cropping land – retirement of cropping land which is unviable and unprofitable due to low yields and higher costs of production
- management of degraded land – land which has been degraded through a range of processes including erosion and dry land salinity
- management for increased perennials – grazing land with low to no perennial plants

Associated with the implementation of each management practice was a number of management actions, these are summarised in Table 2, and detailed on a site basis below.

Site 1 - Orroroo

The property has a long history (soon after settlement in 1870s) of continuous grazing with sheep for extended periods (months) before they were moved to adjacent paddocks. Paddocks were watered with a single watering point, with the surrounding area heavily grazed.

Management actions commenced in 2013 with fencing of the 243 ha paddock into 5 smaller paddocks (4 @ 50 ha and 1 @ 43 ha), and installation of 4 new watering points. Rotational grazing of the new paddocks began in September 2013 with 2 weeks grazing followed by 3 to 4 months rest at 14.9 DSE/ha (280 ewes plus 350 lambs).

Livestock were removed from the paddocks from October to the end of November to enable seed set of perennial grasses.

Site 2 – Booleroo Centre

The property has a long history (130 years) of cropping and grazing with the regional practice of continuous grazing with relatively low stock density for most of the year. The cropping regime prior to 2007 was sowing of a cereal, either barley and wheat and a self-regenerating pasture in the following year. From 2008 to present, continuous cropping of either a cereal (barley or wheat) or legume (vetch) in large paddocks has been undertaken.

Several paddocks, including the trial paddock have been divided in half to i) increase the number of paddocks for rotational grazing ii) make them a similar size. A new dam was constructed to increase water supply and additional watering points installed in 2013. In June 2012, barley was sown at 65 kg/ha with 19:13 sulfate of ammonia at 100 kg/ha. The paddock was sprayed with 1.2 L/ha Trifluralin and 800 mL of Glyphosate in preparation for sowing. The crop was sprayed in August with 700 mL of MCPA amine to control broad leaf weeds (e.g. Capeweed, mustard, thistles). The crop was grazed in August at 35 DSE/ha (450 ewes and lambs) for 2 weeks.

In early May 2013, the paddock was sprayed with 1.5 L/ha Trifluralin and 800 mL of Glyphosate and immediately sown with vetch at 50 kg/ha plus 19:13 sulfate of ammonia fertiliser at 100 kg/ha. The crop was sprayed in June with 75 mL of Verdict ®TM and 50 mL Dimethoate to control grass weeds (e.g. annual Ryegrass, Barley grass, Brome grass) and insects.

The area was grazed at 25 DSE/ha (320 ewes and lambs) for a total of 4 weeks during August and September. Following removal of the livestock the vetch regrew allowing a further grazing of 10 DSE/ha (300 lambs) and supplementary feeders for 1 week.

In May 2014, barley was sown at 52 kg/ha and Cavalier medic at 12 kg/ha with 24:16 fertiliser at 80 kg/ha. The paddock was sprayed, in January with 1.0 L/ha Glyphosate to control summer weeds, and again in preparation for sowing with 1.2 L/ha Trifluralin and 600 mL of Glyphosate. In July 40 kg/ha urea was spread.

Site 3 – Elbow Hill

The area was settled in the 1880's and was cleared for cropping. Since then the paddock has had a history of cropping with both wheat and barley. The cropping regime has varied from cropping and a pasture phase, to continuous cropping in the period 2007-2009. Moderate rates of high analysis fertiliser were applied with the crop, from 1980 to 2009. Prior to this, single superphosphate was applied with the crop. The paddock and adjoining land have not been cropped since 2009, due to a combination of poor yields and increasing costs. The paddocks were set stocked for most of the year at generally low stocking densities.

Fences were repaired or replaced in 2013 to make the paddocks stock proof using 5 ring cyclone mesh. Construction of central watering points using watering yards with a single trough and high water flows allowed four paddocks to be watered from a single point.

Rotational grazing began in May 2013, with sheep grazing at 34 DSE/ha for 5-10 days, followed by up to 120 day rest depending on seasonal conditions.

Site 4 - Orroroo

The paddock has not been cropped since 1984. Prior to this time, the site had been cropped using a 4 year rotation with 2 years of cereals plus MAP or DAP, followed by 2 years of self-regenerating pasture. The paddock was either fallowed in late summer/autumn or cultivated twice before sowing. Prior to the late 1970's single superphosphate was applied at 50 kg/ha. Cow manure was spread on the paddock in 2007 at a rate of 2 t/ha.

As the paddock is close to the; house, yards and feedlot; it has been used as a holding paddock for shearing and the feedlot. During April to November it is usually grazed with sheep for 1 week, and 30-40 cattle are grazed overnight twice per year.

The original pasture consisted of annual grasses and broadleaf weeds (low levels of surface cover), so the pasture was sprayed in August 2013 with 1 L/ha Glyphosate and sown to Windmill grass (*Chloris truncata*) at 3 to 4 kg/ha in September, 2013.

Site 5 - Peterborough

The property has a history of cropping (~ 100 plus years) on a regular basis. Cropping ceased in 2004. The cropping regime was typically sown to cereal and fertilised with moderate rates of phosphorous fertiliser followed by a year of self-regenerating pasture. The property was typically set stocked at a low stocking rate over the whole year.

Following a change in land manager, cropping ceased and pastures were left to regenerate. Following the cessation of cropping, Onion weed (*Asphodelus fistulosus*) began to dominate the pasture composition of the paddock, particularly following summer rains in 2011/12. In April 2013, following summer rain the area was sprayed with 2,4 D 680 at 1 L/ha plus 5 g/ha Ally to control the Onion weed. This achieved a very good control of >95 %.

The original paddock was 127 ha and this was sub-divided into three paddocks (two paddocks each 38.5 ha, and one paddock 49 ha), during 2013 with a central watering yard.

In May 2014, the eastern paddock (38.5 ha) was sprayed with Gramoxone at 1.4 L/ha to control grassy weeds, Onion weed and thistles. The paddock was spread with Wallaby grass at 4 kg/ha and medic seed at 3 kg/ha in late May/early June 2014. Windmill grass seed was spread in late August/ early September at 2 kg/ha.

Rotational grazing commenced in 2013, following establishment of the Wallaby grass (*Austrodanthonia* species) and medic (*Medicago* species). The paddock was grazed in 2014 for two weeks at 11.2 DSE/ha (200 ewes and lambs) in late September 2014 and for 10 days at 6.2 DSE/ha (200 ewes) in mid-October.

***Table 2**. Summary of management practices, number of sites, site number and summary of management actions*

Management practice	Number of sites	Site number	Brief summary of management actions
Rotational grazing	3	1	• Paddock subdivision • Rotational grazing of native pasture
		2	• Paddock subdivision • Rotational grazing of annual cereals and legumes
		3	• Paddock subdivision • Rotational grazing of native pasture
Management of unviable cropping land	3	4	• Spraying to manage annual grasses and broad leaf weeds • Sowing of Windmill grass • Not grazed
		5	• Paddock subdivision • Spraying to manage broad leaf weeds, in particular Onion weed • Sowing of Windmill grass • Sowing of Wallaby grass and annual medic • Implementation of rotational grazing
		6	• Modified pasture cropping • Grazing of pasture and cereals
Management of degraded land	4	7	• Paddock subdivision • Cultivation in preparation for planting forage shrubs • Planting of forage shrubs • Spreading of straw (20-30 t/ha)
		8	• Spreading of straw (8-10 t/ha) • Sowing of Windmill grass • Sowing of Wallaby grass • Rotational grazing of pasture
		9	• Spreading of 2 t/ha gypsum • Sowing Angel medic • Sowing of Wallaby grass • Grazing of pasture
		10	• Spreading of 2 t/ha gypsum • Spraying of annual grasses and broadleaf weeds • Sowing of Lucerne, Tall Wheat grass and Puccinella • Sowing of forage shrubs
Management for increased perennials	3	11	• Spraying of broadleaf weeds, in particular Onion weed • Sowing of Wallaby grass • Rotational grazing of native pasture
		12	• Spraying of woody weeds and annual grasses, in particular Blanket weed • Ploughed to manage woody weeds • Sowing of Puccinella and Tall Wheat grass • Rotational grazing of pasture
		13	• Ripping in preparation for planting forage shrubs • Spraying to control weeds • Planting of forage shrubs • Grazing of pasture

Site 6 - Carrieton

The local area has been cropped on an ad hoc basis for at least 100 years or more. Fertiliser was applied with the crop in most seasons. However with increasing costs and unreliable seasonal conditions, the area is no longer deemed sustainable or profitable for cropping. As a result, paddocks have been progressively removed from cropping since 2001, allowing some recruitment of native perennial grasses, predominantly Spear grasses (*Austrostipa* species) to occur. The trial paddock is large (648 ha) with 5 watering points and has generally been set stocked at a low stocking rate.

An area of the paddock had planned to be pasture cropped in 2013. However due to the low rainfall at the start of the season the owner decided not to proceed. In May 2014, 70 kg/ha of wheat and 8 kg/ha of annual medic seed were broadcast over the area to increase pasture productivity. Cattle and sheep grazed the area during winter and early spring.

Site 7 - Willowie

The local area has been regularly cropped since settlement, although in more recent years the poor seasonal conditions have reduced crop yields. The larger paddock (prior to paddock division) has been regularly sown with cereals followed by pasture phases. Wheat was sown 2003 - 2005 followed by pasture phase 2006 - 2009. Wheat was sown in 2010 - 2011 followed by pasture in 2012, wheat in 2013, and barley 2014. The paddock is usually grazed in a long rotation with short periods of rest at 2.7-2.9 DSE/ha (500-600 ewes) for 2 to 3 weeks followed by 5 to 6 weeks rest. The soils in the area are naturally high in salt, particularly in the subsoil, in some areas the salt has come to the surface via reverse osmosis, resulting in bare areas with little or no cover.

The original 263 ha paddock was fenced into 4 paddocks during 2012 with the trial being in the 'new' 60 ha paddock. A salt scald of approximately 0.5 ha is situated on the boundary of this paddock and was selected for the demonstration site.

The paddock was grazed at 13 DSE/ha (550 ewes) for 2 to 3 weeks in June and again in August 2012, the paddock was not grazed again during the trial. In April 2013, strips were cultivated across the area to loosen the soil and conserve moisture. Forage shrub seedlings were planted into the cultivated rows in June 2013 using a tree planter. The mix of species included Silver saltbush, De Koch oldman saltbush and River Saltbush. The cultivation stimulated germination of salt tolerant species, mainly narrow leaf ice plant, providing significant soil cover on what was previously bare soil.

Cereal straw was spread in July 2014 at 20 – 30 t/ha between the rows of saltbush plants. This was a higher rate than recommended by Kennewell [2] but the owner found it difficult to evenly spread the straw at a recommended rate. The high rate of straw gave excellent ground cover but restricted the growth of plants.

Site 8 - Orroroo

The local area has been cropped since the early 1900's, although cropping ceased in the 1950s due to low rainfall and reduced top soil. During the period of cropping, particularly the period 1930-40, wind and water erosion, drought and cropping practices (long fallow) resulted in large soil losses and parts of the paddock have lost their topsoil. The remaining subsoil is relatively hostile and infertile. However, the current owners are unsure if the area of the trial site has ever been cropped. If the area was cropped, it has not been cropped for over 60 years with minimal fertiliser application. Prior to 2012 the paddock was continuously grazed with 0.5-0.8 DSE/ha (200-300 ewes) all year around.

In 2013, the paddock was grazed for 6 weeks from September to October at 2.0 DSE/ha (450 ewes and young lambs). The paddock was grazed in April 2014 for 4 weeks at 1.6 DSE/ha (600 ewes), and in the period June to November 230 ewes lambed in the paddock. Lambs were also weaned in the paddock (0.8 – 1.1 DSE/ha).

The trial area was spread with medic straw in early June, 2013 at approximately 8-10 t/ha (as recommended by [2]), and Wallaby grass seed was spread at 4-5 kg/ha in late June, 2013. Windmill grass was also spread at 3 kg/ha in late August, 2013.

High numbers of kangaroos utilise the paddock due to good shelter, watering points and the large paddock size, therefore kangaroos are controlled 1-3 times a year to keep numbers at a manageable level.

Site 9 - Peterborough

The area has been cropped since the early 1900s, however cropping ceased in the 1950's due to low rainfall and reduced topsoil. During the period of cropping, particularly the period 1930-40, wind and water erosion, drought and cropping practices (long mechanical fallow) resulted in large soil losses and parts of the paddock have lost their topsoil. The remaining subsoil is relatively hostile and infertile. The paddock would have had a phosphorus fertiliser applied when the paddock was cropped. Prior to 2004 the paddock was grazed at 1.1 -1.5 DSE/ha (~70 ewes) all year round with the addition of supplementary feed as required.

From 2004 to 2014, the paddock has been grazed at 0.9-1.1 DSE/ha (60-70 ewes) and rested from August to October to allow the perennial native grasses to set seed.

Site 10 - Cleve

The local area has been cropped since settlement. Prior to 1997 the demonstration site paddock was cropped for 2 years followed by a one year self-regenerating pasture. From 1997 through to 2011 the paddock was continuously cropped. Recent cropping history includes field peas (2007) sown with 18:20 fertiliser at 100 kg/ha, canola (2008) with 27.12 fertiliser at 100 kg/ha, wheat (2009) sown with 20:15 fertiliser at 100 kg/ha, wheat (2010) sown with Protector fertiliser at 60 kg/ha and barley (2011) sown with 27.12 fertiliser at 100 kg/ha and UAN at 25 L/ha. Stubbles of the previous year's crop are grazed over summer, generally for a period of 6 weeks at 13 DSE/ha (900 ewes). Note the paddock was previously part of a larger paddock. Low lying areas of the paddock regularly become water logged; this is exacerbated by seepage of water from higher in the landscape.

In March 2012, 50 t gypsum was spread over the upper slopes of the paddock (24 ha) at 2.08 t/ha. The paddock was sprayed in early May 2013, to control a range of annual grasses and broadleaf weeds with a mix of 2,4 D 650 @ 0.4 L/ha, Oxyfluorfen 240 @ 0.1 L/ha, Glyphosate @ 1.2 L/ha plus Li 700 (wetter) @ 0.21 L/ha and Ammonium Sulphate (neutralizer) @ 0.7 kg/ha. Following 39 mm of rain in mid May the area was sprayed in late May with a mixture of Gramoxone® at 1 L/ha and Trifluralin 480 at 2 L/ha.

Perennial pastures were planted immediately after spraying with Lucerne (*Medicago sativa*) sown at 4 kg/ha on the upper slopes (northern side of paddock) and a mix of Tall Wheat grass (*Thinopyrum elongatum*) at 6 kg/ha and Puccinellia (*Puccinellia* species) at 4 kg/ha sown on the lower slopes and low lying areas (southern part of the paddock along the creek). Fertiliser was applied with the pasture seed at 100 kg/ha of 27:12. Four rows of forage shrubs were planted in an area between the Lucerne and Tall Wheat grass/Puccinella in single rip lines at 5 m intervals. A mix of Oldman saltbush (*Atriplex nummularia*), River saltbush (*Atriplex amnicola*), Silver saltbush (*Atriplex rhagodioides*) and Creeping saltbush (*Atriplex semibaccata*) seedlings were planted in July 2014.

