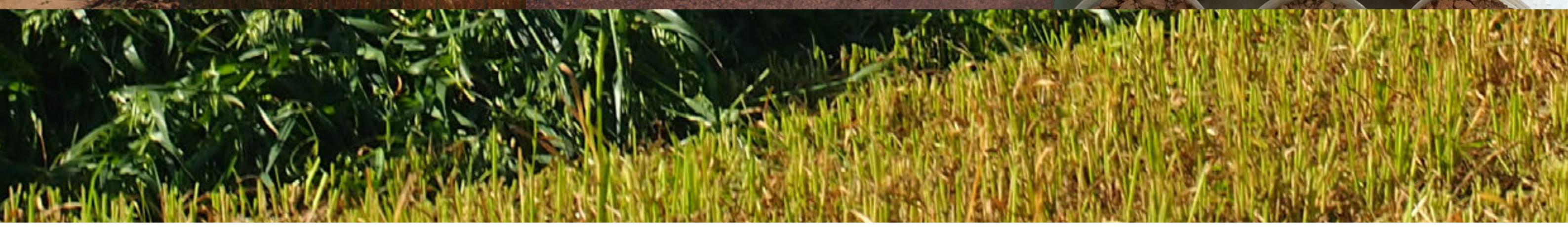
Eyre Peninsula Farming Systems Summary 2015



This publication is proudly sponsored by

GRDC Grains Research & Development Corporation
Your GRDC working with you

Government of South Australia

SARDI
South Australian Research and Development Institute

The research contained in this manual is supported by

Principal Partner

GRDC Grains Research & Development Corporation
Your GRDC working with you

Major Partners

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

EPARF
EYRE PENINSULA Agricultural Research Foundation

SAGIT

Grain & Graze™
Profit through knowledge
EYRE PENINSULA

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Government of South Australia
Eyre Peninsula Natural Resources Management Board

Additional Partners

CSIRO

Ag Excellence Alliance

Australian Government
Department of Agriculture, Fisheries and Forestry

This publication is proudly sponsored by

GRDC Grains Research & Development Corporation
Your GRDC working with you

GRDC Foreword

I have great pleasure in presenting to you the 2015 Eyre Peninsula Farming Systems Summary which is a compilation of agricultural research, development and extension results produced on the Eyre Peninsula during 2015. Many of the projects and activities presented in this summary have been funded through the Grains Research and Development Corporation (GRDC). Our national grains R&D framework, which involves the GRDC investing both grain grower levies and Australian Government funding has benefited the grains industry for more than two decades, and is the envy of many other countries.

Through this partnership framework, growers on the Eyre Peninsula are well serviced by institutions such as the South Australian Research and Development Institute, the University of Adelaide and other universities, the South Australian Grain Industry Trust, CSIRO, EP Agricultural Research Foundation, Lower Eyre Agricultural Development Association, EP Natural Resources Management Board and local farm advisers and agribusinesses who work collaboratively to ensure agricultural enterprises remain sustainably profitable. In partnership with GRDC, these organisations are producing results and knowledge that enhance the viability of grain growers.

Over the past decade or more we've seen significant changes in the grain industry and the research, development and extension landscape. The industry has grown considerably and hence, the investments made by GRDC on behalf of growers has increased. Also, the balance between state-based agencies, grower groups, private advisors, and retail agronomists has shifted.

In response to these changes GRDC is undergoing a renewal process to ensure that we continue to deliver value to our stakeholders. GRDC has changed the way we organise our investments and projects are now categorised into:

i. long-term strategic research that is of national significance and delivers benefits to growers in eight or more years (includes the identification of new genetic traits such as tolerance to diseases, frost and heat, and improved water use efficiency; new chemistry to manage weeds; robotics and machinery);
ii. medium-term applied research and development of regional significance which delivers to growers in three to eight years (includes farming systems, agronomy, soils, nutrition, weeds, diseases and pests);
iii. short-term validation, extension and communication of results to growers and advisors over one to three years at many local areas.

GRDC has recently opened regional offices, including an office in Adelaide. Our previous structures, consisting of the Regional Panel and the Regional Cropping Solutions Network worked well, but adding new teams in regional offices will boost our engagement with industry and relevance, particularly in the areas of farming systems, agronomy, soils, and nutrition, and local validation, extension and communication.

While we face difficult situations from time-to-time, growers and many others are increasingly confident about the future of the grains industry. Science and innovation linked to good old fashion pragmatism is helping drive a cycle of increasing resilience, productivity and profitability for growers and their communities. I am sure you will use the results presented in this summary to make more informed decisions that benefit your business and further fuel the innovation cycle.

Stephen Loss
General Manager – Systems, Agronomy & Soils (South), GRDC

GRDC
Grains Research & Development Corporation
Your GRDC working with you

Eyre Peninsula Farming Systems Summary 2015

Editorial Team

Naomi Scholz	SARDI, Minnipa Agricultural Centre, (MAC)
Amanda Cook	SARDI, MAC
Jessica Crettenden	SARDI, MAC
Brian Dzoma	SARDI, MAC
Nigel Wilhelm	SARDI, MAC/Waite
Andrew Ware	SARDI, Port Lincoln
Blake Gontar	SARDI, Port Lincoln

All article submissions are reviewed by the Editorial Team prior to publication for scientific merit and to improve readability, if necessary, for a farmer audience.

This manual was compiled by The Printing Press

March 2016

Cover design: The Printing Press

ISBN 1838-5540

Contents

Minnipa Agricultural Centre Update

Welcome to the seventeenth Eyre Peninsula Farming Systems Summary. This summary of research results from 2015 is proudly supported by the Grains Research & Development Corporation (GRDC) through the Eyre Peninsula Farming Systems project (EPFS 4 Maintaining Profitability in Retained Stubble Systems EPF00001).

We would like to thank GRDC for their contribution to Eyre Peninsula (EP) for research, development and extension and enabling us to extend our results to all farm businesses on EP and beyond in other low rainfall areas.

Due to increasing costs, this year will be the first year that the hard copy of this publication will only be sent to current EPARF members, collaborators, partners, sponsors and contributors of articles. Access to all articles is available via the EPARF website www.eparf.com.au or directly via this link http://eparf.com.au/research-type/publication/, as soon as possible after the hard copies have been distributed. Previous articles from 2010 onwards are also available on the website.

2015 has been a year of highs and lows for Minnipa Ag Centre and its staff, seasonally, agronomically, personally and professionally. Of course, one of the big highs was the celebration of the centenary of Minnipa Agricultural Centre, and we thank our special guests Mr Leon Bignell MP, Hon David Ridgway MLC, Mr Adrian Pederick MP, Mr Rowan Ramsey MP, Mr Peter Treloar MP and Mr Scott Ashby, PIRSA CEO for dedicating a plaque and cutting the cake (thanks to Rabobank for the cake!), and for Dr Bob Holloway and Dr Annie McNeill for their special presentations about Minnipa Ag Centre over the years. A great effort was made by all the staff at MAC to ensure the place was looking fantastic, and despite the very wet and boggy conditions leading to a change in plans, the day ran smoothly with all 300 attendees enjoying the event.

We look forward to working with our new Senior Scientist, Mariano Cossani due to commence in 2016, and we welcome Mariano to the team and wish him all the best in his role.

Research Officer Brian Dzoma successfully completed a one year post graduate certificate in Climate Change for Primary Industries (University of Melbourne), congratulations Brian!

Our collaborators have been doing well recently, congratulations to both Annie McNiell for winning the Soil Science Society LJH Teakle award and Gupta Vadakattu for the JA Prescott award. James Hunt was awarded the GRDC Seed of Light in early 2016, and Hugh Wallwork received the prestigious award in 2015, congratulations James and Hugh!

We hosted two third year University of Adelaide Agricultural students for work experience, Rochelle Wheaton and Cameron Lynch. They did a great job and we would be keen to host more university students in the future.

Leala’s husband Ian “Hoffy” sadly passed away in December 2015, following a work accident. We offer our sincere condolences to Lil and the Hoffmann family and friends.

Brett McEvoy has decided to move on to use his reliable and considerable farm hand skills on another local property, we wish Brett all the best and will miss his pinwheels at smoko!

And finally we farewell Farm Manager Mark “Marko” Klante as after 8 years of exceptional service to the Minnipa Ag Centre, many comments were received over his time about how well the farm had been maintained and that good seasons were capitalised on, with record yields achieved multiple times in this period. Marko’s good work ethic and sense of humour will be missed by all, and we wish him all the best (even though he is just down the road, still farming!). Hopefully we would have welcomed a new Farm Manager by the time this goes to print.

Projects

New projects commenced in 2015:

- SARDI1515 **Identifying the causes of unreliable N fixation by medic based pastures,** funded by SAGIT, researchers: Ross Ballard, Nigel Wilhelm, Brian Dzoma
- ACT00004 **Application of controlled traffic farming in the low rainfall zone,** funded by GRDC via ACTFA, researcher: Nigel Wilhelm
- CWF00020 **Overdependence on agrochemicals in low rainfall farming systems,** funded by GRDC via CWFS, researchers: Amanda Cook, Barry Mudge

Projects completed in 2015:

- **Developing sustainable weed management strategies for the long term viability of farming systems on the Eyre Peninsula,** EP Grain Growers Rail Fund, partnership with EPARF, researcher: Amanda Cook
- CLG-1205649-434 **Improving management practices of Rhizoctonia 'bare-patch' on upper EP soils,** funded by the Australian Government's Community Landcare Grants, partnership with EPARF, researcher: Amanda Cook
- DAS00119 **Crop Sequencing** funded by GRDC and Low Rainfall Collaboration, researchers: Roy Latta/Suzie Holbery, Nigel Wilhelm
- DAFF01203014 **Increasing carbon storage in alkaline sodic soils through improved productivity and greater organic carbon retention,** funded by the Australian Government's Filling the Research Gap program in partnership with the University of Adelaide, researcher: Roy Latta/Suzie Holbery
- AOTGR1-956996-222 **Efficient grain production compared with N2O emissions,** funded by the Australian Government's Action on the Ground Program, in partnership with BCG and EPARF, researcher: Brian Dzoma
- G001 **Improved nitrogen efficiency across biophysical regions of the Eyre Peninsula,** funded by the Australian Government's Action on the Ground program, in partnership with EPNRM, researcher: Brian Dzoma

Ongoing projects include:

- EPF00001 **Eyre Peninsula Farming Systems 4 – Maintaining profitable farming systems with retained stubble on upper Eyre Peninsula,** GRDC funded, partnership with EPARF, researchers: Amanda Cook, Nigel Wilhelm
- S614 **Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems,** funded by SAGIT, researcher: Amanda Cook
- AOTGR2-0039 **Reducing methane emissions from improved forage quality on mixed farms,** funded by the Australian Government's Action on the Ground program, partnership with EPARF and WA CSIRO, researcher: Brian Dzoma
- SFS00028 **Eyre Peninsula Grain & Graze 3,** GRDC funded, partnership with Southern Farming Systems, researcher: Jessica Crettenden
- **Variety trials** (wheat, barley, canola, peas etc.) and commercial contract research, coordinator: Leigh Davis
- AOTGR1-955086-42 **Farmers leading and learning about the soil carbon frontier,** funded by the Australian Government's Action on the Ground program and GRDC, in partnership with CropFacts Pty Ltd, researcher: Amanda Cook

2016 events

Major field day events at Minnipa Agricultural Centre in 2016:

- EPARF Day – Sandy soils (27 July)
- MAC Field Day – (7 September)

Thanks for your support at farmer meetings, sticky beak days and field days. Without strong farmer involvement and support, we lose our relevance to you and to the industries that provide a large proportion of the funding to make this work possible.

We look forward to seeing you all at farming system events throughout 2016, and all the best for a productive season!

Naomi Scholz

MAC Staff and Roles 2015

Nigel Wilhelm	Science Program Leader (visiting)
Andrew Ware	EP Science Leader
Mark Klante	Farm Manager
Dot Brace	Senior Administration Officer
Leala Hoffmann	Administration Officer
Naomi Scholz	Project Manager
Amanda Cook	Senior Research Officer (Stubble and Weed Management, Fluid systems)
Jessica Crettenden	Research Officer (EP Grain & Graze)
Brian Dzoma	Research Officer (Greenhouse gases)
Leigh Davis	Agricultural Officer (NVT, Contract Research)
Wade Shepperd	Agricultural Officer (EP Farming Systems, Weed management)
Brenton Spriggs	Agricultural Officer (NVT, Contract research)
Ian Richter	Agricultural Officer (Crop Sequencing, Fluid systems, Controlled Traffic)
Brett McEvoy	Agricultural Officer (MAC Farm)
John Kelsh	Agricultural Officer (MAC Farm)
Sue Budarick	Casual Field Assistant
Roanne King	Casual Field Assistant
Lauren Cook	Casual Field Assistant
Jake Barnett	Casual Field Assistant

DATES TO REMEMBER

EPARF Member's Day: Wednesday 27 July 2016

MAC Annual Field day: Wednesday 7 September 2016

To contact us at the Minnipa Agricultural Centre, please call 8680 6200.