Site 11 - Peterborough

The local area has been traditionally cropped with wheat followed by two or three years of self regenerating pasture. Moderate rates of single and high analysis fertiliser were applied when the area was cropped. In 2007 the paddock was removed from the cropping rotation and strips were cultivated north to south, 15 to 25 m apart. Two to three rows of Oldman saltbush (De Koch) (*Atriplex nummularia*) were planted in each of the cultivation strips. In recent years the paddock had become dominated by Onion weed (*Asphodelus fistulosus*), following the cessation of cropping, which is unpalatable, unproductive, produces bare plant tussocks and has a relatively shallow root system. The property has been rotationally grazed at 41-83 DSE/ha since 2005 for 5 to 10 days followed by a rest period of approximately 120 days.

The area was sprayed in October 2012 with 1 L/ha Glyphosate 450 plus 0.5 L/ha ester 2,4 D 680 to control Onion weed. The areas was sprayed with 1.5 L/ha Gramoxone® in May, 2013 and 3 to 4 kg/ha Wallaby grass (*Austrodanthonia* species) seed was spread. The combination of the two spraying operations has achieved good control of the Onion weed, allowing annual grasses and medic to establish. The Wallaby grass germinated with adequate establishment in August 2013. However, very little rain was received from August through to February 2014 and most of the seedlings died.

Site 12 - Cowell

The local area has a regular history of cropping. Before the current owners purchased the property (2010), the paddock was continuously cropped with wheat for 4 years in a row with DAP fertiliser at 40kg. Since purchasing the property, paddocks have had different cropping rotational histories. The demonstration site was previously three paddocks with three different cropping rotational histories:

Paddock 1: Cropped in 2011; 1 year in crop followed by 1 year pasture;

Paddock 2: Cropped in 2012; 1 year in crop followed by 1 year pasture;

Paddock 3: Cropped in 2010.

From 2010 to 2014 the stubbles and pasture were only occasionally grazed, due to a lack of water in the paddock.

Prior to 2010 the area was set stocked all summer but grazing was very sporadic and uneven as the water supply was in an adjacent paddock. In 2012 the demonstration site was sprayed with 1 L/ha Roundup and ploughed to control woody weeds, including blanket weed and annual saltbush (*Atriplex* species). The demonstration site was further sprayed January 2013, with 1 L/ha Roundup and 120 mL/ha ester 2,4 D to control summer weeds. Following good opening rains in May 2013, the demonstration site was sprayed again in June with 1 L/ha Roundup plus 120 mL/ha ester 2,4 D and wetter. The demonstration site was cultivated with a one way disc and then broadcast with Puccinella (*Puccinellia* species) 100 kg in 20 ha (5 kg/ha) and Tall Wheat grass (*Thinopyrum elongatum*) 210 kg in 20 ha (10.5 kg/ha) in June. Fertiliser was spread at 70 kg/ha of 18:20 in June 2013.

The area was grazed at 1.5 DSE/ha with 250 wether lambs during January and February 2014, and with ~1.9 DSE/ha (~200 pregnant ewes) from March to May 2014 over 162 hectares (fences were not completed). The demonstration site fencing was completed in late 2014.

Site 13 – Mambray Creek

The local area has been cropped for over 100 years, however due to the shallow heavy soil and unreliability of growing season rainfall the demonstration site paddock is no longer viable to crop and has been removed from regular cropping. As a result annual weeds began to dominate the pasture, with low levels of surface cover, pasture production and quality. From 1981 to 2001, the paddock was cropped with wheat with 50 kg/ha DAP fertiliser followed by 2 years of self-regenerating pasture, consisting mainly of barley grass and weeds with some annual medic. The paddock is grazed at 2.7 DSE/ha (375 ewes plus lambs) from April to August.

In May 2013, the demonstration site was ripped, in preparation for planting seedling shrubs. In July 2013, 6 m strips were sprayed with 1.2 L/ha glyphosate 450 to control annual grasses and other weeds.

A mix of forage shrub seedlings were planted with a tree planter in mid July 2013. Species planted included Old man saltbush 'Eyres Green' (*Atriplex nummularia*), River saltbush (*Atriplex amnicola*), Silver saltbush (*Atriplex rhagodioides*) and Creeping saltbush (*Atriplex semibaccata*). Approximately 2,000 seedlings were planted on a 6 ha area.

The demonstration site paddock (8 ha) was fenced-off from the rest of the paddock in September 2013. The shrubs and pasture were grazed for 4 weeks in September in conjunction with a 50 ha vetch paddock at 18.5 DSE/ha (370 crossbred ewes with lambs). The stock had access to the area for a further 4 weeks in October in conjunction with the rest of the non-arable paddock. Despite having access to the shrubs they were only lightly grazed.

Sampling Methodology, Results and Discussion

Please see the full report on our website for the full sampling details and results for each site.

Figure 2: Producers enjoying the visit in 2015 to Jim Higgins property , one of the trial sites for this project; Trevor Crawford, Ross McCallum, Michael Battersby, Ian McCallum, Neil Innes and Ian Clarke. Photo - Jodie Reseigh, Rural Solutions

Overdependence on Agrichemicals – UNFS Barley Grass Trial

Author: Barry Mudge

Funded By: GRDC CWF 00020

Project Title: Overdependance on Agrochemicals

Project Duration: 2015-2016

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

Key messages

- 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.

Wheat yield in this trial was much lower than the barley yield. This may have been due to background cereal root disease pressure. Absolute yield reduction from grass competition in wheat (in terms of kg/ha) was similar to that in barley.

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 has already been confirmed on the coastal plain north of Port Germein.

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. One of the purposes of this trial is to provide background information for modelling barley grass carry over under differing management regimes.

This trial 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.

How was it done?

A replicated field trial was established near Port Germein 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 24 April 2015 after receiving 30 mm from 17-19 April. The site had a modest germination of barley grass and ryegrass showing at the time of seeding, and this was suppressed by the application of 600 ml/ha of glyphosate 450. Soil conditions at seeding were damp on the seedbed, but with low levels of plant available water (PAW) in the full soil profile (PAW estimates taken on 14 May 2015 showed 31 mm which would have mainly come from the seeding rainfall event).

One wheat variety (Mace) and two barley varieties (Fathom, a vigorous, more competitive variety and Hindmarsh which is considered less competitive) were sown, each at two seeding rates (40 and 80 kg/ha) along with a treatment for each variety which aimed at best practice weed control (high seeding rate (80 kg/ha) plus appropriate chemical weed control - Sakura @ 118 g/ha on wheat and TriflurX @ 2.5 L/ha on barley). The crop was established using 80 kg/ha 28:13 fertiliser then monitored through the season for nitrogen status using Yield Prophet (additional 94 kg/ha urea applied 20 June 2015). A post-emergent broadleaf weed spray was used across all treatments to remove any competition effects from broad-leafed weeds.

Initial plant establishment counts were taken on 27 May 2015 followed by crop and weed early biomass assessments at tillering stage on 1 July 2015. Anthesis crop and weed biomass and weed panicle assessments were completed on 22 September 2015. 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 29 October 2015 with grain samples retained for subsequent quality analysis.

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

The recent paddock history has been a two year rotation of cereal (usually wheat) with a typically grass-dominant pasture. In 2014, the paddock was a self-regenerating medic pasture but, again, dominated by grass. The pasture was grazed in 2014 with the only treatment being a spring topping glyphosate application. This history suggests the high likelihood of at least some background root disease issues. Root disease testing results were not available at the time of writing this report.

What happened?

The good early break in April was followed by dry conditions in May and early June. Good follow-up rains were received from 14 June 2015 onwards. The remainder of the season saw generally above- average rainfall through winter and early spring, with a dry finish in September and October (refer Table 1).

Table 1 Monthly and growing season rain at Port Germein in 2015

Month	April	May	June	July	August	Sept	October	April- Oct
Rainfall (mm)	55	16	40	42	34	14	10	211

The good break resulted in good initial crop establishment but the lack of follow-up rainfall saw only moderate levels of grass weeds establish. The crop then showed signs of moisture stress in early June with the lack of crop vigour potentially reducing crop competition. The good follow-up rainfall during July and August saw the crops recover well but, at the same time, weed number and size increased substantially. Head emergence and grain fill occurred under cool, favourable conditions with the dry finish coming too late to seriously affect crop performance.

The original site selection was aimed at a site with predominantly barley grass. However, as the season progressed, it became evident that ryegrass was at a higher level than originally envisaged. Subsequent weed establishment counts measured barley grass/ryegrass proportions at around 57%/43%.

The herbicide treatments achieved good (but not perfect) control, allowing effective comparison between high and low weed infestation levels.

Seeding rate impact of Mace wheat

Table 2 compares results from the three sowing treatments for Mace wheat. Crop establishment of Mace at the high seeding rate of 80 kg/ha was reasonably in line with district practice and resulted in plant populations of 125-140 plants/m^2. The lower sowing rate of 40 kg/ha saw observed crop populations of around 80 plants/m^2, which would be regarded as sub-optimal for this district. Different seeding rates (with no herbicide treatments) had no influence on initial grass weed establishment levels. The herbicide treatment (Sakura @ 118 g/ha) resulted in a significant reduction in grass establishment.

At tillering, the lower seeding rate of Mace had significantly lower biomass than the herbicide-treated, high seeding rate treatment, although the low seeding rate crop had largely caught up with the higher seeding rate treatment which also had had no herbicide applied. Total weed tillers and weed biomass at crop tillering was significantly higher in the non-herbicide treated plots. At tillering stage, there was no significant difference in weed numbers or biomass between the sowing rate treatments.

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

	Treatment and sowing rate			
	40 kg/ha (no herbicide)	80 kg/ha (no herbicide)	80 kg/ha (plus herbicide)	LSD (P= 0.05)
Early Crop Establishment-Crop (plants/m^{2})	81	140	125	*20*
-Barley Grass (plants/m^2)	41	42	6	*8*
-Ryegrass (plants/m^2)	30	26	9	*8*
-Total weeds (plants/m^2)	71	68	15	*19*
Tillering-Crop Biomass (gm/m^2)	111.3	118.9	130.7	*21.1*
-Weed Biomass (gm/m^2)	29.5	25.1	4.5	*9.8*
-Total weeds (plants/m^2)	156	162	33	*55*
-Total weed tillers (number)	515	502	96	*188*
Anthesis-Crop Biomass (gm/m^2)	546	497	646	*68*
-Weed Biomass (gm/m^2)	126.6	112.5	20.1	*12.7*
-Total weed panicles (number)	193	195	53	*28*
Harvest-Crop yield (tonne/Ha)	1.56	1.56	2.07	*0.15*
-Test weight (kg/Hl)	79.9	80.1	80.1	*n.s.*
-Screenings	2.1	2.9	2.7	*0.55*

There was no observed influence of seeding rate on total weed panicles measured at crop anthesis.

There was no difference in the final yield of the Mace wheat sown at the two different seeding rates with no herbicide treatments (both yielded 1.56 t/ha). This means there was no benefit to yield from crop competition effects from higher seeding rates. The herbicide-treated Mace yielded 2.07 t/ha. This suggests a yield reduction from grass competition of approximately 25% compared with the crop where weeds were reasonably controlled. This yield reduction represents a loss of about 48 kg of grain for every 10 additional grass plants per m^2 present at tillering (compared with the herbicide-treated plots and at the high seeding rate). There was no significant difference in the quality of grain between the various treatments, although weed seed numbers in the non-herbicide treated plots were visually greater.

Seeding rate impact of Fathom barley

As with the Mace wheat, crop establishment of the 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. Interestingly, the pre-sowing herbicide treatment of 2.5 L/ha of TriflurX (incorporated by sowing) was quite effective at controlling both ryegrass and barley grass on this site where there was a high proportion of grass seeds on the soil surface.

By tillering, crop competition effects from the high seeding rate were evident. Weed biomass and weed tillers in the high seeding rate plots was significantly lower than in the low seeding rate plots. At anthesis, this competition effect from higher plant numbers was still evident. Crop biomass at the high seeding rate was significantly higher when compared with the low seeding rate, with significant reductions in total weed panicles. There were no significant differences between weed biomass at the different seeding rates, although a visual trend was observed towards lower weed biomass at the higher seeding rate.

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

	Treatment and sowing rate			
	40 kg/ha (no herbicide)	80 kg/ha (no herbicide)	80 kg/ha (plus herbicide)	LSD (P= 0.05)
Early Crop Establishment-Crop (plants/$m^{2)}$	66	127	146	*11*
-Barley Grass (plants/m^2)	36	30	5	*24*
-Ryegrass (plants/m^2)	29	19	4	*9*
-Total weeds (plants/m^2)	65	48	9	*22*
Tillering-Crop Biomass (gm/m^2)	108.3	124.5	136.2	*18.0*
-Weed Biomass (gm/m^2)	20.8	13.3	1.1	*6.0*
-Total weeds (plants/m^2)	164	121	23	*50*
-Total weed tillers (number)	502	315	48	*105*
Anthesis-Crop Biomass (gm/m^2)	637	718	796	*55*
-Weed Biomass (gm/m^2)	98.7	69.0	11.2	*34*
-Total weed panicles (number)	154	114	23	*34*
Harvest-Crop yield (tonne/Ha)	2.83	3.03	3.50	*0.18*
-Test weight (kg/Hl)	65.1	65.6	64.8	*n.s.*
-Screenings	2.1	1.6	2.2	*n.s.*

The final Fathom barley yield of the high seeding rate plots was significantly higher (by 0.2 t/ha) than the low rate plots. The overall yield reduction from the non-control of grass weeds at the 80 kg/ha seeding rate was 14% (3.03 t/ha versus 3.50 t/ha). Similar to Mace wheat, this yield reduction represents a loss of about 48 kg of grain for every 10 additional grass plants per m^2 present at tillering (compared with the herbicide treated plots and at the high seeding rate).

Seeding rate impact of Hindmarsh barley

As noted with earlier treatments, crop establishment with Hindmarsh barley was good and, again, differences in seeding rates had no influence on the levels of grass weed establishment.

At crop tillering, there were no statistical differences showing in weed infestations at different seeding rates. However, by anthesis, weed biomass at high seeding rates was significantly lower. Interestingly, Hindmarsh crop biomass in the herbicide-applied plots was not significantly different from those plots where herbicide was not applied. This is in direct contrast with the Mace wheat and Fathom barley plots which showed significantly higher crop biomass at anthesis when compared with the non-herbicide-treated plots.

Final crop yield of Hindmarsh barley showed no differences between the high and low seeding rates. Overall yield reduction when compared with the herbicide plots was around 17%. This yield reduction represents a loss of about 41 kg of grain for every 10 additional grass plants per m^2 present at tillering (compared with the herbicide-treated plots and at the high seeding rate).

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

	Treatment and sowing rate			
	40 kg/ha (no herbicide)	80 kg/ha (no herbicide)	80 kg/ha (plus herbicide)	LSD (P= 0.05)
Early Crop Establishment-Crop (plants/m$^{2)}$	97	175	178	*20*
-Barley Grass (plants/m^2)	35	31	3	*20*
-Ryegrass (plants/m^2)	23	26	5	*10*
-Total weeds (plants/m^2)	58	57	8	*19*
Tillering-Crop Biomass (gm/m^2)	127.4	134.6	135.8	*n.s.*
-Weed Biomass (gm/m^2)	24.3	13.3	1.5	*12.2*
-Total weeds (plants/m^2)	119	147	23	*54*
-Total weed tillers (number)	442	356	48	*158*
Anthesis-Crop Biomass (gm/m^2)	634	653	646	*n.s.*
-Weed Biomass (gm/m^2)	79.8	57.1	11.5	*18*
-Total weed panicles (number)	137	105	28	*45*
Harvest-Crop yield (tonne/Ha)	2.54	2.56	3.07	*0.18*
-Test weight (kg/Hl)	69.2	67.1	69.9	*n.s.*
-Screenings	2.2	3.3	2.1	*n.s.*

Comparison of Species and Variety impact on weed infestation and seed set at different seeding rates

Table 5 Species and variety impact on weed infestation at 40 kg/ha seeding rate

	40 kg/Ha Seeding Rate			
	Mace	Fathom	Hindmarsh	LSD (P=.05)
Tillering-Weed Biomass (gm/m^2)	29.2	20.8	*24.3*	*n.s.*
-Total weed tillers (number)	515	501	442	*n.s*
Anthesis-Weed Biomass (gm/m^2)	126.6	98.7	79.8	*30.2*
-Total weed panicles (number)	193	154	137	*n.s.*

Table 6 Species and variety impact on weed infestation at 80 kg/ha seeding rate

	80 kg/Ha Seeding Rate			
	Mace	Fathom	Hindmarsh	LSD (P=.05)
Tillering-Weed Biomass (gm/m^2)	25.1	13.3	13.3	*6.4*
-Total weed tillers (number)	502	315	356	*137*
Anthesis-Weed Biomass (gm/m^2)	112.5	69.0	57.0	*31.9*
-Total weed panicles (number)	195	114	105	*58*

At the higher seeding rate of 80 kg/ha (refer Table 6), all weed measurements taken at both tillering and anthesis showed significant differences between wheat and barley. The analysis did not reveal any significant differences between the two barley varieties in terms of their impact on weed levels.

There was no clear differences between the performances of the two grass weeds being studied (barley grass and ryegrass) over the treatments (data not presented). The only observation is that the recruitment of barley grass from tillering to panicle stage was consistently much lower than for ryegrass.

What does this mean?

The aim of this trial was to determine how crop yield and weed seed carry-over was affected by different cereal species and varieties under different sowing rates and under barley grass weed pressure.

The trial showed that sowing a vigorous barley variety like Fathom at higher rates in the presence of grass weeds could be beneficial by increasing crop yield. The yield benefit of 0.2 t/ha represents around $40/ha at a barley price of $200/t. This shows a good return on the extra seed required which would be around $12/ha at a "cleaned–seed" cost of $300/t.

The wheat variety Mace and the less competitive barley variety Hindmarsh did not show any yield benefit from higher seeding rates.

Increasing the seeding rate of both barley varieties had an impact on reducing weed biomass as the crops developed. Total weed panicles were lower at the high seeding rate, although high variability across the site only saw this demonstrated at the P=0.05 level for the Fathom variety. The trial did not demonstrate any significant reduction in weed biomass or weed seed carry-over from doubling the wheat seeding rate.

In general, barley had a greater impact on reducing weed seed carry over than wheat, particularly at the high seeding rate. At anthesis, and at the high seeding rate weed biomass and total weed panicles in barley were 56% of those in wheat. This demonstrates the substantial gain which can be made in weed seed carry-over from crop selection alone. It should be noted that in this trial, weed recruitment in even the best plots was still in excess of what is regarded as an acceptable level.

Overall, the wheat yield achieved in this trial was much lower than that for barley. This may be due to suspected background levels of root disease which can be common in rotations involving grass dominated crop break phases. In the trial, the yield suppression from the presence of grasses in terms of absolute yield loss was similar for wheat and barley.

It is proposed to run a similar trial again in 2016 to evaluate results under a different season type. Having a seed rate treatment of, perhaps, double the district practice could be a useful addition.

Acknowledgements

Chris and Graham Pole for providing site and undertaking Urea application. Nigel Wilhelm and Peter Telfer (SARDI) for assisting with trial design and trial seeding and harvest. Viterra, Port Pirie for facilitating grain sample analysis. Amanda Cook (SARDI) for statistical analysis. GRDC for funding trial under Project No CWF00020 Overdependence on Agrochemicals

Products used in trial:

Mace 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.

Trial Information
Location: Port Germein
Farmer Name: Chris and Graham Pole
Group: Upper North Farming Systems
Rainfall; Av. Annual: 326mm, Av. GSR: 227mm
2015 Total: 307mm, 2015 GSR: 211mm
Yield; Potential: Wheat 2.7 tonne/Ha (Yield Prophet) Actual: Mace Wheat 2.07 t/Ha, Fathom Barley 3.5 t/Ha, Hindmarsh Barley 3.07 t/Ha
Paddock history; 2014: Grassy Pasture, 2013: Wheat, 2012: Grassy Pasture
Soil type; Mallee loam
Diseases; Soil sample collected, but Predicta B not available at time of writing
Plot size; Dimensions 21m X 1.8m X 4 replicates

Yield limiting factors; Dry period post seeding, grassy weeds, low N nutrition, root disease?

Seeding rate by row spacing for barley grass management

Author: Amanda Cook, Wade Shepperd, Ian Richter, and Nigel Wilhelm
Funded By: GRDC CWF00020
Project Title: Overdependance on Agrochemicals
Project Duration: 2015-2016
Project Delivery Organisation: SARDI, Minnipa Agricultural Centre

Key Points:

- 18 cm (7") systems showed better plant establishment in a drier seeding than the 30 cm (12") system.
- Higher seeding rates resulted in higher grain yield but also higher screenings and lower protein.
- Grass weeds were lower in the higher seeding rate and in the 18 cm row spacing indicating crop competition is a non-chemical weed reduction method.
- Single row or spread row seeding boots showed little differences in plant establishment, grain yield and quality or grass weed competition.

Project Report:

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 effective but sometimes costly chemical options for grass weed control using pre-emergent and post emergent herbicides. However for longer term sustainability a range of management techniques, not just reliance on chemicals, 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.

How was it done?

A replicated trial was established at the Minnipa Agricultural Centre (MAC) (paddock S4) with Mace wheat sown at three seeding rates (targeting 60, 120 or 240 plants/m^2) on two different row spacings of 18 cm and 30 cm with two different seeding boots, a single row Harrington point and an Atom-Jet spread row seeding boot with press wheels. The paddock was very grassy in 2013 followed by a pasture with moderate levels of grass weeds present in 2014. In 2014 alternative chemicals for spray topping grass weeds in pastures were used in this paddock as potential small patches of herbicide resistant barley grass had been located in the paddock.

In 2015 the trial was sown on 21 and 22 May with minimal moisture with the 18 cm (or 7") treatments being sown first, then the 30 cm (or 12"). A base fertiliser rate of 60 kg/ha of 18:20:0:0 was applied for all treatments. The trial was sprayed with a knockdown of 1.5 L/ha of TriflurX, 1 L/ha of Roundup Powermax and 80 ml/ha of Nail and broad-leaved weeds were controlled with 750 ml/ha Tigrex and 100 ml/ha Lontrel on 23 July.

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 samples were taken on 21 April. Initial paddock weed counts were done on 20 May and soil taken for weed seed bank germination, with monthly assessments on emergence over the next 12-18 months. Plant establishment and weed counts were taken on 18 June. The Leaf Area Index (LAI) measurements were taken on 18 September 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 weed counts were taken on 7 October. The trial was harvested on 9 November. Harvest soil moisture measurements of selected treatments were taken on 27 November.

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

What happened?
The soil analysis showed the trial site is alkaline, with a pH (CaCl) of 7.9. Cowell P measured 46 mg/kg (0-30 cm). Soil mineral N was 76 kg/ha in the top 100 cm. The soil has a moderate phosphorus buffering index of 150 (0-30 cm). At this site, salinity increases down the profile but is still relatively low. The initial soil moisture was 158 mm within the profile to 100 cm depth. The initial PreDicta B^{TM} inoculum level indicated a high risk of *Rhizoctonia* disease (214 pgDNA/g soil) but low Take-all and *Pratylenchus thornei* risk.

Sowing occurred on the 21 and 22 May with minimal moisture and the next significant rainfall event was 40 mm on 15 June resulting in uneven crop germination, with some plants at Zadoks growth stage Z12 (2-3 leaf stage) and others plants just germinating.

The trial was direct drilled into a pasture paddock, so the plots were quite cloddy due to the dry moisture conditions and seed placement was not ideal. In the dry seeding conditions all seeding rates resulted in lower plant establishment numbers than expected and the 30 cm system achieved much lower germination and plant establishment than 18 cm. In the 30 cm row spacing some seed on the side of furrows germinated then died due to the dry conditions at seeding and potentially seeds being placed within the chemical zone.

Figure 1 Left, 30 cm (12") ribbon @ 60 plants/m^2 and right, 18 cm (7") ribbon at 240 plants/m^2.

The initial barley grass weed pressure within the trial area was much lower than expected with all plots having less than 10 plants/m^2. This weed density is considered to be below what is required for adequate grass weed pressure (for reliable measurement) within a grass weed trial (B Fleet, pers. comm.). No barley grass weeds germinated in the weed seed bank trays despite this site being selected due to high barley grass weed numbers in 2014, while ryegrass and broadleaved weeds both had 31 plants/m^2. Wild oats became a more prevalent weed in the 2015 season due to later rainfall events and later germination after the soil applied chemicals at seeding became inactive.

Seeding rate increased the number of plants/m^2 however no rate achieved the targeted plant densities due to the dry seeding conditions. The 18 cm row spacing achieved higher plant density than the 30 cm row spacing, but the seeding system boots had no impact on plant numbers (Table 2). There were no differences in early weed numbers for row spacing or seeding rates (Table 1).

Early crop dry matter was greater in the 18 cm row spacing than in the 30 cm, likely due to higher plant numbers. By 7 October the dry matter differences were not present in seeding rate, however the row spacing effect was still present with the 30 cm and 30 cm ribbon system having lower dry matter than the 18 cm treatments (Table 2).
LAI (the area of leaves per unit area of soil surface) increased with seeding rate. The 18 cm row spacing had a higher LAI than the 30 cm row spacing (Table 2). Head emergence was faster with higher seeding rate and 18 cm row spacing (data not presented).

The total dry matter and numbers of the late grass weeds for ryegrass and wild oats was lower in the higher seeding rate. The 18 cm row spacing showed the same trend with late grass weed dry matter and ryegrass and wild oat plant numbers compared to the 30 cm row spacing. Late barley grass numbers did not change with treatments (Table 1).

Table 1 Grass weed density and canopy measurements taken in seeding rate and row spacing trial sown with Mace wheat at Minnipa, 2015.

Seeding Rate Target plants/m^2	Row spacing (cm)	Early Barley grass (plants/m^2)	Early Rye grass (plants/m^2)	LAI (umols)	Late grass weeds DM (t/ha)	Late Barley grass (plants/m^2)	Late Ryegrass (plants/m^2)	Late Wild oats (plants/m^2)
60	18	0.7	0.6	60	0.48	15.5	3.4	34.4
	18 ribbon	0.7	0.6	59	0.19	2.3	3.7	13.8
	30	2.9	0.4	51	0.67	15	6.3	45.1
	30 ribbon	1.2	1.6	53	0.86	12.9	7.4	62.5
120	18	2.1	0.7	66	0.19	8.0	1.0	14.8
	18 ribbon	0.7	1.0	67	0.16	6.6	0.9	11.9
	30	5.3	4.0	54	0.58	20.0	6.7	33.9
	30 ribbon	4.1	1.9	59	0.91	9.6	4.3	77.3
240	18	6.3	2.5	67	0.13	0	0.4	12.2
	18 ribbon	2.8	0.7	67	0.22	1.4	0.9	20.7
	30	5.3	1.2	61	0.18	12.0	2.6	5.2
	30 ribbon	5.3	1.2	59	0.21	25.2	0.5	7.9
LSD (P=0.05) row spacing x seeding rate		*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
	18	3.1	1.3	64	0.27	7.8	1.6	20.5
	18 ribbon	1.4	0.8	64	0.19	3.4	1.8	15.5
	30	4.5	1.9	56	0.48	15.7	5.2	28.1
	30 ribbon	3.6	1.6	57	0.66	15.9	4.1	49.2
LSD (P=0.05) row spacing		*ns*	*ns*	*2.5*	*0.25*	*ns*	*2.8*	*21.7*
60		1.4	0.8	56	0.55	11.4	5.2	38.9
120		3.1	1.9	62	0.46	11.0	3.2	34.5
240		5.0	1.4	64	0.19	9.7	1.1	11.5
LSD (P=0.05) seeding rate		*ns*	*ns*	*2.2*	*2.1*	*ns*	*2.4*	*18.8*

Grain yield increased with seeding rate (Figure 2). The 18 cm row spacing also out-yielded the 30 cm row spacing but there were no differences between the two seeding boots. This yield difference between the 18 cm and 30 cm system may be due to the difference in initial plant establishment.

Grain protein showed the opposite trend to grain yield with protein increasing with the lower seeding rate and increasing with the 30 cm system compared to the 18 cm, and again the different seeding boots showed no differences. Higher screenings occurred in the lower plant density treatments, 11% to 8.4% from low to high seeding rates. The 18 cm system had an average of 8.9%, with 8.5% on 18 cm ribbon, 30 cm 10.0% and 30 cm ribbon 10.9%. There were no differences in test weight.

Table 2 Wheat growth, yield and grain quality measurements taken in seeding rate and row spacing trial sown with Mace wheat at Minnipa, 2015.

Seeding Rate Target plants/m^2	Row spacing (cm)	Plant establishment (plants/m^2)	Early DM (t/ha)	Late DM (t/ha)	Yield (t/ha)	Protein (%)	Screenings (%)	Test weight (kg/hL)
60	18	64	0.32	8.1	2.88	11.6	10.7	80.0
	18 ribbon	57	0.26	8.7	2.79	11.8	10.0	79.5
	30	31	0.16	5.8	2.03	12.1	11.5	79.5
	30 ribbon	27	0.15	7.0	2.03	12.3	11.7	79.0
120	18	109	0.47	8.8	3.34	11.5	7.6	80.0
	18 ribbon	114	0.53	8.9	3.36	11.4	8.5	79.7
	30	59	0.27	6.5	2.29	12.2	10.5	78.9
	30 ribbon	67	0.26	6.9	2.40	12.2	10.9	79.2
240	18	194	0.65	9.1	3.56	11.4	8.4	79.5
	18 ribbon	186	0.71	8.1	3.54	11.3	7.1	80.2
	30	106	0.42	8.0	2.78	11.6	8.2	79.7
	30 ribbon	103	0.41	7.6	2.64	12.2	9.9	79.6
LSD (P=0.05) row spacing x seeding rate		*19*	*ns*	*ns*	*ns*	*0.3*	*ns*	*ns*
	18	122	0.48	8.7	3.26	11.5	8.9	79.8
	18 ribbon	119	0.50	8.5	3.23	11.5	8.5	79.8
	30	66	0.28	6.7	2.37	12.0	10.1	79.3
	30 ribbon	66	0.27	7.2	2.36	12.2	10.9	79.2
LSD (P=0.05) row spacing		*10.7*	*0.25*	*0.7*	*0.09*	*0.16*	*1.8*	*ns*
60		45	0.22	7.4	2.43	11.9	11.0	79.5
120		87	0.38	7.7	2.85	11.8	9.4	79.4
240		147	0.55	8.2	3.13	11.6	8.4	79.8
LSD (P=0.05) seeding rate		*9.3*	*0.22*	*ns*	*0.08*	*0.14*	*1.6*	*ns*

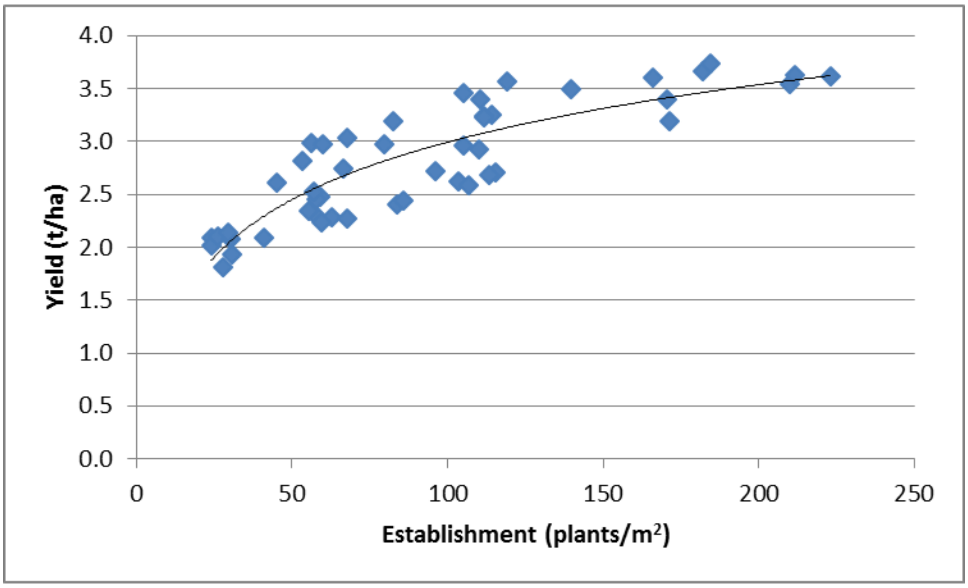

Figure 2 Plant establishment and grain yield at Minnipa in 2015.