EPARF SPONSORS 2015

GOLD

Nufarm

CURTIS'S

SILVER

AGT

LETCHER MORONEY
CHARTERED ACCOUNTANTS

FREE EYRE
-grain-

Rabobank

INTERGRAIN

ADM

VITERRA™

GLENCORE
GRAIN

BRONZE

BankSA

CBH Grain

Agfarm

EPIC

Eyre Peninsula Agricultural Research Foundation Report 2015

EPARF
Eyre Peninsula
Agricultural Research Foundation Inc.

Simon Guerin

Chairperson, EPARF

Board of Management

Simon Guerin, Bryan Smith, Craig James, Shannon Mayfield, Greg Scholz, Dion Trezona, Andy Bates, Mark Stanley, Prof Alan Tilbrook (SARDI), Dr Glenn McDonald (University of Adelaide), John Richardson (LEADA), Mary Crawford (EPNRM), Andrew Ware (Leader EP Science Team), Dot Brace (Executive Officer).

Membership

295 members

EPARF Vision

To be an independent advisory organisation providing strategic support for the enhancement of agriculture.

Mission

To proactively support all sectors of agricultural research including the building of partnerships in promoting research, development and extension on Eyre Peninsula and like environments across Australia.

Role of EPARF

The Eyre Peninsula Agricultural Research Foundation was incorporated in 2004 and has a Board comprising representatives of Eyre Peninsula farmers, local consultants, University of Adelaide, SARDI and the EPNRM Board. Its purpose is to represent the interests of research, development and extension on Eyre Peninsula. We have been very effective over the past ten years in driving program direction and strategy and in attracting external funds to support those programs, many of which we contract in partnership with SARDI.

EPARF is a foundation drawing its income from membership, industry funding and sponsorship.

Under the provisions of the constitution, Board appointments to expire in 2015 were Bryan Smith and Shannon Mayfield. Both were keen and willing to continue their support on the Board and accordingly were re-nominated to the Board. Thank you Bryan and Shannon for your ongoing support to representing farmers in your local area and Eyre Peninsula.

The EPARF Board is committed to ensuring the ongoing development of agricultural systems in low rainfall zones of Australia and recognises its obligations to Eyre Peninsula. This is the expectation of our significant number of farmer financial members, substantial sponsorship and stakeholder base. This base reflects the positive contribution EPARF and its research partners have made to advancing agriculture.

Membership

Membership support is a critical factor when seeking external funding to address local research needs. Membership funds are used to support a range of agricultural research and extension activities on the Eyre Peninsula.

Sponsorship

Thank you to all sponsors for their generous support. In 2015 we recognised and sincerely thank Letcher Moroney Chartered Accountants for ten years of auditing support and financial service to EPARF. This support is highly valued and appreciated.

Sponsorship is a vital link in EPARF being able to provide the services to our members and we hope to be able to continue this relationship.

2015 EPARF Sponsors

GOLD	Nufarm
	Curtis's
SILVER	AGT
	Letcher Moroney - Chartered Accountants
	Rabobank
	Free Eyre grain
	Viterra/Glencore
	ADM Grain

BRONZE BankSA
CBH Grain
Agfarm
EPIC

Events

Member Day

In July, the annual member day focused on 'Innovation and Technology', providing EPARF members with new practical tools and management opportunities available for their farming business. The program consisted of whole group presentations on engineering, weed sensing, mapping, climate forecasting, protein sensors and unmanned aerial vehicles. Small group sessions were presented on water leak detection units, soil moisture probes, eXtensionAus platform, livestock innovations and the latest apps for farmers.

The day was attended by 130, with eight expert speakers. All sessions were well received with a high majority of attendees stating that the information was highly relevant to their business and they would follow up on new knowledge gained.

MAC Centennial Celebration

In September the Minnipa Agricultural Centre celebrated 100 years of support to farmers in the region. It was great to have state government politicians attend along with bipartisan support. I was given the opportunity to present EPARF's involvement and association with the Centre highlighting the importance of Eyre Peninsula to the grain industry, now and into the future. Congratulations to MAC staff for organising such a successful event.

2016 Member Day

Wednesday 27 July - SOILS, getting the most out of your sands

The day will be based on soil constraints and amelioration or adaptation options to improve soil health and productivity.

The format of the day will incorporate keynote speakers including Dr Stephen Davies, WA Department of Agriculture and Food to establish soil science, investigate new agronomic strategies, plus provide practical demonstrations where possible for growers to understand best practice farming strategies to improve soil health and production.

PUT THIS DATE IN YOUR DIARY NOW!

Appreciation and thanks

A special thank you to our dedicated team of Minnipa Agricultural Centre staff for being able to maintain a well-run, functional research program and organising the facility to hold events. Thank you also to SARDI for the use of the Centre's facilities. Thanks to all our members for supporting an organisation that works hard to ensure our farming future on the Eyre Peninsula.

Left to right: Rowan Ramsey Member for Grey, Leon Bignell Minister for Agriculture and Simon Guerin EPARF Chairperson.

Eyre Peninsula Agricultural Research Foundation Members 2015

EPARF
EYRE PENINSULA
Agricultural Research Foundation

Daniel	Adams	CUMMINS SA
Michael	Agars	PORT LINCOLN SA
Brian	Ashton	PORT LINCOLN SA
Terry	Baillie	TUMBY BAY SA
Michael	Baines	LOCK SA
Andrew	Baldock	KIMBA SA
Graeme	Baldock	KIMBA SA
Heather	Baldock	KIMBA SA
Tristan	Baldock	KIMBA SA
Geoff	Bammann	CLEVE SA
Paul	Bammann	CLEVE SA
Ashley	Barns	WUDINNA SA
Andy	Bates	STREAKY BAY SA
Warren	Beattie	CEDUNA SA
Lance	Beinke	KIMBA SA
Joshua	Beinke	KYANCUTTA SA
Peter	Beinke	KIMBA SA
Sue	Beinke	KIMBA SA
Ian	Bergmann	CEDUNA SA
Andrew	Bergmann	CEDUNA SA
Daniel	Bergmann	CEDUNA SA
Brenton	Bergmann	CEDUNA SA
Bill	Blumson	SMOKY BAY SA
Daniel	Bowey	LOCK SA
Dion	Brace	POOCHERA SA
Jason	Brace	POOCHERA SA
Reg	Brace	POOCHERA SA
Bill	Brands	MINNIPA SA
Sharon	Brands	MINNIPA SA
Paul	Brown	CEDUNA SA
Lachlan	Brown	CEDUNA SA
Daryl	Bubner	CEDUNA SA
Jason	Burton	RUDALL SA
Brian	Cant	CLEVE SA
Alexander	Cant	CLEVE SA
Shaun	Carey	STREAKY BAY SA
Peter	Carey	MINNIPA SA
Paul	Carey	STREAKY BAY SA
Matthew	Carey	CHANDADA SA
Damien	Carey	CHANDADA SA
Mark	Carmody	COWELL SA
Steven	Carmody	COWELL SA
Milton	Chandler	CEDUNA SA
Symon	Chase	COWELL SA
Trevor	Cliff	KIMBA SA
Randall	Cliff	KIMBA SA
Trevor	Clifford	KIMBA SA
Matt	Cook	MINNIPA SA
Andrew	Cook	SALMON GUMS WA
Brent	Crettenden	LOCK SA
Brent	Cronin	STREAKY BAY SA
Pat	Cronin	STREAKY BAY SA
Richard	Cummins	LOCK SA
Neil	Cummins	LOCK SA
Alan	Curtis	WUDINNA SA
Wes	Daniell	MINNIPA SA
Kevin	Dart	KIMBA SA
Robert	Dart	KIMBA SA
Paul	Dolling	CLEVE SA
Neville	Dolphin	PORT KENNY SA
Ryan	DuBois	WUDINNA SA
Matthew	Dunn	RUDALL SA
Barry J	Durdin	PORT LINCOLN SA
David	Elleway	KIELPA SA
Ray	Elleway	KIELPA SA
Jim	Endean	MINNIPA SA
Michael	Evans	CLEVE SA
Andre	Eylward	STREAKY BAY SA
Leigh	Fitzgerald	KIMBA SA
Clem	Fitzgerald	KIMBA SA
Mark	Fitzgerald	TUMBY BAY SA

Scott	Forrest	MINNIPA SA	Nik	Jensen	KIMBA SA
Jane	Forrest	MINNIPA SA	Janeen	Jericho	POOCHERA SA
Daniel	Foster	WUDINNA SA	Neville	Jericho	MINNIPA SA
David	Foxwell	CLEVE SA	Marcia	Jericho	MINNIPA SA
Brett	Francis	KIMBA SA	Damien	Johnson	STREAKY BAY SA
Shaun	Freeman	CEDUNA SA	Jodie	Jones	WHARMINDA SA
John	Freeth	KIMBA SA	Jeff	Jones	WHARMINDA SA
Thomas	Freeth	KIMBA SA	Paul	Kaden	COWELL SA
Jon	Fromm	MINNIPA SA	Tony	Kaden	COWELL SA
Jerel	Fromm	MINNIPA SA	Ty	Kaden	COWELL SA
Trevor	Gilmore	STREAKY BAY SA	Grant	Kammerman	LOCK SA
Trevor	Gosling	POOCHERA SA	Mark	Kammermann	WUDINNA SA
Simon	Guerin	PORT KENNY SA	Craig	Kelsh	TYRINGA SA
Terry	Guest	SALMON GUMS WA	Trevor	Kennett	KENSINGTON GARDENS SA
Angus	Gunn	PORT KENNY SA	Toby	Kennett	PORT LINCOLN SA
Ian	Gunn	PORT KENNY SA	Troy	Klante	WUDINNA SA
John	Haagmans	ELLISTON SA	Brett	Klau	PORT LINCOLN SA
Les	Hamence	WIRRULLA SA	Rex	Kobelt	CLEVE SA
Graeme	Hampel	KIMBA SA	Myra	Kobelt	CLEVE SA
Andrew	Heath	PORT LINCOLN SA	Daryl	Koch	KIMBA SA
Basil	Heath	PORT LINCOLN SA	Jeffrey	Koch	KIMBA SA
Derek	Hebberman	POOCHERA SA	Peter	Kuhlmann	GLENELG SOUTH SA
Nathan	Hebberman	POOCHERA SA	Andrew	Lawrie	TUMBY BAY SA
Bruce	Heddle	MINNIPA SA	Howard	Lee	CUNGENA SA
Clint	Hein	STREAKY BAY SA	Roger	Lienert	ARNO BAY SA
Tom	Henderson	ELLISTON SA	Bill	Lienert	KIMBA SA
Andrew	Hentschke	LOCK SA	Nick	Lienert	KIMBA SA
Bill	Herde	RUDALL SA	Nathan	Little	PORT KENNY SA
Mike	Hind	TUMBY BAY SA	Ken	Little	PORT KENNY SA
Max	Hitch	PORT LINCOLN SA	Andrew	Longmire	SALMON GUMS WA
Peter	Hitchcock	LOCK SA	Jeffrey	Longmire	LOCK SA
Nathan	Hitchcock	LOCK SA	Christopher	Lynch	STREAKY BAY SA
Joshua	Hollitt	PORT LINCOLN SA	Bradley	Lynch	STREAKY BAY SA
Ian	Hood	PORT KENNY SA	Joel	Lynch	POOCHERA SA
Mark	Hood	PORT KENNY SA	Craig	Lynch	POOCHERA SA
Jennifer	Horne	WHARMINDA SA	Andrew	Mahar	CEDUNA SA
Sarah	Horne	CLEVE SA	Stephen	Maitland	KIMBA SA
Tim	Howard	CEDUNA SA	Andrew	Major	KIMBA SA
Ed	Hunt	PORT NEILL SA	Justine	Major	KIMBA SA
Evan	Hunt	PORT NEILL SA	Shane	Malcolm	ARNO BAY SA
Leon	Hurrell	LOCK SA	Beth	Malcolm	ARNO BAY SA
Warwick	Hutchings	MINNIPA SA	Jayne	Marshall	WUDINNA SA
Trevor	Inglis	KIMBA SA	Linden	Masters	ARNO BAY SA
Greg	Inglis	KIMBA SA	John	Masters	ARNO BAY SA
Craig	James	CLEVE SA	Todd	Matthews	KYANCUTTA SA