There were no differences in harvest soil moisture between the highest and lowest seeding rates (60 and 240 plants/m^2) at the different row spacing after harvest (data not presented).

What does this mean?
This trial aimed to target barley grass weeds but numbers were much lower than expected due to dry early seasonal conditions, however wild oat numbers were higher than expected and some ryegrass was present. There were no differences in early weed numbers in the row spacing of 18 cm (7”) or 30 cm (12”) or the 60, 120 or 240 kg/ha seeding rates this season in moisture limited conditions.

The seeding rate increased the number of plants/m^2 but no rate achieved the targeted plant densities due to the dry seeding conditions affecting seed placement and possibly chemical damage. The 18 cm row spacing achieved higher plant numbers than the 30 cm row spacing but the ribbon seeding system boots showed little impact on plant numbers.

Overall this season the 18 cm (7”) systems showed better plant establishment in a drier seeding which resulted in plant numbers closer to the targeted seeding rates than the 30 cm (12”) system. The higher seeding rates resulted in higher grain yield but also higher screenings and lower protein due to stressful conditions at the end of the season resulting in poor grain filling.

The total dry matter of the late grass weeds significantly declined with the higher seeding rate in the narrower 18 cm row spacing compared to 30 cm, indicating higher seeding rates and narrower row spacing increased crop competition and lowered grass weed numbers. The late barley grass numbers did not show differences (possibly due to the low starting numbers, as discussed previously) however ryegrass and wild oat did, both showing the same trend as the late weed dry matter with lower weed numbers in the higher seeding rate and in narrower row spacing compared to wider. The reduction in ryegrass and wild oat grass weed numbers demonstrates the potential for barley grass reduction.

The 2015 results show crop competition by using narrow row spacing and increasing plant density is a non-chemical method to reduce grass weed numbers in current farming systems, however the seeding system boots showed little differences. The trial will be repeated for another two seasons hopefully with better initial crop establishment and greater barley grass weed numbers so more information on crop competitiveness and barley grass seed set can be collected.

Acknowledgements
Thank you to Sue Budarick for doing the weed counts and managing the weed germination trays. Funded by the GRDC Overdependence on Agrochemicals project (CWF00020).

Location: Minnipa Agricultural Centre paddock S4
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: (W) 3.0 t/ha
Actual: 2.8 t/ha
Paddock history
2015: Mace wheat
2014: Spray topped medic pasture
2013: Wheat
Soil type
Red loam
Plot size
20 m x 2 m x 4 reps

EPARF
Eyre Peninsula Agricultural Research Foundation Inc.

Government of South Australia

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Row Orientation and Weed Competition

Author: Amanda Cook, Nigel Wilhelm, Wade Shepperd, and Ian Richter
Funded By: GRDC CWF00020

Project Title: Overdependance on Agrochemicals

Project Duration: 2015-2016

Project Delivery Organisation: SARDI, Minnipa Agricultural Centre

Key Points:

- An east-west (E-W) sowing direction increased yield over north-south (N-S) sowing direction in an average season.
- The results showed a decline in yield due to weed competition, but no effect on weed competition due to row direction. So sowing in an E-W direction may give a yield benefit with no difference in weed seed set.
- The wider row spacing of 30 cm resulted in a yield reduction and greater weed biomass at harvest.
- There were no differences in yield with ribbon seeding with either 18 or 30 cm row spacings, but ribbon seeding reduced 'weed' biomass.

Project Report:

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 emergence. Management options other than herbicides need to be considered to address the issue for longer term sustainability. One of the best bets for cultural control of barley grass in-crop is 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. Lower light interception by the weed due to the crop row orientation resulting in a decrease in weed seed set is the cause behind this effect (Borger, 2015).

A trial was established at Minnipa Agricultural Centre to investigate the impact of row direction and row spacing on grass weed competition and cereal performance over three years.

How was it done?

In 2014 paddock N7/8 on the Minnipa Agricultural Centre was sown with Wyalkatchem wheat on 16 May. It was sown on 30 cm row spacing and yielded 2.4 t/ha with 9.6% protein. A paddock demonstration with crop and stubble aligned in the differing directions was located in this paddock.

In 2015 a replicated plot trial was sown with two row orientations; E-W and N-S into the 2014 standing stubble. Treatments within row orientations 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). Plots were direct drilled with press wheels. Oats were spread as a surrogate weed through hoses at the front of the seeder during the seeder pass. Additional "control" plots were sown near each trial block but in the opposite row orientation to that in each block.

The trial was sown on 21-22 May under minimal moisture with Mace wheat and 18:20:0:0 (DAP) fertiliser, both at 60 kg/ha. The oats 'weeds' were spread at a rate estimated to achieve 70 plants/m^2. The trial was sprayed with a knockdown of 1 L/ha of Roundup Powermax on 21 May and also a post-sowing pre-emergent spray of 1.5 L/ha of Sprayseed to control emerging self-sown cereal on 1 June. The trial was sprayed with 750 ml/ha Tigrex and 100 ml/ha of Lontrel on 27 July.

Trial measurements taken during the season included soil moisture (pre-seeding and harvest), PreDicta B root disease test, soil nutrition, weed establishment, weed seed bank germination, crop establishment, crop and weed biomass (early and late), light interception in crop rows, grain yield and quality.

Soil samples for moisture and nutrient analysis were taken on 21 April. Initial paddock weed counts were done on 20 May. Soil samples containing weed seeds from the trial site were grown out in germination trays, with monthly assessments on weed emergence. The weed seed bank trays were watered as required in 2015. Crop establishment and weed counts taken on 26 June.

Leaf Area Index (LAI) was measured on 18 September using an AccuPAR/LAI Ceptometer (model LP-80), taking the average of 5 readings per plot placed at an angle across the crop rows as per the operator's instruction manual. The measurements were taken at Zadoks growth stage (GS) 49-51, aiming for maximum crop canopy. The trial was harvested on 12 November. Harvest soil moisture samples of selected treatments were taken on 27 November.

Design and analysis of this trial was undertaken by SARDI statistician Chris Dyson using GENSTAT 16.

What happened?
In the 2014 season in the broad acre strips the yields were 2.64 t/ha and 2.95 t/ha for the N-S and E-W orientations respectively.

In 2015, crop establishment was similar in both sowing orientations, averaging 130 plants/m^2. There were more wheat plants/m^2 in the 30 cm row spacing treatment than in the 18 cm (Table 1). Seeding point design had no impact on wheat establishment. An oat-only treatment (no wheat sown) resulted in only 26 plants/m^2 which was well below the targeted density of 70 plants/m^2, but still provided some weed pressure.

Late crop dry matter was greater in the narrow row spacing than in the wider row spacing. The ribbon seeding boot had the highest dry matter compared to knife point and the added weed treatments (Table 1).

Wheat yield was greater in the E-W direction than the N-S this season with no difference between seeding boots (Table 1 and 3). The wider row spacing resulted in lower yields compared to narrow (Table 1). The protein level was lower with the higher yield in 18 cm compared to the 30 cm row spacing. There were no differences in protein with the different seeding boots (Table 1).

Oats as a surrogate grass weed decreased wheat yields by 12% regardless of row orientation. The weed levels were very low (Table 2). Dry matter taken at harvest shows greater weed mass in the wider row spacing of 30 cm. The knife point system also had a greater weed biomass compared to the ribbon seeding boot. Other weeds within the trial area, such as ryegrass and wild oat were very low in numbers and did not affect the trial results (data not presented).
Image: UNFS Members at the 2015 Spring Crop Walk hearing all about seeder set up from Jack Desboilles.

Table 1 Mace wheat growth, light interception (LAI), yield and grain quality with different sowing direction, row spacing and seeding systems at Minnipa 2015.

		Crop establishment (plants/m^2)	LAI (umols)	Late DM (t/ha)	Yield (t/ha)	Protein (%)	Screenings (%)
Row spacing (cm)	18	104	51.6	5.71	2.99	9.76	6.9
	30	156	45.9	4.64	2.33	9.93	*6.3*
LSD (P=0.05)		*9*	*2.8*	*0.3*	*0.10*	*0.15*	*0.5*
Seeding system	Knife points	124	48.7	5.81	2.82	9.9	6.4
	Knife points plus weed	131	50.4	5.74	2.53	9.8	7.0
	Ribbon	132	48.9	6.06	2.77	9.9	6.0
	Ribbon plus weed	133	51.3	5.73	2.52	9.8	6.9
LSD (P=0.05)		*ns*	*ns*	*0.45*	*0.14*	*ns*	*0.7*

Table 2 Average weed dry matter at harvest with different sowing direction, row spacing and seeding systems at Minnipa 2015**.**

		Oat 'weed' dry matter (t/ha)	Barley grass dry matter (t/ha)
Row spacing (cm)	18	0.06	0.02
	30	0.12	0.01
Seeding system	Knife points	0.14	0
	Knife points plus weed	0.10	0.01
	Ribbon	0.04	0.01
	Ribbon plus weed	0.08	0.04

Table 3 Mace wheat yield (t/ha) sown on 30 cm row spacing with different sowing orientation and seeding boots at Minnipa 2015. Because the orientation blocks were not replicated formal yield comparison is not possible, but values are believed to be indicative. Note the Extra control directional plots were placed alongside the other orientation block.

Row Direction	Row spacing (cm)	Knife points	Knife points plus weed	Ribbon spread	Ribbon plus weed	Extra control directional plots
North South	30	2.32	1.95	2.29	1.87	2.23
East West	30	2.69	2.38	2.66	2.45	2.38 *CV 8.4%*
North South	18	3.34	3.09	3.32	3.02	
East West	18	2.94	2.70	2.83	2.73	*CV 6.8%*

What does this mean?

These results support previous trial work at Minnipa Agricultural Centre (Cook, 2009) which showed that sowing in an E-W direction increased yield over N-S sowing direction in an average season. Research from Western Australia also showed an increase in grain yield with wheat and barley sown in an E-W orientation due to a decrease in grass weed competition with high ryegrass populations. The extra directional control plots have not fully supported the sowing direction yield increase as the E-W control in the N-S block were not better than the 30 cm N-S treatments (Table 3) which may be due to light interception by the crop.

The trial reported here showed a decline in wheat yield from oats as a surrogate grassy weed, but this competition was similar in both row orientations. The wider row spacing resulted in an increase in 'weed' biomass as did the knife point system compared to the ribbon seeding boots.

The wider row spacing of 30 cm resulted in a large yield reduction regardless of the seeding boots used.

While this trial was sown into stubble with the same orientation as the cropping direction in the previous year, factors such as distribution of nutrients/weeds/diseases or soil constraints prior to the previous crop may also have affected our row orientation blocks differently. This trial will continue for another two seasons.

References

Borger C, Hashem A, Powles S (2015) Manipulating crop row orientation and crop density to suppress *Lolium rigidum*. *Weed Research* **56**, 22-30.

Cook, A., Shepperd, W., and Hancock, J., Row Direction and Stubble Cover. EPFS Summary 2009, p114-115.

Acknowledgements

Thank you to Sue Budarick for processing the weed counts and managing the weed germination trays. Funded by the GRDC Overdependence on Agrochemicals project (CWF00020).

Location: Minnipa Agricultural Centre paddock N7/8
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: (W) 3.0 t/ha
Actual: 2.7 t/ha
Paddock history
2015: Mace wheat
2014: Wyalkatchem wheat
2013: Medic pasture
Soil type
Red loam
Plot size 20 m x 2 m x 4 reps

Image: UNFS Members at the 2015 Spring Crop Walk inspecting Matt McCallums Seeding Setup

Efficient grain production compared with nitrous oxide emissions

Author: Birchip Cropping Group

Funded By: Australian Government Department of Agriculture – Action on the Ground. **AOTGR1-222**

Project Title: Efficient grain production compared with nitrous oxide emissions

Project Duration: 2011-2015

Project Delivery Organisation: Birchip Cropping Group, UNFS, EPARF, CWFS, MSF, SFS

Key Points:

The project demonstrated on-farm cropping practices that reduce nitrous oxide emissions by employing improved nitrous fertiliser use and legume and non-legume pasture crop rotations while maintaining crop productivity. Land managers' awareness and knowledge of options to reduce nitrous oxide emissions has been increased and survey results indicated this.

Emissions tended to be low (given the low replication and monitoring intensity). Productivity implications were difficult to measure but the best option for reducing emissions is to improve overall nutrient use efficiency.

Project Report: Below is an excerpt from the Final Report of this project. Please see the UNFS Website for the full report.

Overview

Previously, limited research into the grain's industry's N_2O emission contribution in various rainfall environments in south eastern Australia had been undertaken. In a bid to better understand N_2O risks, the Department of Agriculture (DA) funded BCG who collaborated with five other farming systems groups: MSF, SFS, CWFS, UNFS, EPARF and Vic DEDJTR to measure N_2O emissions from soils under varying cropping regimes and extend this information to growers and their advisors.

The project aimed to trial and demonstrate on farm practices/technologies to reduce agricultural greenhouse gas emissions by measuring N_2O fluxes from legume and cereal rotations and various fertiliser types and rates in trials across southern Australia.

Eighteen demonstrations and trials measured N_2O emissions via static chambers across low medium and high rainfall broadacre cropping zones. These were undertaken by five farming systems groups including BCG (low and medium rainfall), MSF, CWFS (low rainfall) UNFS, EPARF (medium rainfall) and SFS (high rainfall) across a range of farming systems.

N_2O emissions were measured in response to N rates, N products, legume residues, summer fallow, and paddock zones.

It was anticipated that N_2O measurements were taken one day prior, one day after and one week following rainfall and/or fertiliser application to capture peak N_2O emissions.

Analysis indicated that peak emissions often occurred on the sampling day following rainfall.

Nitrous oxide fluxes measured from low and medium rainfall zones following rainfall and or nitrogen fertiliser application were generally low; up to 4.5 g N_2O-N/ha/day. If this was extrapolated on an annual basis then 1.5 kg N_2O-N/ha/year would be produced. In reality this would be far less as rainfall events occur infrequently in such environments.

Peak N_2O fluxes from higher rainfall zones in southern Victoria were similar also, which was reflective of relatively small rainfall events that occurred of 5 mm to 20 mm during the sampling period.

In the higher rainfall environment of Tasmania, measured N_2O emissions were greater with peak N_2O emissions measuring approximately 25 to 50 g N_2O-N/ha/day.

The best mitigation approach for any rainfall environment is to only apply as much synthetic nitrogen as is demanded by the crop's yield potential on the land in which it is grown. Any additional nitrogen applied that is not required by crop growth is unnecessary and uneconomic. Therefore, maximising the efficiency of nitrogen fertiliser use will ultimately minimise greenhouse gas emissions.

Matching nitrogen fertiliser application to crop demand will improve the crop's performance, the paddocks' gross margin and will benefit the environment. A win-win-win situation for the Australian agricultural industry.

This is supported by Barton *et al.* 2008 who says "we expect N_2O emissions, resulting from the direct addition of N fertiliser to rain-fed, cropped soils in semi-arid regions, to be low if the timing and amount of N fertiliser (and N mineralised) is reasonably well matched with crop demand and does not coincide with significant rainfall."

The challenge for farmers however, is to maximise these efficiencies in an environment of climate variability. And such variability was demonstrated in this project when using rainfall forecasts to determine sampling timings; in some cases the predicted rainfall event and/or amount did not eventuate.

There is still a level of uncertainty and confusion among growers surrounding nitrogen losses from volatilisation and how this contributes to total on farm nitrogen loss and GHG emissions.

Methodology Summary

Eighteen demonstration trials measured N_2O emissions via static chambers. These trials were undertaken by six farming systems groups including: Birchip Cropping Group (BCG), Mallee Sustainable Farming (MSF), Upper North Farming Systems (UNFS), Eyre Peninsular Agricultural Research Foundation (EPARF), Central West Farming Systems (CWFS) and Southern Farming Systems (SFS) in low, medium and high rainfall zones (see Figure 1).

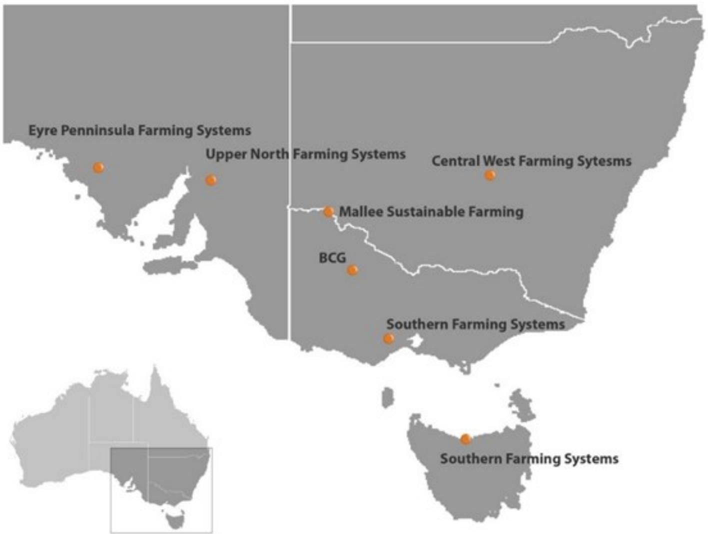

Figure 1. Grower group locations

Treatments investigated were:

- N_2O from N rates top-dressed
- N_2O from fertiliser products
- N_2O from vetch residue
- N_2O from legume and fallow residue
- N_2O from N applied to paddock zones
- N_2O from canola + N fertiliser versus legumes
- N_2O from different stubbles over summer

Demonstration scale measurements of N_2O emissions were collected following fertiliser application or rainfall. These were measured from sealed PVC static chambers of approximately 30 cm in diameter, positioned on farm in small plots or in large paddocks. N_2O was drawn from airtight chambers via medical syringes into evacuated vials. N_2O flux measurements were generally collected at intervals of 0, 30 and 60 minutes one day prior to, one day after and approximately seven days following a rainfall event. N_2O Samples were measured by Melbourne University and later by the Queensland University of Technology.

Ambient and soil temperatures were also measured and soil (0-10 cm) was collected to enable testing for moisture and nitrogen at each sampling.

Table 1. Demonstrations and trials undertaken.

Site	Organisation	Timing of N_2O monitoring	Treatments monitored
1	EPARF	Minnipa 2013-2014	Canola + N compared to legumes followed by wheat in year 2.
2	BCG	Birchip 2012	Zero, medium (138kg/ha urea) and high (258kg/ha urea) urea rates
3	BCG	Rupanyup 2012	Zero, medium (180kg/ha urea) and high (450kg/ha urea) urea rates
4	BCG	July 2013	Vetch end-uses: Fallow (control), brown manure, grazed, hay, incorporated
5	UNFS	July 2013	Three soil zones (sandy loam, sandy clay loam, clay loam) topdressed with urea of 85, 55, 40kg/ha
6	BCG	August 2013	Liquid vs granular fertiliser: 0N, UAN applied to inter-row, UAN standard nozzles, UAN streaming nozzles, urea
7	BCG	August 2013	0N, granular urea, Green urea (urease inhibitor), Entec (nitrification inhibitor) urea and polymer coated slow release urea
8	SFS (Victoria)*	August 2013	0N, UAN PSPE & UAN PSPE + UAN with nitrification inhibitor at GS22
9	SFS (Tasmania)*	September 2013	Urea rates of 80, 160 & 240 kg/ha
10	MSF	February 2014	Wheat, field pea, vetch stubble
11	CWFS	February/March 2014	Field Pea stubble (3x replicates)
12	CWFS	April 2014	Field Pea stubble (3 x replicates)
13	BCG	June 2014	0N, urea, polymer coated urea (slow release), UAN, Entec (nitrification inhibitor) urea
14	UNFS	July 2014	0N, 50kgN/ha, 100kgN/ha
15	MSF	September 2014	N applied to wheat: 0N, 50kg urea/ha, 150kg urea/ha
16	SFS (Victoria)	September 2014	0N, 100kg urea, 30kg Entec + 70kg urea
17	BCG	September/October 2014	Fallow, early vetch termination, late vetch termination, field peas late termination
18	SFS (Tasmania)	October, November	Urea, Tropicote and Gran Am products

N_2O variability and static chambers

N_2O emissions are highly variable in both time and space. This project was of a demonstration scale and therefore it was decided to investigate treatments where clear differences were most likely. Key drivers of N_2O emissions are:

↑ soil water
↑ soil mineral N
↑ soil carbon
↑ temperature

For this reason it was possible to anticipate periods where the risk of N_2O emissions were likely to be greater. For example; work carried out as part of the NAMI project indicated that in the Wimmera, N_2O emissions were not particularly high, however increased emissions could occur after topdressing urea followed by rainfall (Hill *et al* 2012).

In general, a high risk situation for N_2O loss can be expected during warm conditions, with high background levels of both soil nitrate (e.g. following fertiliser application) and soluble carbon (C) following significant rainfall resulting in topsoil being at or around field capacity. Examples of this include the work of *Barton et al 2010,* which indicated the potential for increased emissions in low rainfall environments following significant summer rainfall. However, the proportion of N lost as N_2O can actually decrease if soil moisture exceeds field capacity as more N is emitted as N_2 rather than N_2O.

The key aim of the trials/demonstrations was to illustrate the increase in emissions following rainfall and/or fertiliser applications followed by a decline over time (Figure 2) thereby providing a practical demonstration of the mechanics behind N_2O loss.

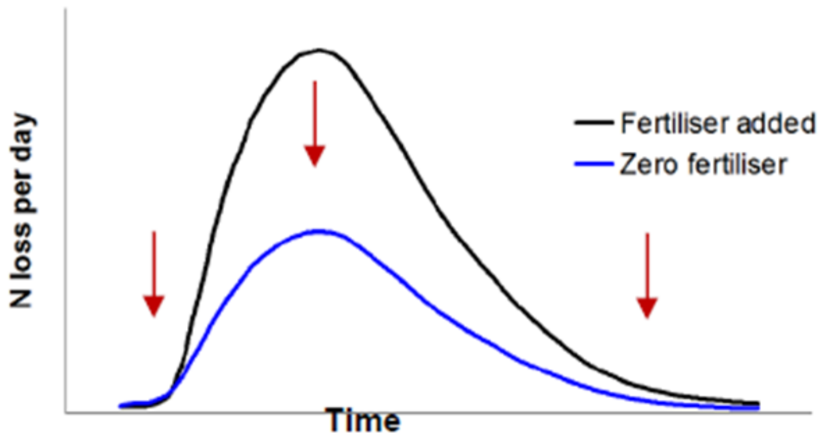

Figure 2(L). Theoretical pattern of N loss as N_2O prior to and following fertiliser application combined with a significant rainfall event followed by dry conditions. Red arrows indicate potential sampling days.

Sampling

Chambers (see figure 3) were installed at least 24 hours prior to gas sampling to avoid the possibility of soil disturbance influencing emissions.

Chambers were installed between crop rows. Chambers were installed to a depth of around 5 cm to ensure that the soil formed a seal around the base. A spirit level was used to make sure chambers were level with the soil surface to accurately capture subsequent rainfall. Lids were removed between sampling days (to allow rainfall in and background temperatures to prevail).

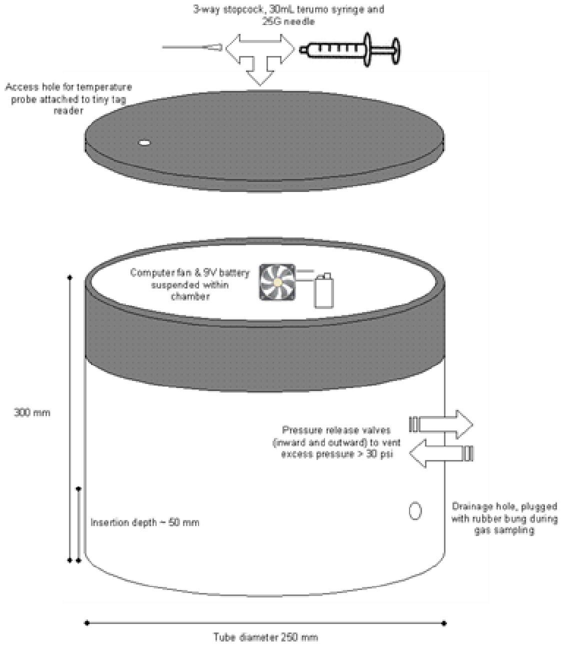

Figure 3: Diagram of static chamber design

N_2O samples were collected at 0, 30 and 60 minutes. The individual samples were collected from sealed static chambers and placed into evacuated exetainers which were sent for analysis by gas chromatography. Ambient temperature was recorded at each sampling interval, while soil temperature was recorded at the first and last sampling. 0-10 cm soil was collected for water content and soil mineral nitrogen.

Discussion

<u>Effect of N application rate on N_2O loss</u>

N_2O flux across all sites were generally low with the main exception being Tasmania in 2013 where peak fluxes approached 30 g N_2O-N/ha/day and were generally >10 g N_2O-N/ha/day. This was despite high soil water filled pore space (WFPS) at some sites (e.g. Birchip and to a lesser extent Rupanyup). The question left unanswered is why emissions were so low given high WFPS at Birchip and Rupanyup, but so high at Tasmania given relatively low WFPS. The data collected was unable to shed light on this issue, but given that mineral N levels at the Tasmanian site (further commentary below) were not significantly higher than the other sites it is hypothesised that it may be related to differences in availability of labile carbon. Soil organic carbon of approximately 1 percent was collected at Birchip and Rupanyup but soil carbon data was unfortunately not collected from Tasmania, however differences would be expected given different environment, soil type and farming systems. It was also possible that the conversion of NO_3^- to N_2O and N_2 gas was much slower in an acid soil (Tasmania) and hence higher losses of N_2O occurred compared with alkaline soils (Wimmera and Mallee).

The relationship between applied N and N_2O flux was not clear or consistent, which indicated that N_2O flux was not limited by the availability of mineral N in the situations monitored. Where soil mineral N data (not shown) was available there was a clear relationship between the application of N and soil mineral N. This was particularly the case for the ammonium form of N, likely related to the fact that N was applied as urea and sampling occurred in the immediate days after application. As a result, it is possible that part of the lack of a response in N_2O flux to N application may be due to limited 'fertiliser induced denitrification' as the applied N was yet nitrified. This was further complicated by moderate levels of background mineral N available for release as N_2O, further diminishing the likelihood of a response to fertiliser application. Whether this relationship would hold over the rest of the season with subsequent rainfall (potential waterlogging) events is unknown.

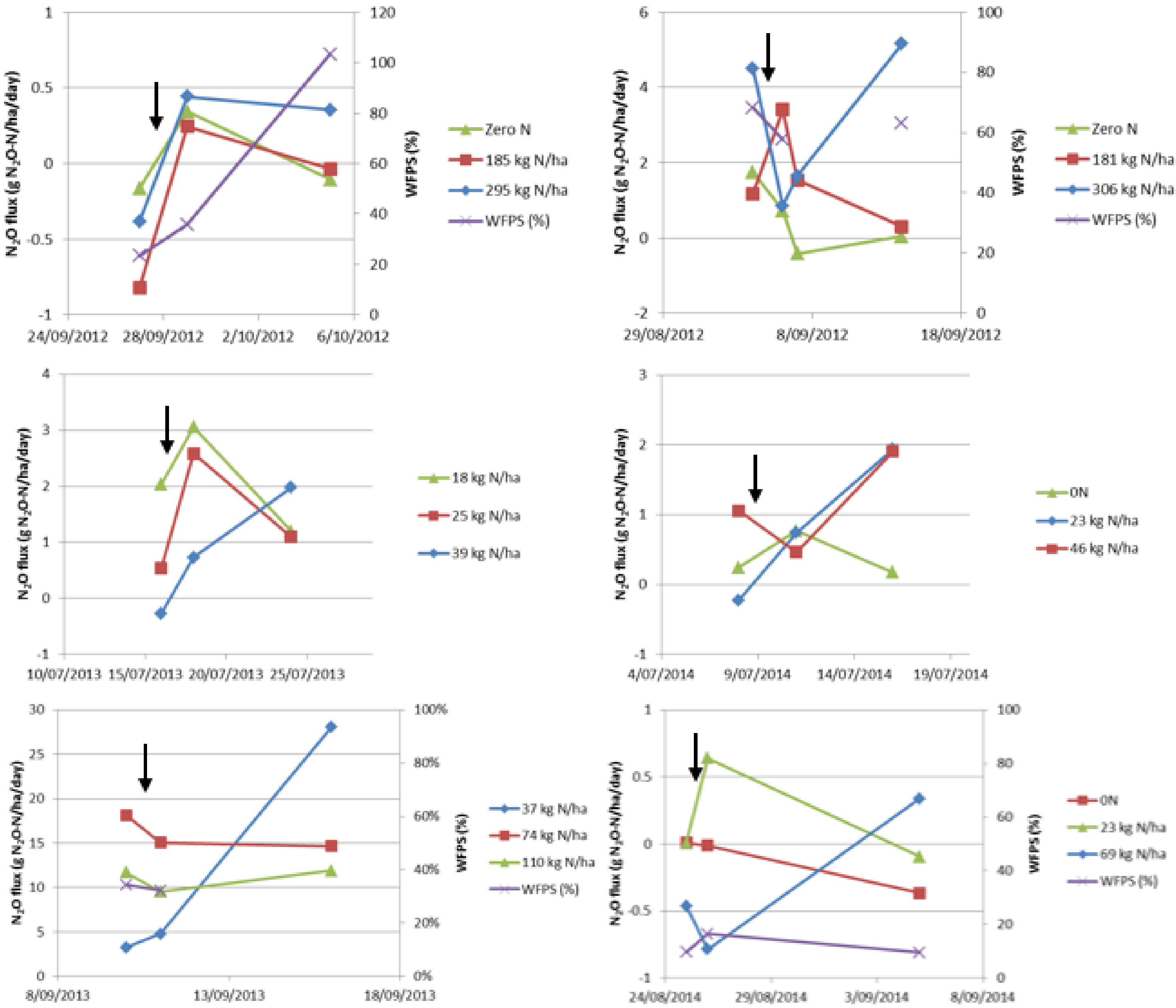

Figure 4: N_2O flux in response to varying N application rates at Birchip (top left), Rupanyup (top right), Jamestown (middle, both), northern Tasmania (bottom left) and Mildura (bottom right). Where available, topsoil water filled pore space (%) is included. Arrows indicate timing of fertiliser application, all applications made as granular urea.