Wes	Matthews	KYANCUTTA SA	Peter	Rayson	KIMBA SA
Lindsay	Matthews	KYANCUTTA SA	Gavin	Rehn	ARNO BAY SA
Nigel	May	ELLISTON SA	Marty	Rodda	KIMBA SA
Paul	May	KYANCUTTA SA	Martin	Ryan	KIMBA SA
Ashley	May	KYANCUTTA SA	Kane	Sampson	WARRAMBOO SA
Shannon	Mayfield	KIMBA SA	Veronica	Sampson	WARRAMBOO SA
John	Michael	WUDINNA SA	Brett	Sampson	WARRAMBOO SA
Ashley	Michael	WUDINNA SA	Jack	Sampson	WARRAMBOO SA
Darren	Millard	VERRAN SA	Allen	Sampson	KAPUNDA SA
Leone	Mills	COWELL SA	Paul	Sargent	WUDINNA SA
John	Montgomerie	STREAKY BAY SA	Michael	Schaefer	BALHANNAH SA
Carolyn	Mudge	MILTABURRA SA	Terry	Schmucker	KYANCUTTA SA
Darren	Mudge	MILTABURRA SA	Thomas	Schmucker	KYANCUTTA SA
Damien	Mullan	WUDINNA SA	Greg	Scholz	WUDINNA SA
Amy	Murray	KIMBA SA	Nigel	Scholz	WUDINNA SA
Len	Newton	ELLISTON SA	Neville	Scholz	WUDINNA SA
Anthony	Nicholls	CEDUNA SA	Lyle	Scholz	YANINEE SA
Ian	Noble	WHARMINDA SA	Mick	Scholz	YANINEE SA
Daryl	Norris	RUDALL SA	Gareth	Scholz	MINNIPA SA
Dwayne	North	WUDINNA SA	Leigh	Scholz	MINNIPA SA
Darren	O'Brien	KYANCUTTA SA	Stuart	Scholz	WUDINNA SA
Brett	O'Brien	KYANCUTTA SA	Yvonne	Scholz	WUDINNA SA
Craig	O'Brien	KYANCUTTA SA	Kevin	Schopp	LOCK SA
Natasha	O'Brien	KYANCUTTA SA	Brook	Seal	KIMBA SA
Clinton	Olsen	WIRRULLA SA	Bill	Shipard	PENONG SA
John	Oswald	YANINEE SA	John	Simpson	WUDINNA SA
Clint	Oswald	YANINEE SA	Mark	Siviour	LOCK SA
Nigel	Oswald	WUDINNNA SA	Bryan	Smith	COORABIE SA
Lauren	Oswald	WUDINNA SA	Reid	Smith	MAITLAND SA
Tim	Ottens	WHARMINDA SA	Dustin	Sparrow	WUDINNA SA
Simon	Patterson	STREAKY BAY SA	Mark	Stanley	PORT LINCOLN SA
Glen	Phillips	MINNIPA SA	John	Stillwell	CEDUNA SA
Darcy	Phillips	MINNIPA SA	Rodger	Story	COWELL SA
Jamie	Phillis	UNGARRA SA	Suzanne	Story	COWELL SA
Andrew	Polkinghorne	LOCK SA	Aleks	Suljagic	CLEVE SA
Tim	Polkinghorne	LOCK SA	Anton	Taylor	CUMMINS SA
Lindsay	Pope	WARRAMBOO SA	Jarad	Tomney	CHANDADA SA
Ben	Pope	WARRAMBOO SA	Clint	Tomney	STREAKY BAY SA
John	Post	MINNIPA SA	Rhys	Tomney	CHANDADA SA
Clint	Powell	KIMBA SA	Myles	Tomney	CHANDADA SA
Kevin	Preiss	ARNO BAY SA	Sarah	Traeger	CLEVE SA
Peter	Prime	WHARMINDA SA	Neville	Trezona	PETINA SA
Chris	Prime	WHARMINDA SA	Dion	Trezona	PETINA SA
Caleb	Prime	WHARMINDA SA	Shane	Trowbridge	CEDUNA SA
Jarrod	Prime	WHARMINDA SA	Craig	Trowbridge	CEDUNA SA
Rowan	Ramsey	KIMBA SA	Mark	Turnbull	CLEVE SA
Ben	Ranford	CLEVE SA	John	Turnbull	CLEVE SA
			Nigel	Turnbull	CLEVE SA

Quentin	Turner	ARNO BAY SA
Tim	van Loon	WARRAMBOO SA
Daniel	Vater	GLEN OSMOND SA
Simon	Veitch	WUDINNA SA
Sally	Veitch	WUDINNA SA
Leon	Veitch	WARRAMBOO SA
Daniel	Vorstenbosch	WARRAMBOO SA
Graham	Waters	WUDINNA SA
Dallas	Waters	WUDINNA SA
Tristan	Waters	WUDINNA SA
Peter	Watson	WIRRULLA SA
Ryan	Watson	WIRRULLA SA
Paul	Webb	COWELL SA
Ken	Webber	PORT LINCOLN SA
Craig	Wheare	LOCK SA
Philip	Wheaton	STREAKY BAY SA
Brian	Wibberley	PORT LINCOLN SA
Gregor	Wilkins	YANINEE SA
Stefan	Wilkins	YANINEE SA
Jordan	Wilksch	YEELANNA SA
Gwenda	Williams	KIMBA SA
Peter	Williams	WUDINNA SA
Josie	Williams	WUDINNA SA
Scott	Williams	WUDINNA SA
David	Williams	PORT NEILL SA
Jack	Williams	PORT NEILL SA
Dean	Willmott	KIMBA SA
Lyall	Wiseman	LOCK SA
Craig	Wissell	ARDROSSAN SA
Graham	Woolford	KIMBA SA
Dion	Woolford	KIMBA SA
Peter	Woolford	KIMBA SA
James	Woolford	KIMBA SA
David	Woolford	KIMBA SA
Simon	Woolford	KIMBA SA
Michael	Zacher	LOCK SA
Michael	Zerk	LOCK SA
Allan	Zerna	COWELL SA
Lisa	Zibell	KIMBA SA

New EPARF Board members Dion Trezona and Greg Scholz with Simon Guerin, Chairperson

MAC Events 2015

Naomi Scholz

SARDI, Minnipa Agricultural Centre

EP Grain & Graze 3/Sheep Connect SA Sheep Group meetings were held at Tumby Bay, Kimba, Lock, Poochera and Ceduna from 3-5 March 2015. Barry Mudge ran a session on risk in mixed farming businesses and evaluation of the Sheep Groups. Mary Crawford facilitated part of the session and Jessica Crettenden attended on behalf of the G&G project to assist in evaluation and future of sheep groups discussion.

Research outcomes from 2014 were presented at farmer meetings across upper Eyre Peninsula from 16-20 March 2015. 190 farmers, agribusiness representatives and NRM staff attended meetings at Minnipa, Wirrulla, Charra, Port Kenny, Buckleboo, Cowell, Rudall and Warramboo. Key messages on varieties, break crops, livestock, soil diseases, stubble management, greenhouse gases, plus other current research were presented by SARDI staff. Lively crop nutrition information and discussion sessions were led by Andy Bates and Craig James, who were supported by the GRDC More Profit from Crop Nutrition project via BCG. Farmers were presented with their copy of the EP Farming Systems Summary 2014, documenting regionally relevant agricultural research outcomes of 2014. The main concerns identified by farmers include grass weeds including barley and brome grass, herbicide resistance and implications to current farming systems, soil constraints, increasing cost of production, pests (snails and mice), poor medic nodulation, using break crops in rotation, rhizoctonia and getting nutrition right.

Nutrition crop walks as part of the GRDC More Profit from Crop Nutrition project, were conducted by Linden Masters and Andy Bates at Wudinna/Yaninee, Minnipa and Lock on 9-10 July 2015.

Jessica Crettenden presented information and results from lamb survival research and information about sheep technology at five Sheep Group meetings at Lock and Minnipa on 15 July, Piednippie and Ceduna on 16 July and Kimba on 17 July 2015 to approximately 70 farmers, consultants and agribusiness representatives.

On 21-23 July SAGIT board representatives Malcolm Buckby, Allan Mayfield, Michael Treloar and Bryan Smith visited SAGIT funded trial sites on Eyre Peninsula with researchers Amanda Cook, Brian Dzoma and Andrew Ware.

The EPARF Member Day 'Innovation and Technology' was held at SARDI Minnipa Agricultural Centre on 22 July 2015. 130 farmers, consultants and agribusiness representatives attended. Presentations included the latest in agricultural engineering, James Barr; weed sensing and mapping, Sam Trengrove; long range forecasting, Graeme Anderson; protein sensors, Ashley Wakefield; water leak units and soil moisture probes, Shane Oster; apps for farmers and unmanned aerial vehicles, Leighton Pearce; livestock innovations, Michelle Cousins; and eXtension AUS, Robert Norton.

Nelshaby Agricultural Bureau members visited Minnipa Agricultural Centre as part of a regional bus tour on 27 August 2015.

The Minnipa Agricultural Centre annual field day was held on 2 September 2015, with 300 people attending. The field day commemorated the 100th anniversary of the Minnipa Agricultural Centre. Mr Leon Bignell MP, Hon David Ridgway MLC, Mr Adrian Pederick MP, Mr Rowan Ramsey MP, Mr Peter Treloar MP and Mr Scott Ashby, PIRSA CEO participated in the commemoration of the 100th anniversary with a plaque presentation and cake cutting. Alan Tilbrook, SARDI Research Chief, Livestock & Farming Systems, opened the event.

Thirteen Sticky Beak Days were held across upper Eyre Peninsula from 9 September to 23 October 2015, visiting various trial sites and inspecting other items of interest to farmers.

An "Open Day" was held at Minnipa Agricultural Centre on 14 October 2015, with 50 growers, researchers and agribusiness reps touring the field trials. MAC staff presented their trials and feedback was very positive, particularly around being able to see the trials close to completion for the season.

The GRDC Southern Panel visited Minnipa Agricultural Centre on 17 September 2015. Minnipa Agricultural Centre staff and EPARF Board representatives provided the Panel members with an overview of Minnipa Ag Centre and the role of EPARF, then toured the farm and visited some of the GRDC funded research sites.

Eyre Peninsula seasonal summary 2015

Brett Masters
Rural Solutions SA, Pt Lincoln

OVERVIEW

The 2015 season constituted a “mixed bag” for many farmers across the Eyre Peninsula. Despite recording average to below average autumn rainfall, it was evenly distributed throughout this period producing heavy crops with above average yield potential by the end of winter. The Far West and coastal districts south to Mt Hope, and adjacent areas inland, were the exception to this where an extremely dry start reduced the area of crop sown and the continued below average rainfall limited crop yields. There was below average rainfall across the region from the start of September with hot, dry conditions in the first week of October, which brought crops to rapid maturity, reducing yield potential. Despite these challenges most farmers harvested average to above average yields, and reasonable prices for quality grain made it a profitable season for most.

Apart from isolated thunderstorm activity in the first week of January, dry conditions continued over summer resulting in low levels of mineralised nitrogen in pre-season soil samples. Although 2014 stubbles contained generally high levels of residue, on the heavier soil types of western and eastern Eyre and the pasture paddocks of lower Eyre feed reserves were low by the end of summer and growers needed to supplementary feed stock. Given issues with high aphid numbers, Beet Western Yellows virus and Diamond backed moth in 2014, growers were quick to control summer weeds germinating following the January rains to break the “green bridge”. Mild temperatures during summer limited the opportunity for growers to control snails by chaining and rolling. Many growers burnt paddocks prior to sowing and baited vulnerable crops such as legumes and canola to reduce snail numbers.

With poor returns from canola in recent seasons the area sown to canola was reduced by as much as 10% this year. Growers increased the area of legume break crops and also took advantage of low disease inoculum levels in 2014 increasing the area of wheat on wheat. The area sown to vetch and oats was also increased to replenish hay supplies used over the summer. Concern around potential herbicide residues, given the very dry conditions in the period since August 2014 meant that many growers revised their cropping programs to minimise crop damage.

Rains in March gave growers an opportunity to sow feed paddocks and medic pastures and growers began sowing their winter cropping program after widespread rainfall in April. An early germination of weeds allowed most growers to apply knock-down herbicides prior to sowing with post-emergent herbicide applications effective in controlling both broadleaved and grass weeds. Mild and damp conditions on eastern and lower EP resulted in a rapid germination of early sown crops and pastures with a noticeable difference in vigour compared to early and later sown crops. By the end of winter most crops had high biomass levels and above average yield potential. Above average biomass levels on medic and vetch pastures in most districts also gave landholders an opportunity to bale hay to replenish on-farm feed stores.