<u>Effect of fertiliser product and application method on N_2O loss</u>

As was the case above, trials investigating emissions based on fertiliser product choice generally resulted in low N_2O flux. Once again, in some cases this was despite significant WFPS (Horsham). Where available, differences between the zero N control and where fertiliser had been added were generally limited and as a result any differences associated with altering the method of application or the use of products to slow release or nitrogen cycling within the soil were unlikely to result in meaningful differences. This is not to say that such products do not function in the intended way and they have certainly shown promise in other research for the reduction of N_2O loss (for example Chen *et al.,* 2010). However the deployment of such technologies will only ever be effective in situations where the likelihood of losses is increased from fertiliser addition. Furthermore, for any agronomic benefit to be obtained such products should only be used where likely N losses are of an agronomically relevant magnitude and are sufficient to offset the cost of the amendments.

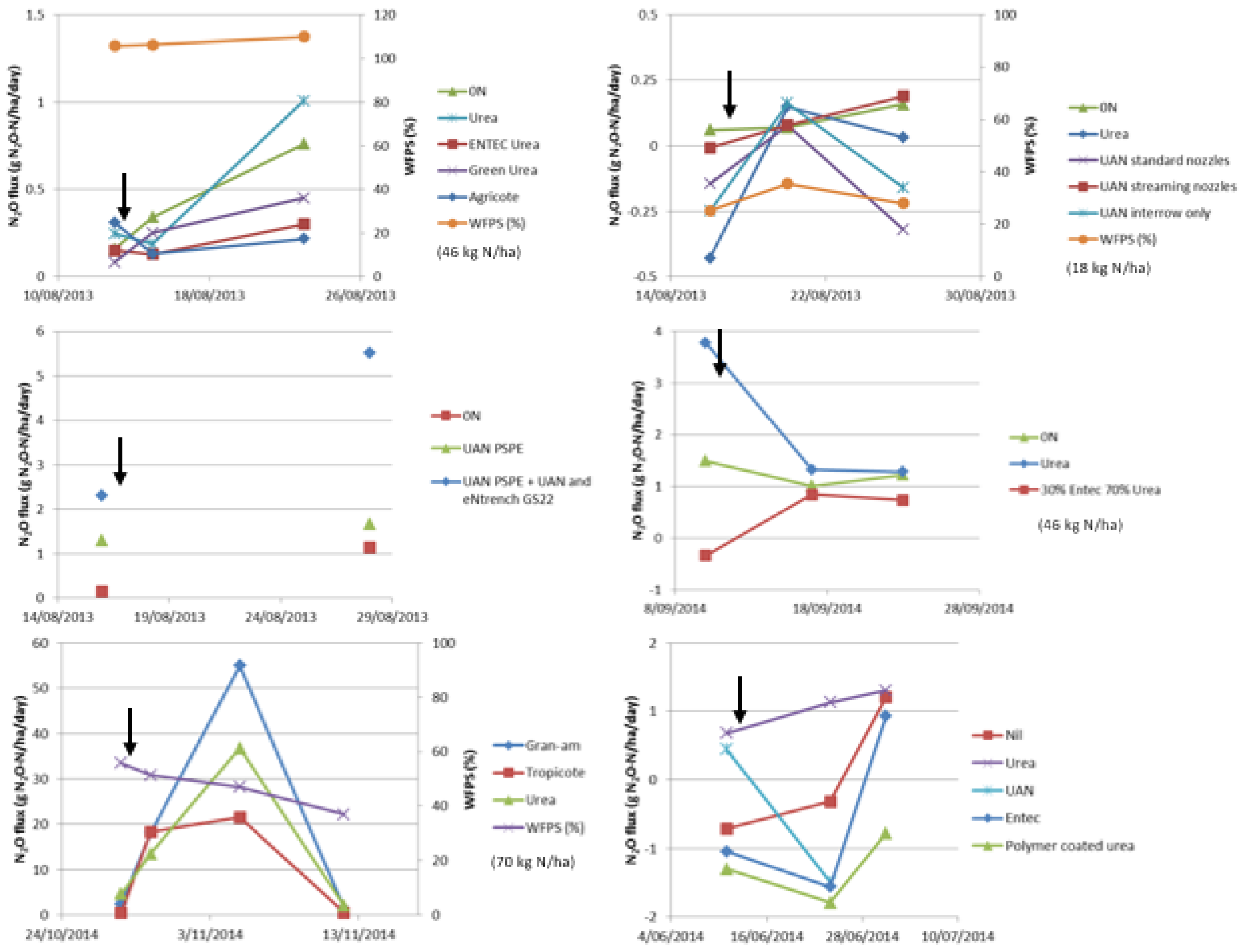

Figure 5: N_2O flux in response to various N fertiliser products / application method at Horsham (top left), Birchip (top right), Inverleigh* (middle left), Tarrington (middle right), northern Tasmania (bottom left) and Horsham (bottom right). Where available, topsoil water filled pore space (%) is included. N included in parenthesis. Arrows indicate timing of fertiliser application. ENTEC: Nitrification inhibitor treated urea; Green Urea: Urease inhibitor treated urea; Agrocote: Polymer coated controlled release urea; PSPE: Post-sowing, pre-crop emergence; eNtrench: Nitrification inhibitor; Gran-am: Ammonium sulphate; Tropicote: Calcium nitrate *Sampling undertaken on three days between 16-Aug and 28-Aug 2013, however samples were broken in transit for sampling undertaken on 21-Aug.

<u>Effect of rotation choice on N_2O loss</u>

N_2O flux across the various rotation trials was generally low (predominantly <1 g N_2O-N/ha/day) and while most treatments trended upwards in response to rainfall following the initial sampling at each site clear treatment differences were limited. At Mildura, comparing cereal stubble with legumes during the summer fallow produced slightly lower emissions. In theory, this could be related to a lower C:N ratio of legume residues leading to greater breakdown following rainfall.

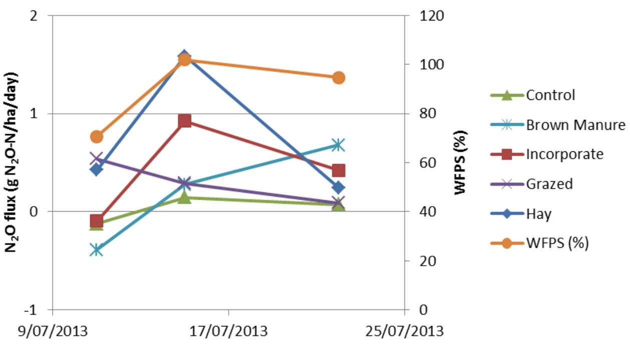

Figure 6: N_2O flux prior to and following rainfall in response to various rotations followed by wheat at Birchip (top left) and following different rotations at Mildura (top right) and Birchip (bottom). Where available, topsoil water filled pore space (%) is included.

This would appear to be at odds with the general premise that inclusion of legumes in rotations can assist with reducing N_2O loss, however this monitoring was restricted to a specific period of the season and it is thought that over the balance of a rotation the additional emissions induced by fertiliser addition (where legume use was less frequent) could potentially outstrip differences associated with breakdown of legume residues. This was illustrated by Schwenke *et al.,* (2015) which indicated that emissions from fertilised canola were significantly higher than chickpea, faba bean or field pea over a twelve month period. Furthermore, peak emissions were recorded for the canola treatment during the growing season, whereas 75 percent of emissions from the legume treatments were measured during the post-harvest period.

Monitoring the impact of rotation on N_2O loss over multiple seasons

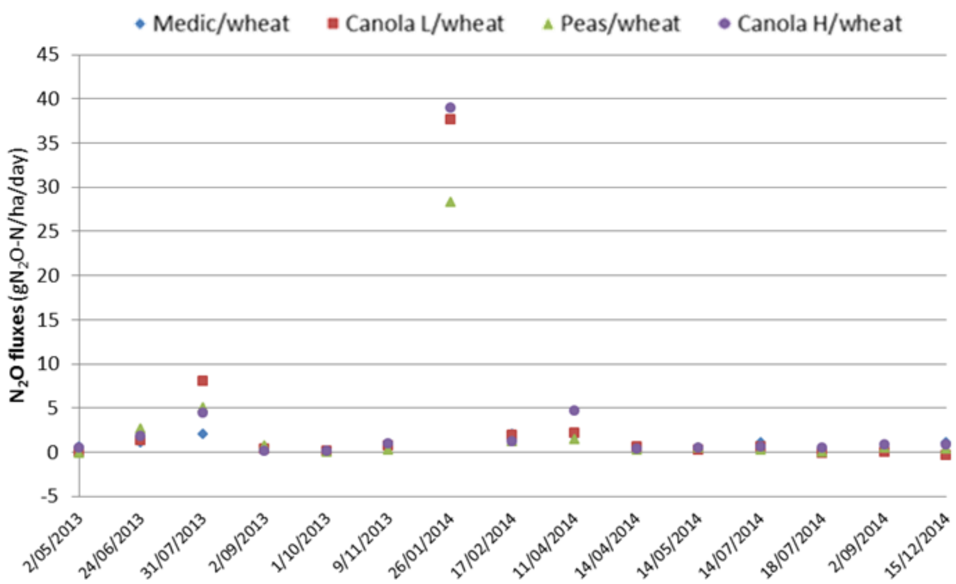

Figure 7: N_2O flux during 2013 and 2014 for various rotations at Minnipa including fertilised canola (46 kg N/ha) followed by wheat with (H) and without (L) urea fertiliser at a rate of 21 kg N/ha.

Compared to other trials undertaken as part of this project, N_2O fluxes were measured over a much longer time frame at Minnipa (approximately monthly for a period of 18 months). In the first season measurements were taken from a variety of crops including medic pasture, fertilised canola and field peas. In the subsequent year wheat was sown across the entire site and measurements were taken from all treatments with the canola treatment being split for wheat grown with additional N fertiliser and without. Across the monitoring period, emissions were generally low (<2.5 g N_2O-N/ha/day), the main exception being during January 2014 following significant summer rainfall when emissions peaked at approximately 40 g N_2O-N/ha/day. Even though the small magnitude of emission differences between treatments tended to be low, on days with higher emissions the canola 2013 rotation appeared to produce greater N_2O emissions, however this was restricted to a small number of sampling dates and further soil data would be required to investigate whether this was related to changes in mineral N or labile carbon associated with the treatments.

Results:

Full results can be found in the project final report, available for download from our website.

Outcomes

This project has reinforced that good practices are already in use, while clear benefits of changing product choice have not necessarily occurred.

The best mitigation approach for any rainfall environment is to only apply as much synthetic nitrogen as is demanded by the crop's yield potential on the land in which it is grown. Any additional nitrogen applied that is not required by crop growth is unnecessary and uneconomic. Therefore maximising the efficiency of nitrogen fertiliser use should help to minimise greenhouse gas emissions both in absolute terms and on an intensity basis.

Matching nitrogen fertiliser application to crop demand will improve the crop's performance, the paddocks' gross margin and will benefit the environment. A win-win-win situation for the Australian agricultural industry.

Economic losses of N_2O are not significant on a farm scale in low to medium rainfall environments.

For example, a paddock where maximum emissions of 4.0 gN_2O-N/ha/day (1.5 kgN_2O-N/ha/year) occurred, then the nitrogen loss would be only $1.62/ha/year, assuming $500/tonne of urea.

Given that greenhouse gas emissions are reported in carbon dioxide equivalents (CO_2-e) the above emission level would be the equivalent of 702 kg of CO_2-e. At an assumed carbon price of $13.95/t CO_2-e, the value of N_2O emitted would be $9.8/ha/year. However, the likelihood is that emissions for low rainfall cropping systems are far lower than the 1.5 kgN_2O-N/ha/year, which means that the cost of emissions loss would be much less.

Therefore motivation from economics is unlikely to reduce N_2O losses. However, nitrogen as a whole can form up to 30 percent or more of broadacre variable input costs and hence using nitrogen efficiently engages growers in discussion.

However, matching nitrogen inputs to crop demand can be challenging in a variable climate where production risk is substantial.

Acknowledgements;

Grower groups including: Birchip Cropping Group (BCG), Mallee Sustainable Farming (MSF), Central West Farming Systems (CWFS), Upper North Farming Systems (UNFS), Eyre Peninsular Agricultural Research Foundation (EPARF), Southern Farming Systems (SFS Vic and Tasmania), Victorian Department of Economic Development, Jobs, Transport and Resources (Vic DEDJTR) undertook trials and demonstrations and extended N_2O emissions knowledge. Vic DEDJTR provided scientific analysis, rigor and review.

Application of Controlled Traffic Farming in Low Rainfall South-Eastern Australia

Author: Rebecca Mitchell, Agriculture Victoria, Department of Economic Development, Jobs, Transport and Resources.

Funded By: Grains Research and Development Corporation (ACT00004) with in kind contributions from project partners Agriculture Victoria; South Australian Research and Development Institute; Birchip Cropping Group; Eyre Peninsula Agricultural Research Foundation; Upper North Farming Systems; Mallee Sustainable Farming; Central West Farming Systems and Society of Precision Agriculture Australia.

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

Project Duration: 2014-2019

Project Delivery Organisation: Australian Controlled Traffic Farming Association.

Key Points:

First year findings from the project show;

- On light soils, a double pass by a heavy vehicle on dry soil had no effect on wheat yield
- That many passes by a heavy vehicle traffic on wet soils decreased wheat yield
- On a heavy red soil all trafficking decreased wheat yields

In addition to four research trials, there have also been 10 development and extension activities in the project's first year of engagement.

Project Report:

This project aims to answer questions being asked by growers about the practicalities and economics of Controlled Traffic Farming (CTF) in this zone of lighter soils, large farms, wide equipment and low input systems. Growers need answers to those questions to make informed decisions about whether or not to invest money and effort in changing their systems to full CTF.

This project has defined CTF as all machinery having the same or modular working and track width, allowing for the establishment of permanent traffic lanes, and all machinery being capable of precise guidance along the permanent traffic lanes.

The most important grower questions and issues identified by GRDC's Southern Panel and Low Rainfall Zone (LRZ) Regional Cropping Solutions Network concern the effects of machinery wheels on LRZ soils and crops. Do LRZ soils suffer compaction damage from heavy machinery, and what effect does that have on crop yield and profit? If a grower adopts full CTF, will any such soil damage "self-repair", or will it require remedial action?

The project will also address several other important issues identified by LRZ grain growers. These include the compatibility of CTF with very wide seeding equipment, wheel track erosion and weed growth, and the economic effects of CTF such as costs of adoption, improved operational timeliness, increased yield and profit, and reduced fuel and input costs.

The project has four research sites on typical southern region LRZ soils, on which detailed soil physics and crop production work is investigating the effects of compaction on soils and crops. These are located at Loxton and Minnipa SA, Swan Hill VIC and Lake Cargellico NSW. Each trial site consists of five treatments replicated four times.

A range of development sites and activities have and will continue to be set up over the duration of the project by Farming Systems Group project partners. The objective of these is to answer many of the other questions posed by the project, and to assist growers and groups answer their own CTF related questions. This will provide plenty of opportunity for LRZ growers to engage with, and take part in, this project.

Table 1. Treatments applied to the four research sites in 2015.

Treatment	Definition
Control	No heavy vehicle trafficking
Dry compaction	A double pass of a 30 tonne vehicle prior to seeding when soil was dry
Wet 1 x compaction	A double pass of a 30 tonne vehicle prior to seeding when soil was moist
Wet 3 x compaction	Six passes of a 30 tonne vehicle prior to seeding when soil was moist
Soil amelioration	Deep ripping to loosen any historical trafficking

Since the start of the project, the project team has organised or participated in field days, expos and crop walks. Adding value to these days is the integration of farmers, consultant and research experts, and showcasing of equipment such as green seeker and digital penetrometer as part of the events. Media exposure has been through a Twitter account and articles in farmer targeted newsletters.

Matt McCallum and UNFS have had a key role in the development and extension of a research grade penetrometer from Rimik. As well as presenting the preliminary information from this, Matt led discussions about CTF at the UNFS Precision Agriculture day in March 2015, the Members' Expo in August 2015 and the eastern spring crop walk in September 2015, engaging over two hundred people.

The cone penetrometer was used to assess compaction at depth on CTF properties, looking at differences between trafficked and non-trafficked areas. Focusing on three different depths; 5, 15 and 35 centimetres, the preliminary results below from one of the penetrometer sites suggest that compaction was becoming an issue at depths below 20 cm, with a pressure greater than 2000 kPa. At this site, heavy machinery on the trafficked areas of the property, is suggested to have exacerbated this compaction at depth.

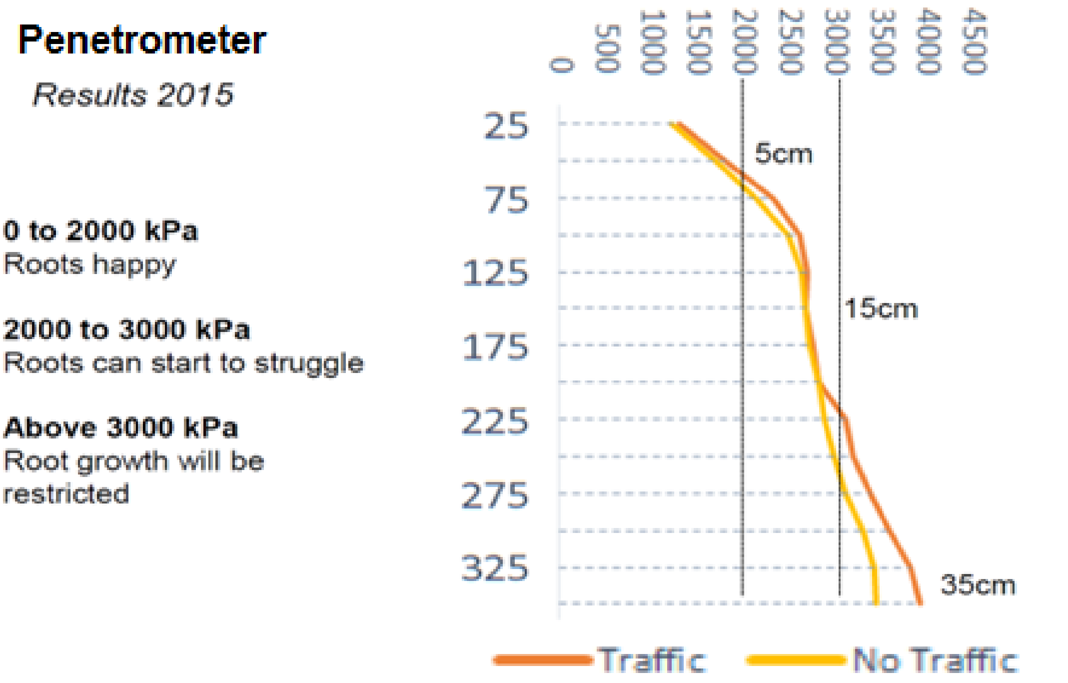

***Image 1** : Graph produced by M McCallum showing the data that can be collected from the penetrometer. Y axis is mm from the soil surface, x axis is kPa of pressure.*

Like the UNFS group, other project partner groups have made important contributions to the project's development and extension activities. CWFS have been leading the development of case studies looking at properties who currently use CTF and inter-row sowing. They have also been undertaking farm surveys across their 14 regions. This season they will be taking NDVI readings across the width of the seeder bars to examine the impacts of wheels on crop performance.

Similar to the penetrometer work from the UNFS groups, this season BCG will be exploring compaction effects across the farm. In the previous season, they have run soil and water crop walks, demonstrating the effects of compaction of soil water infiltration and drainages, and inviting Wayne Chapman to speak at their main field day on CTF.

This season, all the farming groups will look at the effect of wheel tracks on yield, taking crop cuts at harvest on and off the wheel track. Some FS groups will have the opportunity to utilize pull meter technology, which is a unit to measure the towing force required to pull machinery across the paddock on both compacted and non-compacted soils. This is closely related to the fuel consumption of tractors, harvesters and other self-propelled equipment. A tillage energy unit draw bar, which measures the energy (and therefore fuel) used in tillage and seeding on and off wheel tracks, will be trialled in 2016.

This project has also joined with another ACTFA led project that has been monitoring greenhouse gas emissions from the soil. This work is comparing nitrous oxide (N_2O) emissions from wheel tracks and uncompacted CTF cropping beds at Swan Hill in Victoria. The first two years of the project have shown that wheel tracks emit more N_2O than un-trafficked beds across five sites and three states. This means that compaction may cost growers money in lost nitrogen which could have been used by crops.

The project has three more growing seasons remaining and will continue to collect data on the four research sites as well as the development and extension activities. For more information on the project please contact project leader Chris Bluett chris.bluett@hrzconsulting.com, 0409 336 113 or contact any of the project partners. For those inclined, follow us on twitter @CTF_GRAINS or #LRZ_CTF

Acknowledgements: The project would like to acknowledge the GRDC for their funding of the project as well as contributions and support from the 9 project partners. The project would also like to acknowledge the persistence of Joe Koch, a local grower from Booleroo, who overcame the initial issues with the penetrometer and gathered some valuable data for the project and this report.

Australian Controlled Traffic Farming Association Inc

Economic Development, Jobs, Transport and Resources

AGRICULTURE VICTORIA

UNFS Upper North Farming Systems

BCG shared solutions

SPAA Society of Precision Agriculture Australia

Government of South Australia

SARDI South Australian Research and Development Institute

EPARF Eyre Peninsula Agricultural Research Foundation

CWFS Central West Farming Systems Inc.

Mallee Sustainable Farming

GRDC Grains Research & Development Corporation

Cereal Variety Disease Guide 2016

Author: Hugh Wallwork, Principal Cereal Pathologist and Pamela Zwer, Oat Breeder

Project Delivery Organisation: SARDI

Summary of 2015 season and implications for 2016

A cold winter, dry spring and lots of fungicide kept most cereal diseases at bay during 2015.

Rusts were not a serious problem and the barley net blotches were at a low level compared to recent years. The most concerning developments were an increase in septoria tritici blotch and eyespot in wheat crops across a wide area. Take-all hit many wheat crops along the far west coast and central EP particularly in calcareous soils and in paddocks where there was a history of intensive wheat and grass weeds combined with reduced stubble breakdown. Red leather leaf was severe in oaten hay crops in the Marrabel Valley. Loose smut affected many Hindmarsh barley crops and was also reported in Scope on the Eyre Peninsula.

Rusts in wheat and barley

Stripe rust was observed in wheat crops throughout the Mid and Lower North from mid August onwards. In most cases the hotspots were observed in crops of Mace whilst growers were applying their protective fungicides. These sprays and earlier applications of in-furrow fungicides kept stripe rust under good control. Very little leaf or stem rust was observed in wheat in 2015.

Barley leaf rust was not a serious problem in 2015. A much reduced area sown to very susceptible varieties such as Keel and Schooner have kept this disease in check in recent years. Virulence on Compass was observed just once in 2015 on the far west coast in South Australia. The crop was sprayed and no further reports of rust on this variety were received in SA. Virulence on Compass was present in Western Australia and the eastern states where it is rated as very susceptible.

Eyespot

Eyespot was again observed more widely than in previous years with crops lodging from the disease around Cleve on the Eastern Eyre Peninsula and Lower Yorke Peninsula areas as well as the more common higher rainfall areas of the Lower and Mid North and South-East. In 2016 eyespot inoculum will be included in the PredictaB reports for the first time.

Variety evaluation trials run by SARDI with funds from GRDC indicate that Trojan and Emu Rock have some useful resistance whereas Axe, Cobra, Corack, Mace, Scout, Shield and Wyalkatchem are all quite susceptible. The long season wheat Manning is also known to have a useful resistance gene derived from a UK variety.

Septoria tritici blotch

This disease was observed in small hotspots in many crops across the Mid and Lower North, Yorke Peninsula, Lower and Eastern Eyre Peninsula from mid September onwards. An area to the west of Point Pass in the Mid North was exceptional in that a number of crops in this area were uniformly infected with septoria suggesting that this area would have had septoria building up in the previous season and may have been the source for the wider infection in 2015. From 1994 until 2015 septoria tritici blotch has been quite rare in most of the state although it has been an increasing concern in the South-East of SA where cereal cultivation has intensified and rotations shortened. Most of the infection observed in 2015 was on Mace which indicates that the septoria population derives from the South-East and/or Victoria where virulence has increased on this and other varieties such as Wyalkatchem and SQ Revenue. Whilst these outbreaks caused little damage in the past season the wide distribution of virulent inoculum means that the potential for greater losses now exists for future years. Damage is most likely to occur where crops are early sown and good rainfall in winter /spring allows the fungus to splash up the canopy.

Spot form net blotch

In GRDC funded trials at Wharminda where SFNB was severe, Hindmarsh (S) lost yield of around 16%, La Trobe (MSS) 10% and Scope (MS) 11% compared to plots treated with Systiva and foliar sprays. A similar trial in 2014 showed figures of 13% for Hindmarsh and 10% for La Trobe. SloopSA (SVS) lost 21% and 18% in 2015 and 2014 respectively.

These trials are providing good estimates of potential yield losses for a range of resistance levels to SFNB across seasons and indicating that for many varieties, the economic benefits of fungicide applications are not as clear cut as they are for net form net blotch, leaf rust and scald.

Oats

For a second successive year there was little in the way of disease development in oats with the exception that in the Marrabel valley red leather leaf symptoms were prevalent in crops. This was likely caused by the wet conditions in September combined with close rotations in the valley. Most of the infection was in Mulgara oats indicating that the previous MS rating for this variety should now be changed to at least MSS. Control with fungicides is not a good option so avoiding susceptible varieties is clearly important.

Explanation for Resistance Classification

R The disease will not multiply or cause any damage on this variety. This rating is only used where the variety also has seedling resistance.

MR The disease may be visible and multiply but no significant economic losses will occur. This rating signifies strong adult plant resistance.

MS The disease may cause damage but this is unlikely to be more than around 15% except in very severe situations.

S The disease can be severe on this variety and losses of up to 50% can occur.

VS Where a disease is a problem this variety should not be grown. Losses greater than 50% are possible and the variety may create significant problems to other growers.

Where a '-' is used then the rating is given as a range of scores that may be observed depending on which strain of the pathogen is present.

This classification based on yield loss is only a general guide and is less applicable for the minor diseases such as common root rot, or for the leaf diseases in lower rainfall areas, where yield losses are rarely severe.

Other information

This fact sheet supplements other information available including the South Australian Sowing Guide 2016 and Crop Watch email newsletters. Cereal Leaf and Stem Diseases and Cereal Root and Crown Diseases books (2000 editions) are also available from Ground Cover Direct or from Hugh Wallwork in SARDI.

A link to the Resistance Tables will be placed on the UNFS Website.

Disease identification

A diagnostic service is available to farmers and industry for diseased plant specimens.

Samples of all leaf and aerial plant parts should be kept free of moisture and wrapped in paper not a plastic bag. Roots should be dug up carefully, preserving as much of the root system as possible and preferably kept damp. Samples should be sent, not just before a weekend, to the following address:

SARDI Diagnostics

Plant Research Centre

Hartley Grove

Urrbrae SA 5064

Further information contact:
hugh.wallwork@sa.gov.au

Government of South Australia

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

A Catalyst for Change – Productive Grazing Strategies for the Upper North

Jim Higgins Case Study

Jim Higgins strong interest in livestock and improved grazing systems has increased farm profitability compared to his previous farm system, which had a greater emphasis on cropping.

QUICK FACTS	
Location	Booleroo Centre, Willowie, Morchard and Hammond (Upper North, SA)
Property size	1,200 ha
Average annual rainfall	311 mm (Hammond) to 392 mm (Booleroo Centre)

The farm business consists of 5 blocks including arable cropping areas at Booleroo Centre, Morchard and Willowie and pastoral grazing at Hammond. The Booleroo Centre block has a cropping and grazing history of more than one hundred and thirty years. Like most properties in the district livestock were continuously grazing at relatively low stock density for most of the year. Prior to 2007, wheat was the main crop sown followed by either barley or a self-regenerating medic pastures. From 2008 to 2012 cropping intensity was increased on the Booleroo Centre property to improve profitability with a rotation of wheat, barley and vetch.

The sheep flock consists mainly of merino ewes mated to White Suffock rams and a small self-replacing merino flock with additional ewes bought in as required.

The Drivers of Change

Following careful consideration and discussions with the family, Jim realised changes were needed to improve their farming business. Jim says "There were many factors influencing changes, including the interests and career choices of family members, the expense of upgrading machinery and my preference for working with livestock rather than cropping. My three daughters are very capable on the farm but have chosen careers off farm. In 2011, I realised the maintenance requirements of cropping machinery were increasing and the gear wasn't suited to our future needs. When I investigated upgrading our air-seeder, tractor and harvester I found even the cost of second hand machinery was difficult to justify given our relatively small crop area."

Making the Change

In January, 2012 Jim decided to reduce his cropping area and intensively graze sheep on his Booleroo Centre block, this change would be complimented by his other properties where he would continue with a mix of grazing and cropping. He decided to sell his harvester and use a contractor. Jim kept his old air-seeder and purchased a more reliable tractor for seeding, moving hay and mixing feed. Jim focussed on increasing his livestock production and profitability to cover their reduced cropping income.

The actions Jim identified to increase livestock carrying capacity and improve grazing management included; sowing 'improved' pastures, improving farm layout, and upgrading the farm water supply and delivery system.

Implementation

Jim fenced the Booleroo Centre block into five paddocks of approximately 30 hectares each in a north south direction, running into a laneway which is a disused railway line. 30 hectare paddocks were chosen as they would be a reasonable size for cropping when sold in the future and enable adequate stocking densities for grazing. A new dam was constructed to increase water supply and additional watering points installed in 2013 with a solar pump installed on a bore to supply water to the feedlot to reduce his mains water bill.