Apart from minor damage to emerging pastures from Lucerne flea and Red legged earth mite (RLEM), insect pest numbers during the season were low. Fungal diseases; including powdery mildew, net blotch, ascochyta and botrytis were observed during the season, however growers were able to control these with routine fungicide applications. Isolated light frosts were reported in August.

A string of hot days with drying winds in the first week of October caused moisture stress to flowering crops resulting in estimated yield losses of up to 20%. Although not as high as early estimates, yields were generally average to above average with some exceptional yields on better soil types in more reliable rainfall districts. Given the season, canola yields were exceptional with yields of 1.3 to 1.8 t/ha common across the region with good oil content. Cereal and pulse yields were highly variable depending upon soil type and the patchy rainfall distribution. Grain quality was also variable with high screenings and low test weight a common issue at delivery.

DISTRICT REPORTS

Western Eyre

Growers controlled germinating weeds after January rains to remove the "green bridge" for disease and pest control. Dry conditions to mid-April, resulted in low levels of paddock feed. Although this left paddocks reasonably clean at the start of seeding livestock producers were forced to supplementary feed. Limited opportunity for snail control during summer resulted in above average levels of stubble burning, to reduce numbers. Although high mice numbers were observed in isolated hotspots around Wirrulla, Mudamuckla, and Streaky Bay, baiting of early sown crops was effective to reduce populations below critical thresholds.

Medic and vetch pastures were sown following April rains and most growers started sowing cereals in early May. Rainfall to mid-June was below average but good rains at the end of June allowed growers to finish their seeding program. Crop germination and early vigour was good except for some RLEM, Bryobia mite and Lucerne flea damage on heavy textured soils and some weevil damage on grey calcareous soils.

Good rainfall, mild conditions and low pest and disease levels resulted in good crop growth and above average yield potential at the end of winter, apart from barley crops infected with Rhizoctonia on some soils. Vetch and medic pastures grew large amounts of biomass in most districts, allowing growers to cut hay in early October to replenish on-farm supplies depleted over the summer.

Most growers had begun harvest by the end of October. The patchy distribution of growing season rainfall meant crop yields varied greatly between districts and soil types. Despite the dry finish and hot start to October cereal yields were above average, with yields of 3.0 to 3.5 t/ha common on central EP. Yields were much lower for coastal areas from Mt Hope to Streaky Bay and adjacent inland areas, and further west. High screenings and low test weights caused quality downgrades of cereals at delivery. Pea crops yielded 0.8 to 1.0 t/ha despite isolated reports of damage from frost and a late flight of native budworm. Canola yields, at 1.2 to 1.5 t/ha, were better than expected and had generally high oil content.

Eastern Eyre

Heavy thunderstorm activity in early January brought rainfall totals above the monthly average in most eastern Eyre districts. Most growers applied herbicides to control the weeds that germinated following this rain to conserve moisture. There was also some cultivation for weed control in the Franklin Harbour district. Dry conditions to the end of March resulted in low levels of paddock feed with many growers supplementary feeding livestock.

Widespread rain in April, bringing double the monthly average, resulted in good soil moisture levels for seeding in all districts except Kimba/Buckleboo. A high amount of stubble burning was undertaken during April to manage weed seeds and high stubble loads from 2014. Good weed germination provided growers the opportunity to apply knockdown herbicides prior to seeding. Above average snail activity, perhaps resulting from January rains also led many growers to bait vulnerable crops such as canola and pulses. Medic pastures and early pasture feed paddocks, along with some canola and legumes were sown toward the end of April, with growers starting to sow cereals in the first week of May.

Ideal conditions enabled growers in most districts to finish seeding by the middle of June, with mild conditions resulting in rapid crop growth. Continued dry conditions in Kimba/Buckleboo caused further seeding delays until good rains were received in late June. Later sowing and cooler conditions resulted in poor crop germination on heavier soil types in these districts. Lucerne flea and RLEM also damaged germinating crops and pastures, but insecticide applications and cooler weather late in the month brought these under control. High levels of net blotch and isolated incidents of leaf and stem rust were observed in cereal crops, however routine fungicide sprays to protect susceptible varieties were effective in protecting yield potential. Rhizoctonia damage was also common in crops grown on inherently prone soils.

Well above average August rainfall increased stored soil moisture across most of the region. Crops responded to warm conditions late in the month, and even crops around Buckleboo had average to above average yield potential at the end of winter. Spring was generally dry with hot winds in early October rapidly senescing crops. Variations in seeding date, soil type and rainfall resulted in large variations in crop maturity. Native budworm caused some damage to canola and pea pods but late insecticide applications were effective to minimise yield and quality impacts.

Most growers began harvest toward the end of October and although rain in November caused some delays harvest was mostly finished by 20 December 2015. There was a high germination of summer weeds following these rains and many growers applied herbicides immediately following harvest.

Yields were generally average to above average but varied considerably depending on rainfall received and variations in soil type. Canola yields were reported at around 0.6 to 0.8 t/ha on the heavy red soils near Buckleboo and 1.2 to 1.5 t/ha and generally high oil content reported at Darke Peak and Lock. Cereal yields were above average with reports of 3.5 to 4.0 t/ha for barley and 3.0 to 3.5 t/ha for wheat common. Pulse yields were highly variable, reflecting soil type with pea yields around 1 t/ha, and lupin yields generally poor with many reports of less than 0.5 t/ha. Grain quality was also variable with high screenings and low test weights being major issues at delivery.

Lower Eyre

Summer was extremely dry with nil recordable rainfall for February in some districts. These dry conditions limited summer weed growth and maintained the quality of feed in stubble paddocks. Feed reserves on pasture paddocks south of Edillilie were very low with some growers needing to supplementary feed stock. Mild summer temperatures also limited landholders' opportunities to control snails by rolling and chaining stubbles, which resulted in many growers baiting paddocks at seeding.

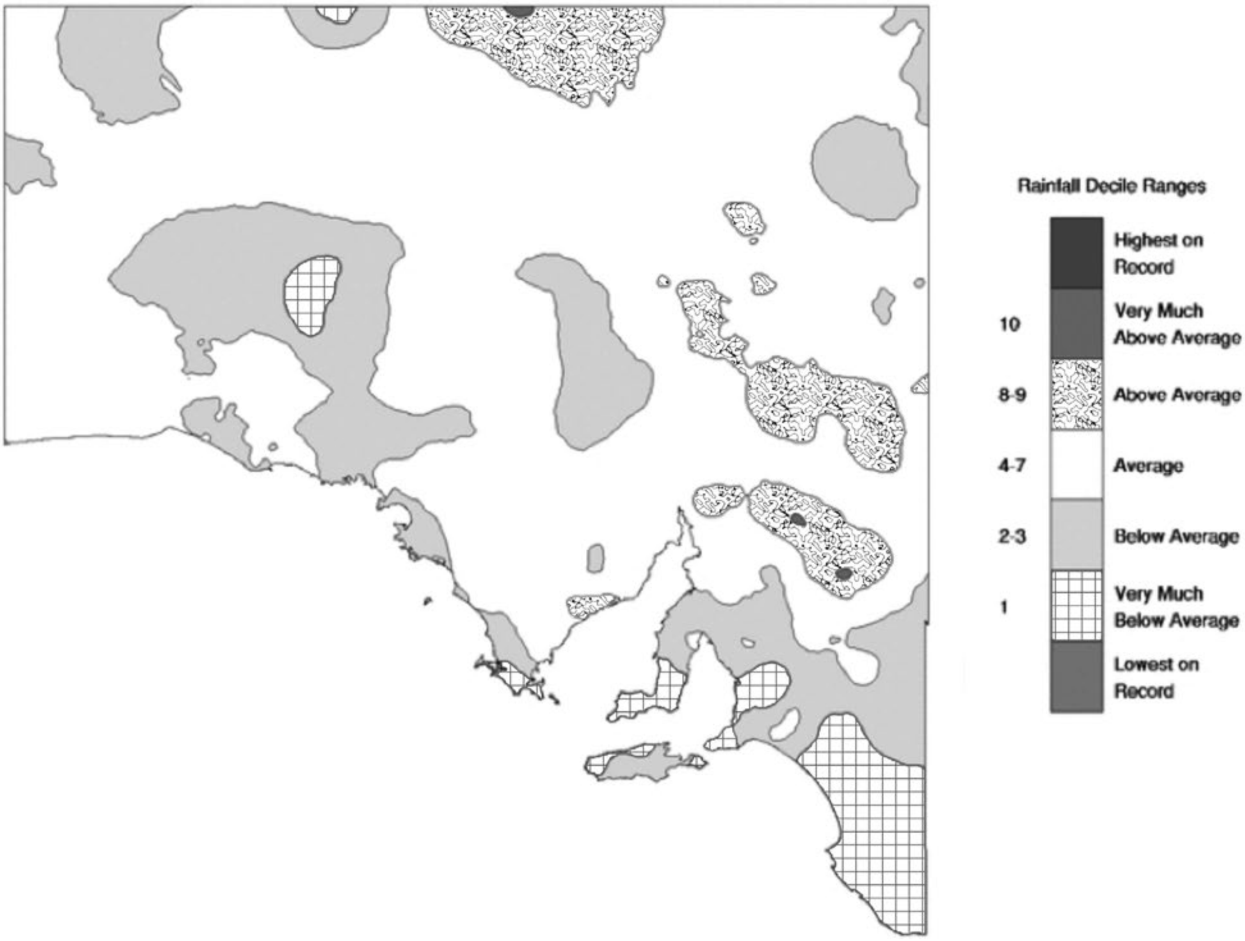
March was dry but widespread rains in April brought more than double the monthly average rainfall to all centres. Canola and pulses were sown following the April rain and most growers finished seeding by mid-June. Sunny days and damp soil profiles resulted in a rapid germination of crops and pastures. Lucerne flea and RLEM caused some damage to emerging pastures and canola crops but growers controlled these early and numbers were low as cool conditions set in at the end of June. Apart from continued dry conditions in the western coastal districts around Mt Hope good rains were received to the end of winter across the region. Regular small rain events increased stored soil moisture without waterlogging soils. These ideal growing conditions resulted in crops with exceptional yield potential at the end of winter. High biomass in pasture paddocks provided growers with an opportunity to cut hay to replenish on-farm supplies. Although there was some disease reported in crops including powdery mildew in wheat, net blotch in barley and aschocyta, chocolate spot and grey mould on pulses, most growers were able to control these using routine fungicide applications with minimal impact on yield or quality. Insect pest numbers were below control thresholds.

Well below average spring rainfall with a number of hot windy days at the beginning of October followed by cooler conditions at the end of October resulted in uneven ripening in and between paddocks. Growers windrowed canola at the beginning of October and began harvest toward the end of the month. A number of growers also windrowed barley crops to induce even ripening and prevent head loss. Widespread rain in early November germinated a large number of summer weeds and many growers applied herbicides immediately after harvest. Canola yields were above average ranging from 1.5 to over 2.0 t/ha with generally good oil content.

Most growers finished harvest by the end of December however, cool, damp mornings and some hot windy days caused harvest delays in areas south of Edillilie. Cereal yields were slightly better than average with reports of 4.0 to 4.5 t/ha common. Despite growing high amounts of winter biomass, yields were poorer than expected on lighter textured soil types. Pulse yields were around the long term average with peas around 1 t/ha, beans and lentils 1.2 to1.5 t/ha. Lupin yields were disappointing with reports of less than 1 t/ha common, reflecting the poorer soils that lupins are generally grown on. Grain quality also varied greatly with soil type and low test weights and high screenings causing quality downgrades at delivery.

South Australian Rainfall Deciles 1 April to 31 December 2015

Distribution Based on Gridded Data
Australian Bureau of Meteorology



http://www.bom.gov.au

RURAL SOLUTIONS SA

Government of South Australia

MAC Farm Report 2015

INFORMATION

Mark Klante
SARDI, Minnipa Agricultural Centre

Try this yourself now

Location:
Minnipa Ag Centre
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm

Key outcomes

- **On average MAC wheat yielded 2.3 t/ha, barley yielded 3.4 t/ha, canola 1.7 t/ha and peas 1.3 t/ha in 2015.**
- **66% of the total farm area was cropped.**
- **346 breeding ewes produced 126% lambs at marking.**
- **80 tonnes of certified seed was made available for sale to growers.**

Background

The performance of the Minnipa Agricultural Centre (MAC) commercial farm is an essential component in the delivery of relevant research, development and extension to Eyre Peninsula. The effective use of research information and improved technology is an integral part of the role of the MAC farm.

MAC had white peg trials in seven paddocks and whole paddock demonstrations in N1 (focus paddock), S7 (soil health), cumin in S5, sulla in N12 and the competition paddocks (lucerne and oats +/- spray topping) were used for methane production testing.

What happened?

There was no rain in January, February and March and then 29 mm fell on 16-17 April and we were off and running! Then there was 25 mm of rain, but this fell on 21 days until 15 June, when 40 mm fell. 80 mm in August set the farm up for good potential yields, but after 4 September there was only 1 mm of rainfall for September and 5 mm rainfall in October. Seven days over 35°C including two days of 38°C on 15 and 24 October impacted on the final outcome. In total we received 258 mm of growing season rainfall (GSR), falling on 85 days, compared to 290 mm of GSR in 2014.

We started sowing Sturt canola and Jaguar medic on 22 April, Trojan wheat 23 April, Green cumin 24 April, Gunyah and Pearl peas 27 April, Compass barley 28-29 April, Grenade wheat 30 April and one paddock of Mace wheat on 1 June. Sowing stopped until 12 June as rain was forecast for a couple of days' time (15 June), then oats and vetch for hay was sown as reserves were running low and we did not want to buy it in.

Then problems occurred with the Caterpillar tractor when the drive shaft snapped. A demo tractor from Curtis' arrived on 20 June and we resumed sowing wheat on 21 June, finishing seeding on 27 June. With the different tractor we encountered problems with the guidance system, going from 2 cm to 15 cm. This changed the inter row sowing and when it sowed on row it left a mess and had to be prickle chained, resulting in seed being buried too deep.

The MAC farm was sown to wheat 560 ha (46%), barley 84 ha (7%), oats and vetch 55 ha (4.5%), canola 45 ha (3.75%), peas 45 ha (3.75%) and cumin 3 ha (0.25%) of 1,200 ha, including Minnipa Progress Association land.

Two varieties of certified seed were sold; Scepter wheat and Compass barley.

Harvest commenced on 27 October (Compass barley) and finished on 27 November (Cutlass wheat). The average farm yields were; wheat 2.3 t/ha, barley 3.4 t/ha, canola 1.7 t/ha, peas 1.3 t/ha and oats 2 t/ha.

According to the modified French and Schultz yield calculation, the potential yields were; wheat 3.0 t/ha, barley 3.4 t/ha, peas 1.9 t/ha and canola 2.2 t/ha. The yields achieved were; wheat 76%, barley 100%, peas 68% and canola 77% of the calculated potential yield.

Issues encountered and questions asked in 2015:

- Burning header rows proved a problem when chaff on the ground wouldn't burn, and despite no rain it remained damp.
- A lot of self-sown cereal and some grass weeds are coming up in the header rows.
- Had poor germination because of spreader plate putting seed away from moisture.
- Cumin sown broad acre as well as in trials. More work to be done to see if it is worth growing in this environment. Issues with disease and insects in 2015.
- Wondered how Trojan would fare on a year like this? A long season wheat sown first, with a short finish – lower yield than farm average but quality was okay.
- Grazed Compass barley in Paddock S6E as Jess couldn't find any farmers willing to graze crops considering the start to the season (will I suffer any yield penalty?). Average yield was 4.2 t/ha in the paddock, grazed yield 3.9 t/ha.

Table 1 Harvest results, 2015 grain yields and protein aligned with paddock rotational histories

Paddock	Paddock History 10-14	Crop 2015	Sowing Date 2015	Yield (t/ha)	Protein (%)	Screenings (%)
North 1	W W P W W	Medic (P)				
North 2	P W W B P	Sturt (C)	22 April	1.7		
North 3	Pe P W W V	Mace (W)	12 May	2.6	11.8	5.1
North 4	W W B P W	Mace (W)	22 May	2.1	11.4	12.4
North 5 N	B P P W W	Compass (B)	28 April	3.4	8.4	0.5
North 5 S	P W W W B	Medic (P)				
North 6 E	W W W B Pe	Mace (W)	15 May	2.2	13.7	15.8
North 6 W	B Pe W W C	Emu rock (W)	22 May	2.3	12.8	6.8
North 7/8	W W B P W	Mace/Emu rock (W)	24 May	1.9	10.6	5.6
North 9	P W W B V	Trojan (W)	23 April	1.7	11.4	4.9
North 10	Pe W P W W	Medic (P)				
North 11	W W P W P	Cutlass (W)	26 May	2.2	12.4	8.6
North 12	W C W W S	Medic (P) & Wilpena (S)				
South 1	W W B C W	Pearl (Pe)	27 April	1.2		
South 1	W W B C W	Gunyah (Pe)	27 April	1.3		
South 1 Scrub	B B B C W	Medic (P)				
South 2/8	P W W Pe W	Mace (W)	1 May	2.6	10.3	2.9
South 3 S	W W W P P	Scepter (W)	25 May	2.3	16.4	15.0
South 3 N	W C W B P	Grenade (W)	29 April	2.4	12.0	4.0
South 4	W B P W P	Oats & Vetch	13 May			
South 5	W W C B W	Jaguar medic (P)	22 April			
South 6 E	B P M W W	Compass (B)	29 April	3.4	8.4	0.5
South 6 W	B Pe W Pe B	Winteroo (O)	13 May	2.0		
South 7	P W P W W	Medic (P)				
South 9	W P W W B	Medic (P)				
South 10	W P W V B	Compass (B)	29 May	3.4	8.4	0.5
Competition 1		Lucerne	27 May			
Competition 2		Lucerne	27 May			
Competition 3		Oats	14 May			
Competition 4		Oats	14 May			
Barn	P P	Grenade (W)	30 April	2.0	14.0	20.0

P = pasture, Pe = field pea, W = wheat, B = barley, O = oats, C = canola, V = vetch, S= sulla

Farm improvements and equipment

- Purchased second hand truck (Nissan UD) for grain carting
- Purchased new seed and super unit
- Replaced old pump shed with new building
- Six kilometres of fence has been replaced
- Started upgrade on sheep yards
- Planted approximately 200 native trees

Livestock

Numbers: 415 ewes, 360 hoggets, 11 rams

In the first week of February 2015 the rams were put in with 420 ewes in single sire mating groups of approximately 50 ewes per ram. Unfortunately one ram was a failure and only mated 2 ewes, leaving us with a scanned percentage of 130%. Some of the ewes suffered from pregnancy toxaemia but this was brought under control as quickly as possible. 534 lambs were born to 346 ewes (154%), marking was 126% and weaning was 125%.

The 78 dry ewes were put in with all the rams after pregnancy scanning and all but 11 of these had lambs.

All our data for Merino Select® has been submitted and we will be analysing this data early in the new year to set our breeding program for 2016. We have chosen 4 rams from Turretfield with linkage for the 2016 mating in the last week in January.

The ewes averaged 7.0 kg of wool at 12 months, fibre diameter 20 microns and hoggets averaged 3.75 kg at 8 months, fibre diameter 18.1 microns.

The sheep were utilised in the Sheep Genetics, Methane Emissions and Grain and Graze research projects. 18 of our ewes were used to collect data in a project looking at the stress response of lactating and non-lactating ewes to human presence and lamb handling. This project is the work of Alan Tilbrook, Cameron Ralph and Jessica Crettenden.

Acknowledgements

MAC farm staff, Brett McEvoy and John Kelsh.

Mark Klante, Farm Manager and Leigh Davis, Senior Agricultural Officer at the break crops trial site in 2015.

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

"A grower group that specifically addresses issues and finds solutions to improve farming systems in your area"

LEADA's 2015 achievements and 2016 focus

LEADA celebrated 10 years in operation in 2015. It was great to look back on the success of the group and the range of projects that have been delivered over the years. A summary of the history of the LEADA committee was compiled as part of the celebration. A dinner was held for past and present committee members providing a great opportunity to share stories and celebrate the success.

LEADA continued to deliver the GRDC stubble management project along with other smaller projects funded by a range of partners. Trials are continuing and results from the project will be extended through LEADA's Expo and Field Days in the following years.

LEADA was successful in graining funding through the National Landcare Program to develop two case studies summarising farmer's management of acid soils. These case studies will be published early 2016 providing a great guide for others on the positive results farmers are getting.

LEADA was also successful with a GRDC grant through the trial extension network program. Trials have been undertaken to assess the efficacy of spray topping on canola pre-harvest. The results from this project will be available mid-2016.

LEADA gained funding support through an EPNRM Adapt grant to develop guidelines for the management of sub-soil constraints. The project will revisit sites previously treated and analyse long term effects on soils characteristics as well as production. The guidelines will be finalised mid-2016.

LEADA continued the development of the New Horizons site, funded with support from the EP Rail Levy funds, with a second cropping cycle established on the trial plots. Although the season was not a kind finish, there are still some positive interim results. LEADA is planning to continue the site in partnership with PIRSA and others going forward.

LEADA was able to follow up last year's successful session with year 9 geography students from Port Lincoln High School, with a second group visiting the industry in 2015. Students were enthralled by the range of crops grown and learnt some techniques for soil testing. A visit to the flour mill and bakery rounded up an informative day.

The EP Rail Levy Fund also supported two leadership development programs on lower EP. A series of workshops and forums were held for a group of young farmers, learning about themselves and improved farming systems. A series of three development workshops were held for farmers, covering team work, governance and succession planning.

As always, links with GRDC, the Australian Government, Rural Solutions SA, SARDI, EPARF and the Eyre Peninsula NRM Board continue to be critical to the ongoing success of LEADA.

Contact:
John Richardson, Chair **0429 407 073**
Helen Lamont, Executive Officer **0409 885 606**

Committee members:
John Richardson, Daniel Adams, David Giddings, George Pedler, Bruce Morgan, Dustin Parker, Mark Habner, Jamie Phillis, Tim Richardson, Kieran Wauchope, Derek Macdonald, Josh Telfer, Mary Crawford (EPNRMB), Andrew Ware (SARDI), David Davenport (RSSA) and Mark Stanley (Ag Ex Alliance).

An initiative of the Australian Government Department of Agriculture.

Understanding trial results and statistics

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

The average (or mean)

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

The LSD test

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

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

Results from replicated trial

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

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

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

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

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

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

On-farm testing – Prove it on your place!

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

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

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

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

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

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

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

Types of work in this publication

The following table shows the major characteristics of the different types of work in this publication. The Editors would like to emphasise that because of their often un-replicated and broad scale nature, care should be taken when interpreting results from demonstrations.

Type of Work	Replication	Size	Work conducted by	How Analysed
DEMO	No	Normally large plots or paddock size	Farmers and Agronomists	Not statistical, trend comparisons
RESEARCH	Yes, usually 3	Generally small plot	Researchers	Statistics
SURVEY	Yes	Various	Various	Statistics or trend comparisons
EXTENSION	N/A	N/A	Agronomists and Researchers	Usually summary of research results
INFORMATION	N/A	N/A	N/A	N/A

Some useful conversions

Area
1 ha (hectare) = 10,000 m² (square 100 m by 100m)

1 acre = 0.4047 ha (1 chain (22 yards) by 10 chain)

1 ha = 2.471 acres

Mass
1 t (metric tonne) = 1,000 kg

1 imperial tonne = 1,016 kg

1 kg = 2.205 lb

1 lb = 0.454 kg

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

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

Wheat = 60 lb, Barley = 48 lb, Oats = 40 lb

1 bu (wheat) = 60 lb = 27.2 kg

1 bag = 3 bu = 81.6 kg (wheat)