Confinement Feeding

Jim had run a lamb finishing feedlot for over 20 years with a small investment in fencing, feeders and silos. Finishing his own lambs, as well as store lambs purchased from other producers. After talking to a number of neighbours he built a new confinement feedlot in 2012. With the capacity to hold 1,500 adult sheep or 1,600 lambs, close to his sheep yards and the laneway.

This feedlot is now an integral part of his system and he uses it for both finishing lambs for sale, and as a risk management tool for maintain condition of his breeding ewes and other stock. Having the feedlot has enabled Jim to confidently run high stocking rates on his Booleroo Centre block.

Jim feels that confinement feeding is the best thing he has done. "I have taken my breeding stock off my paddocks at the break of the season to allow the pastures to establish. It is very versatile; we can run the sheep between the feedlot and the establishing pastures. For example, two days on pasture and three days in the feedlot." This has ensured more rapid growth of pastures during mid to late winter.

Jim has learnt that it is important to get the feed ration right in the feedlot when confinement feeding pregnant ewes. In the first year (2012) the ewes appeared healthy and strong and were released onto good pasture for lambing with good lambing rates. However at shearing the ewes had a break in the wool with very low tensile strength. He now places more importance on ensuring he gets the ration right, using the 'Feeding and Managing Sheep in dry times' to guide his decision making.

Pasture Management

With more intensive grazing management Jim realised he needed to increase pasture productivity and he has found sowing the majority of paddocks each year significantly increases available feed.

Species and variety selection

Jim has had good success with Cavalier spineless burr medic sown at 15 kg/ha with a cover crop of Hindmarsh barley at 32 to 35 kg/ha. These pastures are grazed early and then either grazed again in spring or harvested for grain. Oats did not prove to be a successful cover crop as they grew too tall and smothered out the medic. Existing Paraggio medic stands have also regenerated well, following a change in grazing management. Other legumes and grasses have been trialled with varying success: Morava vetch has been sown into paddocks with a good medic seed bank and has produced a large amount of bulk when sown early. Paraponto and snail medic produced good bulk but do not recover from early heavy grazing. Tetrone ryegrass did not perform well and Balansa clover has not regenerated under there conditions.

Weed management

Capeweed, stemless thistles and silver grass are becoming more prevalent, as that they are not being controlled as they would be in a cropping situation. Jim plans to sow every paddock on his Booleroo Centre block with a cover crop of cereal into his medic pastures in early to mid-April to provide additional feed and help to control weeds.

Grazing Management

When to graze pastures has been a challenge for Jim, grazing too early reduces pasture growth and productivity but grazing too late results in trampling and wastage. Jim recollects a quote from his father, "pasture any higher than 5 cm is only good for one thing – photographs!"

Left: Jim Higgins explaining his livestock system at the recent Farm Gate Meeting. Photo - Jodie Reseigh, Rural Solutions

- Grazing density – high rates of 25 to 35 DSE/ha are used
- Grazing time – depends on the size of the paddock and mob but varies from 1 to 4 weeks.
- Rest periods are used to allow pastures to recover or to ensure adequate ground cover remains.
- Cell grazing using electric fencing to further sub-divide paddocks and increase grazing pressure has worked well and will be continued.

Livestock management

Jim has made a number of management changes including:

- Splitting his lambing with half the ewes lambing in June and half in September to enable lambs to be finished at different times of the year in the feedlot. This has also reduced the number of rams required.
- Shearing young ewes at 7-8 months (70-80 mm wool length) and mating then at 10 months (47 kg live weight) with 90% lambs marked.
- Using lick feeders in paddocks to help introduce grain to lambs and other stock before they are placed into the feedlot.
- Marking crossbred lambs as early as possible using rings, which has reduced the number of lambs getting infections.
- Vaccinating all lambs going into the feedlot with a 3 in 1 vaccine.
- Culling any poor performing lambs before they go into the feedlot as they do not improve and "you have to look at them every day".

Jim has used Auctions Plus to purchase store lambs and finished lambs are sold over the hooks direct to meatworks with every lamb weighed before sale.

Maintaining adequate ground cover

Jim has learnt that it is important to always leave adequate ground cover. In August 2012, a barley crop was heavily grazed and with a dry spring, it did not regrow leaving the paddock bare until the following autumn. He now aims to leave at least 1 t/ha dry matter to minimise the risk of wind and water erosion on his clay loam and light sandy clay loam soils.

Biodiversity

A number of creeks run through Jim's Booleroo Centre block with a good range of native vegetation. The main creek has been fenced on both sides and excluded from grazing to allow further regeneration of native vegetation and to reduce the risk of bank erosion.

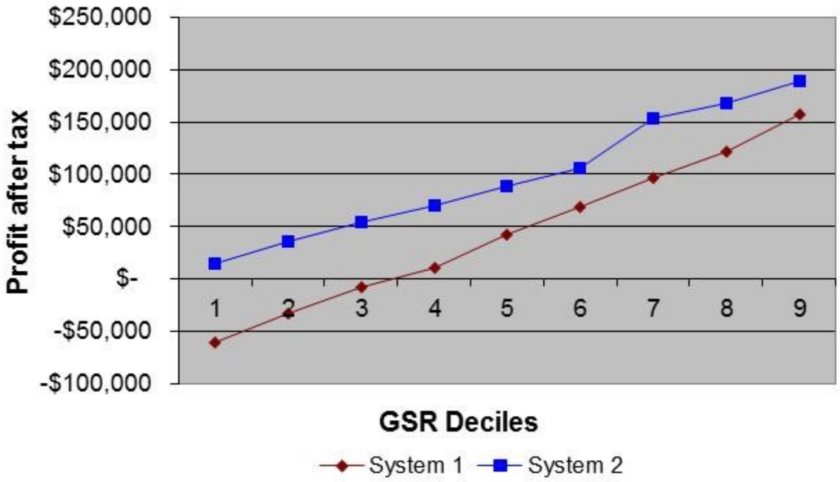

Figure 1; Business profit and loss before tax for System 1 (old system) and System 2 (current system) over a range of growing season rainfall (GSR) deciles.

Economic Benefits

The economic benefits of Jim's new system (called 'System 2') with 15% of income from cropping and 85% from livestock has been evaluated against his old system ('System 1') with 65% of income from cropping and 35% from livestock (See graph below). System 2 assumes an additional $200,000 investment would have been required to upgrade his cropping machinery (second hand air-seeder and harvester and larger tractor).

Profit for the two systems is shown in the graph with System 2 achieving an additional $46,000 profit in a decile 5 season. Current prices have been used for both systems with no allowance for price changes in poor seasons. In System 2 feed costs would increase in a decile 1 season- $30,000 feed costs, decile 2 season - $20,000 feed costs and decile 3 season - $10,000 feed costs. An additional 250 ewes would be purchased in decile 7, 8 and 9 seasons. There is potential to increase cropping intensity in System 1, by intensively cropping the Morchard block, however analysis has shown that this would increase risk and only improve profitability in above average seasons (Decile 7, 8 and 9).

At current prices System 2 is still profitable in a decile 1 season, however with a 20% fall in lamb prices profit would fall to -$19,000 compared to -$86,000 for System 1. Jim has developed risk management strategies for poor seasons such as selling up to 50% of lambs early (August) and heavily culling ewes in late July/early August to reduce stock numbers. Therefore the new system appears to be both highly profitable with a lower risk profile as long as risk management practices are implemented early in poor seasons.

Summary

Jim has struggled to change his mind set from being a grain producer to thinking as a grazier. "Once that was settled, I think that after 3 years I have managed to achieve most of my desired outcomes." The system is versatile and the flexibility has enable Jim to make the most of opportunities such as purchasing an additional 357 pregnant ewes in July, 2014, due to the good start to the season and excess pasture growth. These ewes produced 380 lambs which were finished for sale in the feedlot and the ewes shorn and sold in January, 2015. "This system has led to increased profit and other producers may benefit from this but will need to consider their situation".

More information

Department of Agriculture and Food (2006) Feeding and Managing Sheep in Dry Times. Government of Western Australia.

Prepared by Michael Wurst (Rural Solutions SA).

Funding provided by Ag Excellence Alliance.

UNFS Membership List 2015-2016.

Title	First Name	Last Name	Partners Name	Town
Mr	Gus	Arbon	Janet	Booleroo Centre
Mr	Jordan	Arthur		Booleroo Centre
Mr	Ashley John	Ayles	David Hombsch	Booleroo Centre
Mr	Peter	Barrie	Di	Orroroo
Mr	Howard	Bastian		Booleroo Centre
Mr	Braden	Battersby	Michael	Wilmington
Mr	Michael	Battersby	Braden	Wilmington
Mr	Colin	Becker	Colin	Caltowie
Mr	William	Bennett	Henry	Orroroo
Mr	Henry	Bennett	Wililam	Orroroo
Mr	Dustin	Berryman		Booleroo
Mr	Shaun	Borgas		Booleroo Centre
Mr	Donald	Bottrall	Heather	Jamestown
Mr	Brendon	Bradtke		Jamestown
Mr	Andrew	Bretag		Mannanarie
Mr	Chris	Bretag		Mannanarie
Mr	Gerard	Burt	Dawn	Hawker
Mr	Benjamin	Bury		Wilmington
Mr	Malcolm	Byerlee		Orroroo
Mr	Neil	Byerlee		Orroroo
Mrs	Emily	Byerlee		Orroroo
Mr	Todd	Carey	John	Wilmington
Mr	John	Carey	Todd	Wilmington
Mr	John (JP)	Carey	Nicole	Booleroo Centre
Mr s	Nicole	Carey	John	Booleroo Centre
Mr	Ben	Carn	Susan	
Mrs	Susan	Carn	Ben	
Mr	David	Catford		Gladstone
Mr	Gilmore	Catford	Michele and Andrew	Orroroo
Mr	Andrew	Catford	Gilmore and Andrew	Orroroo
Mr	Grant	Chapman	Margaret	Orroroo
Mr	Dion	Clapp	Danielle (and Barry)	Peterborough
Mr	Barry	Clapp	Norma	Peterborough
Mr	Luke	Clark	Dette	Jamestown
Mr	Scott	Clark	Jaimie	Jamestown
Mr	David	Clarke		Booleroo Centre
Mr	Ian	Clarke		Booleroo Centre
Mr	Piers	Cockburn	Peter (Business)	Wirrabarra
Mr	Peter	Cockburn	Toni-Louise (and Piers)	Wirrabarra

UNFS Membership List 2015-2016 Cont.

Mr	Trevor	Crawford	Christine	Jamestown
Mr	Ben	Crawford	Beck	Georgetown
Mr	Bruce	Crawford	Jan	Georgetown
Mr	Mark	Crawford	Heidi	Georgetown
Mr	John	Crawford	Jan	Georgetown
Mr	Chris	Crouch	Iris	Wandearah via Crystal
Mr	Graeme	Crouch	Cathy	Wandearah
Mr	Nick	Davis	Wayne Davis	Jamestown
Mr	Wayne	Davis	Nick Davis	Jamestown
Mr	Robert	Dennis	Michellle	Port Germein
Mr	Ian	Ellery	Sue and Damian	Orroroo
Mr	Sue	Ellery	Ian and Damian	Orroroo
Mr	Damian	Ellery	Ian and Sue	Orroroo
Mr	Toby	Fisher		Murray Town
Mr	Bentley	Foulis	Michelle	Willowie
Mr	Matt	Foulis		Booleroo
Mr	Douglas	Frances		Quorn
Mr	Kym	Fromm		Orroroo
Mr	Phil	Green		Booleroo
Mr	Brendan	Groves	Neville Wayne, Beverly	Booleroo Centre
Miss	Rebecca	Gum	Trevor	Orroroo
Mr	Trevor	Gum	Dianne	Orroroo
Mr	Kym	Harvie	Leeane	Booleroo Centre
Mr	Jonathan	Hancock		Brinkworth
Mr	Jim	Heaslip	Genevieve	Appila
Mrs	Genevieve	Heaslip	Jim	Appila
Mr	Daniel	Henderson		Caltowie
Mr	David	Henderson	Joy	Caltowie
Mrs	Joy	Henderson	David	Caltowie
Mr	Jim	Higgins		Booleroo Centre
Mr	David	Hill		Booleroo Centre
Mr	David Lloyd	Hombsch	Rebecca	Booleroo Centre
Mr	Darren	Hughes		Orroroo
Mr	Ben	Jefferson		Jamestown
Mr	Brendon	Johns	Denise	Port Pirie
Mr	Steven	Johns		Port Pirie
Mr	Bart	Joyce		Wanderah West
Mr	Ian (Danny)	Keller		Wirrabarra
Mr	Matt	Keller		Wirrabarra
Mr	Trevor	Kennett	Josie	Kensington Gdns
Mr	Michael	Kerin		Crystal Brook
Mr	Andrew	Kitto	Maria	Gladstone
Mr	Joe	Koch	Jess	Booleroo Centre
Mr	Jamie	Koch	Jody	Maitland

UNFS Membership List 2015-2016 Cont.

Mr	Robert	Koch	Joyleen	Georgetown
Mr	Brenton	Koch	Melissa	Booleroo Centre
Mrs	Jess	Koch	Joe	Booleroo Centre
Mr	Jim	Kuerschner	Gaye	Orroroo
Mr	Sam	Kuerschner	Jim	Orroroo
Mr	Tom	Kuerschner	Jim	Orroroo
Mr	David	Kumnick	Katrina	Booleroo Centre
Mr	Neil	Lange	Judy	Laura
Mr	Brian	Leue		Port Pirie
Mr	Kevin	Lock		Booleroo entre
Mr	Mark	Ludgate		Peterborough
Mr	Kevin	Malycha	Christine	Peterborough
Mr	Andrew	McCallum	Melissa	Booleroo Centre
Mr	Matt	McCallum	Matt, Ross, Heidi	Laura
Mr	Warren	McCallum	Jennifer	Booleroo Centre
Mr	Simon	McNamara		Orroroo
Mr	Robert	Mills	Lachlan Williams	Booleroo Centre
Mr	Kerry	Modystach	Gill	Wilmington
Mrs	Gill (Gillian)	Modystach	Kerry	Wilmington
Mr	Greg	Monaghan		Port Pirie
Mr	Tony	Moten	Marilyn	Pekina
Mr	Barry	Mudge	Kristina	Port Germein
Mr	Matthew	Nottle	Alice	Booleroo Centre
Mr	Len	Nutt	Carolyn	Orroroo
Mr	Todd	Orrock	Brooke	Murray Town
Mrs	Brooke	Orrock	Brooke	Murray Town
Mr	Nicholas	Piggott	Emily	Booleroo Centre
Mr	John	Polden		Booleroo Centre
Mr	Denis	Redden		Orroroo
Mr	Michael	Redden		Orroroo
Mr	Mark	Reichstein		Appila
Mr	Michael	Richards		Crystal Brook
Mr	Steve	Richmond		Jamestown
Mr	Paul	Rodgers		Quorn
Mr	Graham	Stokes		Quorn
Mr	Bill	Vandepeer		Manoora
Mr	Brenton	Vanstone	Matt Dunning	Wandearah East
Mr	Ken	Walter	Denise	Melrose
Mr	Lachlan	Williams	Robert Mills	Booleroo Centre
Mr	Bradley	Wundke		Brinkworth
Mr	Samuel	Young		Port Pirie
Mr	Wayne	Young	Louise	Port Pirie
Mr	Andrew	Zanker		Laura

Appendix : UNFS Stubble Initiative Guidelines Produced in 2015

Images from our events and activities in 2015