Volume
1 L (litre) = 0.22 gallons

1 gallon = 4.55 L

1 L = 1,000 mL (millilitres)

Speed
1 km/hr = 0.62 miles/hr

10 km/hr = 6.2 miles/hr

15 km/hr = 9.3 miles/hr

10 km/hr = 167 metres/minute = 2.78 metres/second

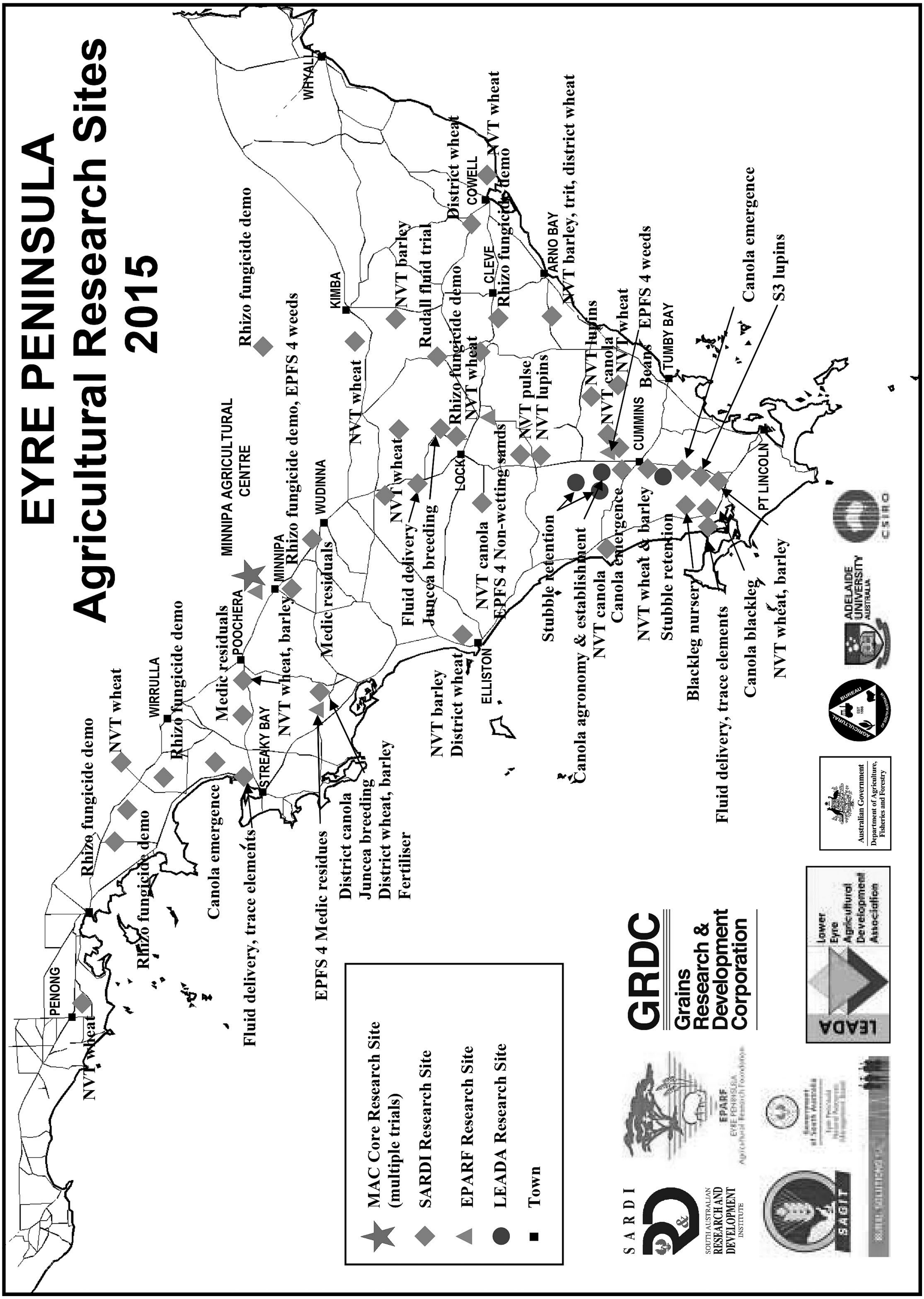
Pressure
10 psi(pounds per sq inch) = 0.69 bar = 69 kPa (kiloPascals)

25 psi = 1.7 bar = 172 kPa

Yield
1 t/ha = 1000 kg/ha

Yield Approximations

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


EYRE PENINSULA
Agricultural Research Sites
2015
MINNIPA AGRICULTURAL CENTRE
PENONG
WIRRULLA
POOCHERA
MINNIPA
WUDINNA
STREAKY BAY
KIMBA
WHYALLA
COWELL
CLEVE
ARNO BAY
LOCK
ELLISTON
CUMMINS
TUMBY BAY
PT LINCOLN
NVT wheat
Rhizo fungicide demo
Canola emergence
Fluid delivery, trace elements
Rhizo fungicide demo
NVT wheat
Medic residuals
NVT wheat, barley
EPFS 4 Medic residues
District canola
Juncea breeding
District wheat, barley
Fertiliser
Rhizo fungicide demo, EPFS 4 weeds
Medic residuals
NVT wheat
Fluid delivery
Juncea breeding
NVT barley
District wheat
NVT barley
Rudall fluid trial
Rhizo fungicide demo
NVT wheat
NVT canola
EPFS 4 Non-wetting sands
District wheat
NVT wheat
NVT barley, trit, district wheat
NVT pulse
NVT lupins
Stubble retention
Canola agronomy & establishment
NVT canola
Canola emergence
NVT wheat & barley
Stubble retention
NVT lupins
NVT canola
NVT wheat
Beans
EPFS 4 weeds
Canola emergence
S3 lupins
Blackleg nursery
Fluid delivery, trace elements
Canola blackleg
NVT wheat, barley
MAC Core Research Site (multiple trials)
SARDI Research Site
EPARF Research Site
LEADA Research Site
Town
GRDC
Grains Research & Development Corporation
LEADA
Lower Eyre Agricultural Development Association
Australian Government
Department of Agriculture, Fisheries and Forestry
SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE
EPARF
ADELAIDE UNIVERSITY AUSTRALIA
CSIRO
SAGIT

Section 1

Section Editor:
Jessica Crettenden
SARDI
Minnipa Agricultural Centre

Cereals

Crop estimates by district (tonnes produced) and average yield (t/ha) in brackets in 2015

	Wheat	Barley	Oats	Triticale
Western EP	705,500 (1.5)	94,000 (1.6)	19,500 (1.2)	550 (1.4)
Eastern EP	823,000 (2.1)	156,000 (2.2)	8,500 (1.4)	1,000 (2.0)
Lower EP	451,000 (3.1)	214,500 (3.3)	8,000 (2.5)	1,500 (3.0)

Source: PIRSA, January 2016, Crop and Pasture Report, South Australia.

Port Kenny, Franklin Harbour, Elliston and Wharminda wheat and barley variety trials in 2015

Leigh Davis[1], Andrew Ware[2] and Amanda Cook[1]
[1]SARDI, Minnipa Agricultural Centre, [2]SARDI, Port Lincoln

EXTENSION

Try this yourself now

Location: Port Kenny - Nathan Little
Mt Cooper Ag Bureau
Rainfall
Av. Annual: 400 mm
Av. GSR: 300 mm
2015 Total: 284 mm
2015 GSR: 241 mm
Yield
Potential: 2.61 t/ha (W), 3.01 t/ha (B)
Actual: Trial Av. 1.51 t/ha (W), 2.70 t/ha (B)
Paddock History
2015: Wheat
2014: Grass free medic pasture
2013: Clearfield wheat
Soil Type
Calcareous loamy sand
Plot Size
1.5 m x 10 m x 3 reps
Yield Limiting Factors
Tough start to the season with little sub soil moisture

Key messages

- **Mace, Yitpi and Wyalkatchem were the top three performing wheat varieties at Port Kenny in 2015.**
- **The top barley varieties yielded nearly 3 t/ha in a well below average rainfall season at Port Kenny.**
- **Franklin Harbour had an outstanding trial average of 3.35 t/ha.**
- **Mace was a standout in a tough year at Elliston, yielding 0.93 t/ha.**
- **The Wharminda trial average was 3.50 t/ha.**

Why do these trials?

These variety trials were identified as priorities by local agricultural bureau groups to evaluate commonly grown varieties, compare them to newly released varieties and provide further information on varietal performance in soil types and rainfall regions where wheat and barley National Variety Trials (NVT) are not conducted.

Port Kenny district wheat and barley trials

How was it done?

Fifteen wheat varieties and nine barley varieties, replicated three times, were sown on 15 May with both trials receiving 69 kg/ha of 19:13:0:9.4S and 69 kg/ha of 46:0:0:0 (urea) fertiliser at sowing. 1.5 L/ha of Weedmaster DST, 1.5 L/ha of Triflur Xtra, 45 ml/ha of Hammer, 800 g/100L of SOA and 500 ml/100L of Li700 were applied to both trials pre-sowing. On 24 July, 300 ml/ha of LeMat was used for Lucerne flea control and 750 ml/ha of Tigrex and 30 ml/ha of Lontrel Advanced was applied for broad-leaved weed control. No fungicides were applied to either trial.

What happened?

Port Kenny trials were sown into a grass removed medic pasture stubble from 2014 and the paddock was worked by the farmer prior to sowing in 2015. Although 40 mm of rain fell in April, there was no subsoil moisture and no substantial follow up rains until July, severely reducing the yield potential and putting the crops under moisture stress.

Location: Franklin Harbour - Bevan and Cindy Siviour
Franklin Harbour Ag Bureau

Rainfall
Av. Annual: 350 mm
Av. GSR: 256 mm
2015 Total: 400 mm
2015 GSR: 294 mm

Yield
Potential: 2.91 t/ha (W)
Actual: 1.98 t/ha (W)

Paddock History
2014: Pasture
2013: Wheat
2012: Wheat

Soil Type
red clay loam

Plot Size
1.5 m x 20 m x 3 reps

Location: Elliston - Nigel and Debbie May
Elliston Ag Bureau

Rainfall
Av. Annual: 427 mm
Av. GSR: 353 mm
2015 Total: 311 mm
2015 GSR: 265 mm

Yield
Potential: 3.10 t/ha (W)
Actual: Trial Av. 0.52 t/ha (W)

Paddock History
2014: Grassy pasture
2013: Grassy pasture
2012: Barley

Soil Type
Grey light sandy clay loam

Plot Size
1.5 m x 10 m x 3 reps

Yield Limiting Factors
Below average rainfall

Location: Wharminda - Tim Ottens
Wharminda Ag Bureau

Rainfall
Av. Annual: 338 mm
Av. GSR: 253 mm
2015 Total: 345 mm
2015 GSR: 284 mm

Yield
Potential: 3.49 t/ha (W)
Actual: Trial Av. 3.50 t/ha (W)

Paddock History
2014: Grassy pasture
2013: Barley
2012: Wheat

Soil Type
Sand

Plot Size
1.5 m x 10 m x 3 reps

Table 1 Grain yield and quality of wheat varieties sown at Port Kenny in 2015

Variety	Yield (t/ha)	Protein (%)	Test Weight (kg/hL)	Screenings (%)
Mace	1.80	11.9	75.3	6.7
Yitpi	1.80	12.4	73.1	2.2
Wyalkatchem	1.74	12.4	72.3	6.0
Phantom	1.60	12.7	68.8	3.8
Cosmick	1.58	12.5	75.5	7.3
Corack	1.53	11.9	71.3	6.1
Trojan	1.52	12.3	73.3	7.5
Shield	1.51	11.9	74.5	7.7
Kord CL Plus	1.49	12.6	71.8	6.4
Scout	1.44	11.9	64.5	6.8
Grenade CL Plus	1.40	12.2	69.3	4.0
Cobra	1.37	12.7	66.4	7.3
Emu Rock	1.36	13.1	68.5	7.7
Hatchet CL Plus	1.33	13.6	73.9	6.3
Axe	1.21	13.2	75.1	4.2
Mean	**1.51**	**12.5**	**71.6**	**6.0**
CV (%)	*5.4*			
LSD (P=0.05)	*0.15*			

Table 2 Grain yield and quality of barley varieties sown at Port Kenny in 2015

Variety	Yield (t/ha)	Protein (t/ha)	Test weight (kg/hL)	Screenings (%)	Retention (% by weight)
Fathom	2.91	13.2	57.1	4.9	78.9
La Trobe	2.89	12.3	60.2	12.3	58.8
Compass	2.85	13.0	61.3	4.8	80.7
Hindmarsh	2.83	12.7	60.0	12.4	58.5
Keel	2.72	13.3	56.7	18.2	68.8
Commander	2.61	13.1	55.1	9.4	66.7
Fleet	2.60	13.7	54.9	6.3	71.5
Buloke	2.43	13.0	57.0	15.7	40.6
Scope	2.43	13.0	58.1	15.3	39.3
Mean	**2.70**	**13.0**	**57.8**	**11.0**	**62.7**
CV (%)	*3.1*				
LSD (P=0.05)	*0.15*				

Surprisingly, the early maturing lines performed poorly in a short-seasoned year, which is shown in Table 1. This could be explained by lack of rainfall after sowing causing the early maturing lines Emu Rock, Hatchet CL Plus and Axe stress and triggering the varieties to run up to head before the relieving rains fell in July. The longer maturing lines that didn't run to head capitalised on the kinder weather in July, August and September.

The top four yielding barley varieties in 2015, presented in Table 2, were Fathom, La Trobe, Compass and Hindmarsh. Compass barley shows its superior grain quality compared to the other varieties with exceptional test weight, screenings and retention considering the tough season.

Franklin Harbour district wheat trial

How was it done?

The trial at Franklin Harbour included sixteen wheat varieties, replicated three times, and was sown on the 17 May with 60 kg/ha of DAP fertiliser. Chemicals of 1.25 L/ha of glyphosate, 0.125 L/ha of Ester 680, 1% wetter, and 120 g/ha of Sakura were applied at sowing. 0.5 L/ha of MCPA LVE was used for broadleaved weed control and 1.8 L/ha of a product called RUM was used for nitrogen and trace element boost.

Table 3 Grain yield and quality of wheat varieties sown at Franklin Harbour, 2015

Variety	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Mace	3.75	9.6	84.6	1.2
Corack	3.69	9.3	84.1	2.0
Trojan	3.57	9.0	86.4	3.2
Espada	3.56	9.9	84.1	3.3
Wyalkatchem	3.53	10.0	84.0	1.1
Shield	3.52	10.0	83.2	2.2
Yitpi	3.40	9.8	85.4	3.5
Cobra	3.38	9.6	83.3	3.0
Scout	3.36	9.5	85.8	2.6
Emu Rock	3.25	10.2	84.9	3.0
Kord	3.19	10.0	84.8	7.7
Justica	3.14	10.1	84.0	3.2
Gladius	3.12	10.3	84.6	2.9
Phantom	3.10	9.7	84.6	2.8
Axe	3.08	10.3	84.7	2.3
Grenade	3.03	10.0	85.3	2.1
Mean	**3.35**	**9.8**	**84.6**	**2.9**
CV (%)	*5.0*			
LSD (P=0.05)	*0.31*			

Table 4 Grain yield and quality of wheat varieties sown at Elliston, 2015

Variety	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Mace	0.93	9.0	3.4	80.5
Kord CL Plus	0.62	9.3	7.2	79.4
Shield	0.54	9.3	7.1	78.6
Phantom	0.53	8.9	5.3	80.6
Grenade CL Plus	0.52	9.2	4.4	80.2
Wyalkatchem	0.52	9.4	3.5	80.2
Cobra	0.52	9.2	4.0	78.8
Axe	0.51	10.3	4.0	79.4
Cosmick	0.51	8.8	4.2	80.1
Scout	0.48	8.5	4.2	81.8
Yitpi	0.47	9.3	7.2	80.4
Emu Rock	0.47	9.6	5.5	80.3
Hatchet CL Plus	0.43	11.1	3.3	80.5
Corack	0.38	8.9	3.9	80.3
Trojan	0.38	8.1	4.2	81.6
Mean	**0.52**	**9.3**	**4.8**	**80.2**
CV (%)	*12.9*			
LSD (P=0.05)	*0.11*			

What happened?

Franklin Harbour had an exceptional season with the district wheat trial averaging 3.35 t/ha. There was no significant difference between the top six varieties, and all varieties tested yielded about 3 t/ha. Test weights and screenings were of excellent quality, apart from Kord with 7.7%, which would have caused a downgrade at the silos. Protein content was on the lower side with all varieties below 10.5% APW target percentage.

Grain from this trial was pinched, which may have been caused by the tough finish due to low rainfall in spring. Most other areas on upper EP had a substantial rainfall event in February of 40-100 mm, whereas Elliston only received 22 mm on average.

Table 5 Grain yield and quality of wheat varieties sown at Wharminda, 2015

Variety	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Wyalkatchem	3.87	9.4	3.6	80.2
Mace	3.84	9.0	3.4	80.5
Corack	3.82	8.9	3.9	80.3
Cobra	3.79	9.2	4.0	78.9
Cosmick	3.73	8.8	4.2	80.1
Trojan	3.59	8.1	4.2	81.6
Yitpi	3.56	9.3	7.2	80.4
Scout	3.56	8.5	4.2	81.8
Emu Rock	3.49	9.6	5.5	80.3
Phantom	3.47	8.9	5.3	80.6
Shield	3.41	9.3	7.1	78.6
Grenade CL Plus	3.24	9.2	4.4	80.2
Axe	3.09	10.3	3.7	79.4
Kord CL Plus	3.03	9.3	7.2	79.4
Hatchet CL Plus	3.00	11.1	3.3	80.5
Mean	**3.50**	**9.3**	**4.7**	**80.2**
CV (%)	*5.5*			
LSD (P=0.05)	*0.32*			

Elliston district wheat trial

How was it done?

Fifteen wheat varieties, replicated three times, were sown on 25 May with 80 kg/ha of DAP fertiliser and treated with Impact at 400 ml/ha at sowing, with applications of 2 L/ha glyphosate @ 540 gm/L, 2.5 L/ha of Boxer Gold, 1.6 L/ha of Avadex Xtra and 80 ml/ha Oxyfluorfen @ 240 g/L. 1.4 L/ha of Bromicide MA was applied for broadleaved weed control on 28 September. 300 ml/ha of Prosaro fungicide was applied to combat any foliage diseases. Yield, protein, test weight and screenings were measured.

What happened?

Yields and rainfall were well down at Elliston in 2015, but Mace was the standout variety yielding 0.93 t/ha in a tough season (Table 4). High screenings in some varieties and low protein was common in this trial but test weights were well within the benchmark of 76 kg/hL.

Wharminda district wheat trial

How was it done?

Fifteen wheat varieties, replicated three times, were sown on 11 May with 85 kg/ha of DAP fertiliser treated with Impact @ 400 ml/ha at sowing, with applications of 2 L/ha of glyphosate @ 540 gm/L, 2.5 L/ha of Boxer Gold, 1.6 L/ha of Avadex Xtra and80 ml/ha of oxyfluorfen @ 240g/L. 1.4 L/ha of Bromicide MA was applied for broadleaved weed control on 23 June. 300 ml/ha of Prosaro fungicide and 100 ml/ha of BS 1000 were applied to combat any foliage diseases. Yield, protein, test weight and screenings were measured.

What happened?

The Wharminda trial had an exceptional start to the season with 77 mm of rain falling in April and an exceptional finish with 84 mm in August. There were no significant differences between the top eight yielding varieties and all the test weights were well above the 76 kg/hL limit (Table 5). Protein levels were down but this is expected in a high yielding environment. Screenings were a little high in some varieties.

What does this mean?

Variety selection should be made by evaluating yield performance over more than one year. The disease resistance package (either root or leaf), sprouting tolerance, maturity, height, herbicide tolerance (Clearfield) and grain quality are all important characteristics that should be considered when choosing a variety to fit your farming system.

For more extensive options and details on any variety visit the National Variety Trials (NVT) website at www.nvtonline.com.au, or refer to the articles in the EPFS Summary 2015 NVT Cereal Yield Performance Tables and the Cereal Variety Disease Guide.

Acknowledgements

Thanks to Nathan Little and his family for the use of their land at Port Kenny, Nigel and Debbie May for the use of their land at Elliston, Tim Ottens for the use of his land at Wharminda, and Bevan and Cindy Siviour for the use of their land at Franklin Harbour.

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

100 years of wheat breeding at Roseworthy: the Eyre Peninsula impact

Andrew Egar, James Edwards and Haydn Kuchel

Australian Grain Technologies (AGT), Roseworthy Campus

RESEARCH

Key messages

- **Data from the Eyre Peninsula (2013 and 2014) shows that since 1955 there has been a 1.4 t/ha improvement in wheat yields, or approximately 1% per year. Prior to 1955, there was no improvement in grain yield.**
- **The largest improvements have been driven by increased funding and the inclusion of semi dwarf varieties.**
- **The last fifteen years has seen an average 1.4% growth in yields per annum.**

Why do the trial?

This trial aimed to measure the value of wheat breeding at Roseworthy, and the impact of private investment, for growers in South Australia.

How was it done?

Forty eight wheat varieties bred at Roseworthy between 1906 (Fan) and 2012 (Shield) were grown at six locations over two years (Clearfield tolerant varieties were excluded). The locations were: Rudall (2013), Pinnaroo (2013), Roseworthy (2013 and 2014), Angas Valley (2014) and Minnipa (2014). All varieties in each trial were managed (sowing rate, fertiliser and in-crop treatments) according to current practices for each specific region. Grain yield, protein, test weight, thousand grain weight and screenings were measured and analysed both within individual sites and across sites. Yield and quality data for this paper is mostly taken from the Eyre Peninsula sites.

What happened?

Grain yield

The results from all sites indicated that wheat breeding at Roseworthy has resulted in a 103% yield increase, or approximately 1% per year. The results from the trials on Eyre Peninsula also demonstrated a near 1% per year increase (0.96%), which amounted to 1.98 t/ha from Fan to Mace (Figure 1). Three events appear to have had a major influence on yield during this time.

Firstly, the Federal Government introduced the 'Wheat Research Act' in 1957 which diverted proceeds from the wheat tax into wheat breeding. This enabled wheat breeders to increase the size of the programme, improve mechanisation and expand testing into additional environments. The results of this trial indicate a yield increase of 0.47% per year (0.6 t/ha) from Fan to Halberd, the first variety with a major yield increase after the 'Wheat Research Act'.

Secondly, exotic semi-dwarf varieties were introduced into the breeding programme in the late 1960s. The first semi-dwarf variety released from the Roseworthy programme was Lance in 1975, which corresponded to a yield increase of 0.3 t/ha or 1.26% per year from Halberd to Lance.

The third event that has had a significant impact on wheat breeding was the introduction of End Point Royalties (EPRs) which enabled wheat breeding to become a commercial enterprise. This has led to an expansion in the size of the breeding programme and increased adoption of new technologies, including DNA selection, advanced statistics, precision agriculture and robotics. Excalibur was the highest yielding variety developed at Roseworthy before the advent of EPRs. There was a 0.35 t/ha grain yield increase from Lance to Excalibur, or 0.9% per year, while the improvement from Excalibur to Mace has been 0.73 t/ha or 1.3% per year.

Protein

As grain yield has increased, the protein dilution effect has led to a small decrease in protein concentration (Figure 2). Although protein percent has dropped, when the protein yield per hectare is calculated, a marked increase corresponding to the large increases in grain yield is evident over the history of wheat breeding at Roseworthy (Figure 3). This demonstrates the 'protein dilution effect' where the nitrogen available for converting to protein is limited due to the increased yield and therefore the protein percent of the grain is lower, or diluted. Although protein percent has reduced from 13.7% to 12.5%, which is a change of approximately 8.8%, the actual amount of protein harvested has increased 42%, from 304 kg/ha to 430 kg/ha, due to the increased yield, as shown in Figure 3.

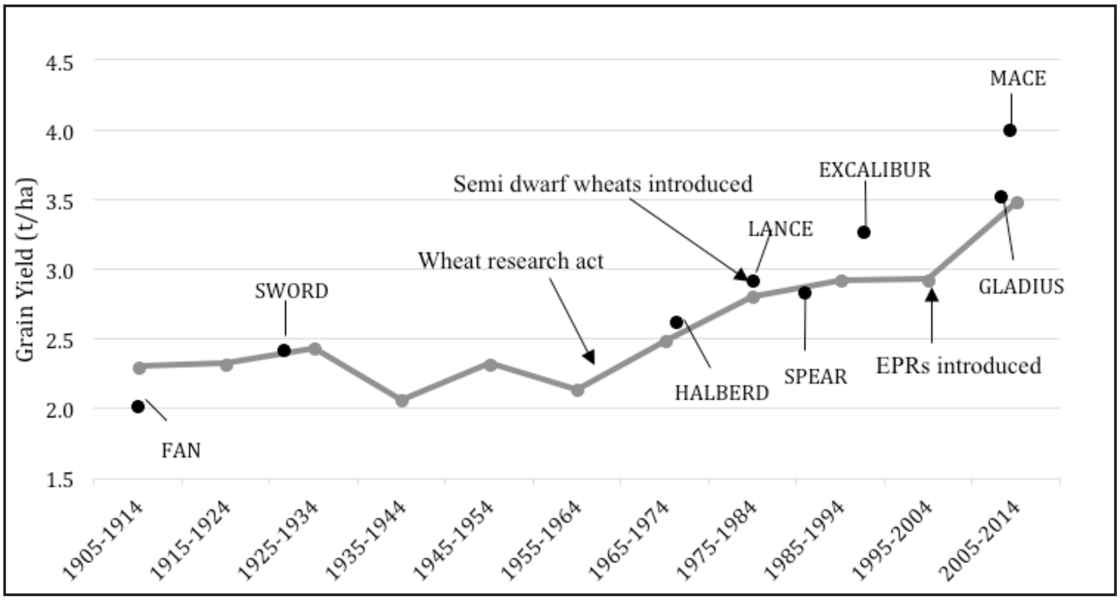


Figure 1 Yield of varieties grown on the Eyre Peninsula sites, averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy. Key varieties and events are also shown.

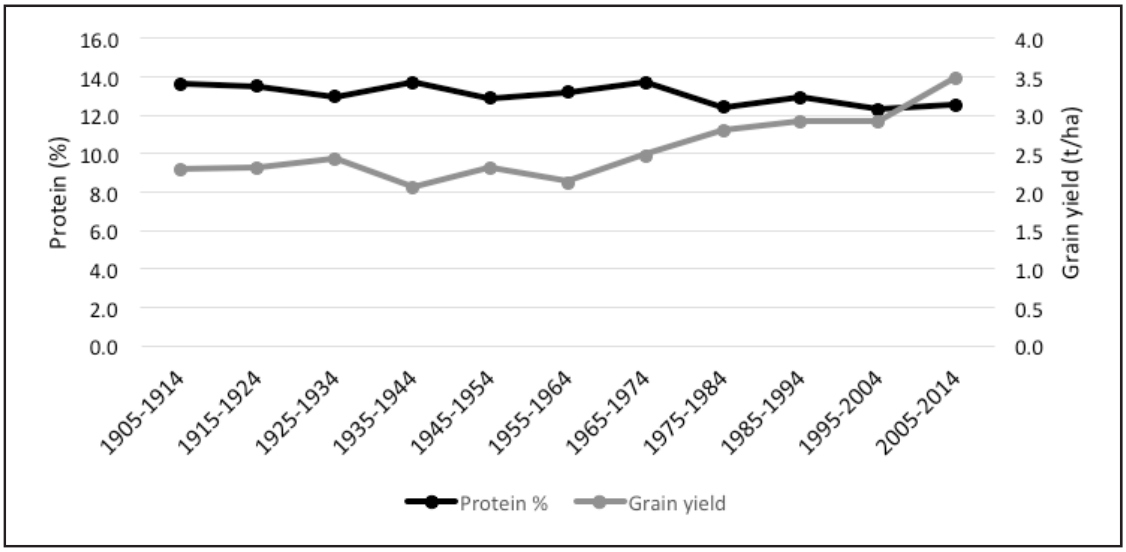


Figure 2 Protein content (percent) and grain yield of wheat varieties grown on the Eyre Peninsula, averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

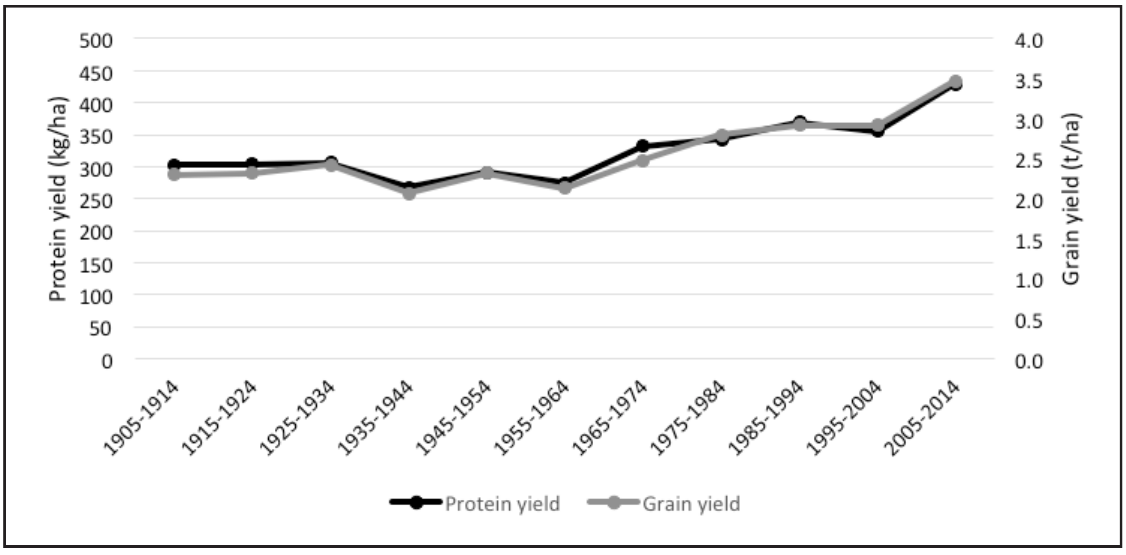


Figure 3 Grain and protein yield of wheat varieties grown on the Eyre Peninsula, averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

Agronomic traits

Overall, tiller number per plant has increased (data not shown). Similarly, grain number per square metre has increased and appears to be the primary driver of the grain yield increase (Figure 4).This increase in grain number has led to a slight reduction in grain size. Thousand grain weight has reduced, while the percentage of screenings has increased (Figure 5). It is interesting to note that due to high selection pressure over the last 15 years, grain size has increased (Figure 5) as has test weight (Figure 6), after some previous reductions. There has been a 2.4% increase in test weight (82.5 to 84.4), 12.4% increase in thousand grain weight (30.5 to 34.3), and a 23.4% decrease in screenings (4.22 to 3.23). The days from sowing to heading has decreased approximately six days since the beginning of formal wheat breeding at Roseworthy. Lodging and plant height have both reduced over time (Figure 7). This figure shows that lodging has improved over time with selection, with the largest improvement made with the reduction in plant height associated with the introduction of the semi dwarf wheats.

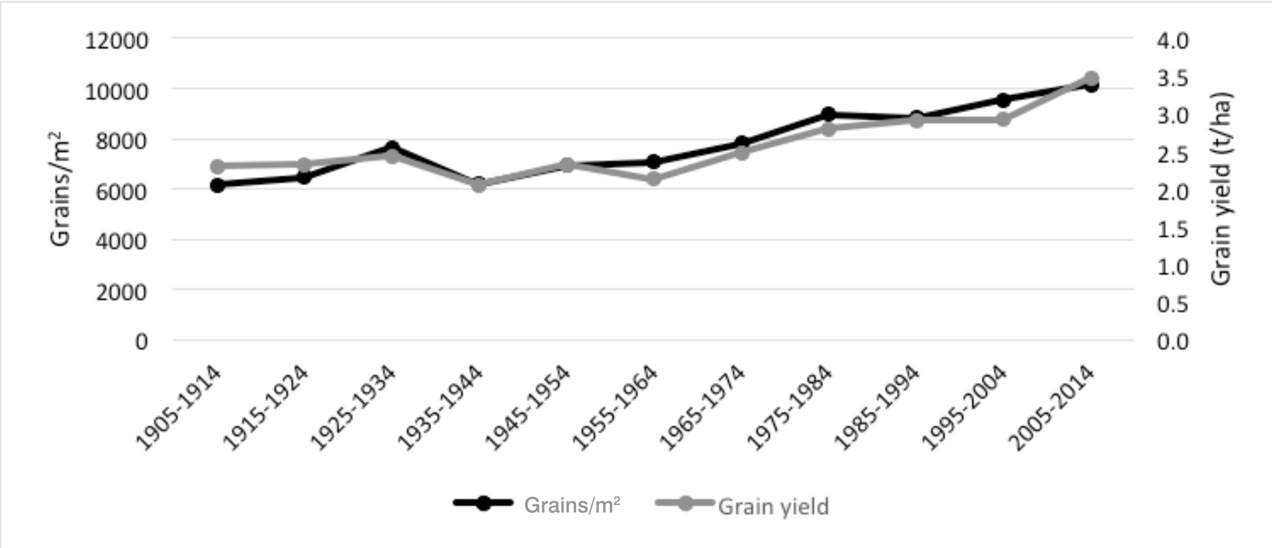


Figure 4 Number of grains per square metre of wheat varieties grown on the Eyre Peninsula, averaged in ten year periods compared to yield from the beginning of formal wheat breeding at Roseworthy.

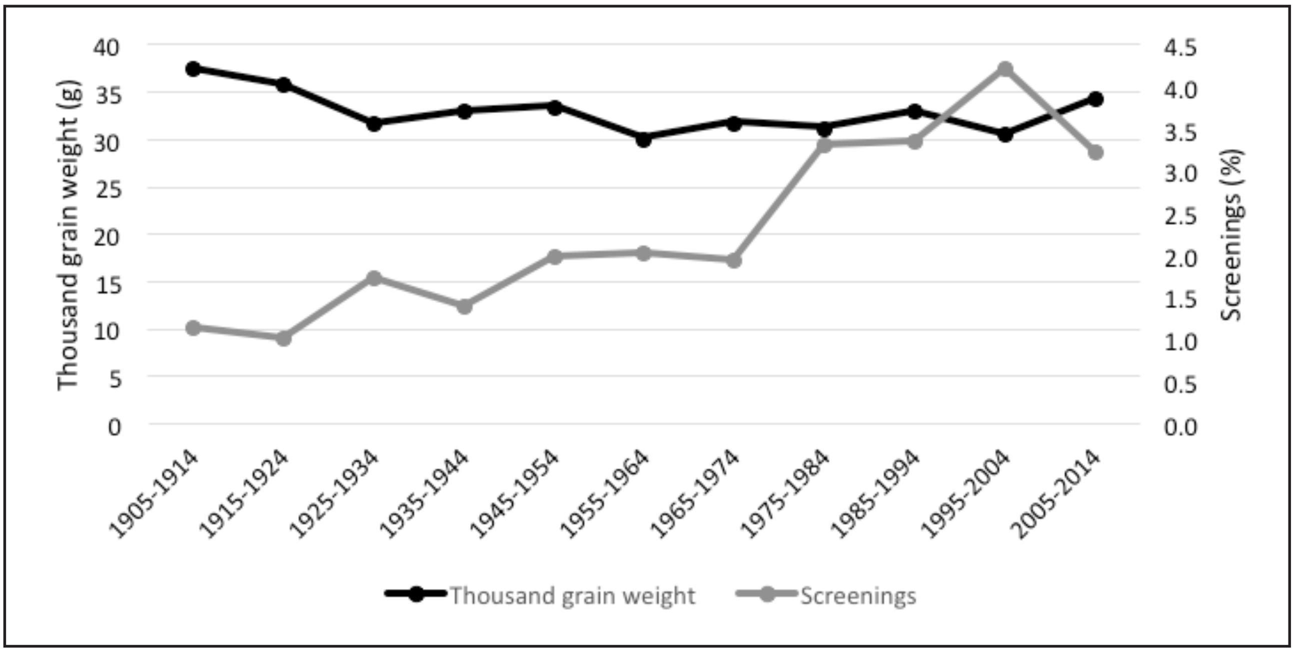


Figure 5 Thousand grain weight and screenings percent of wheat varieties grown on the Eyre Peninsula, averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

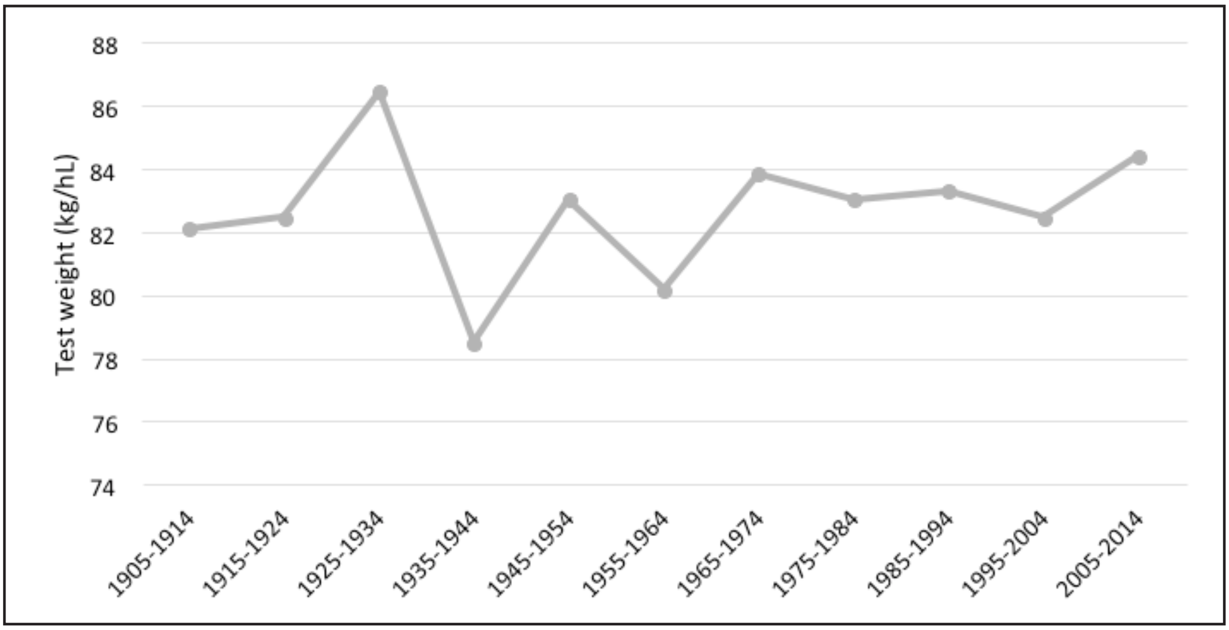


Figure 6 Test weight of wheat varieties grown on the Eyre Peninsula, averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

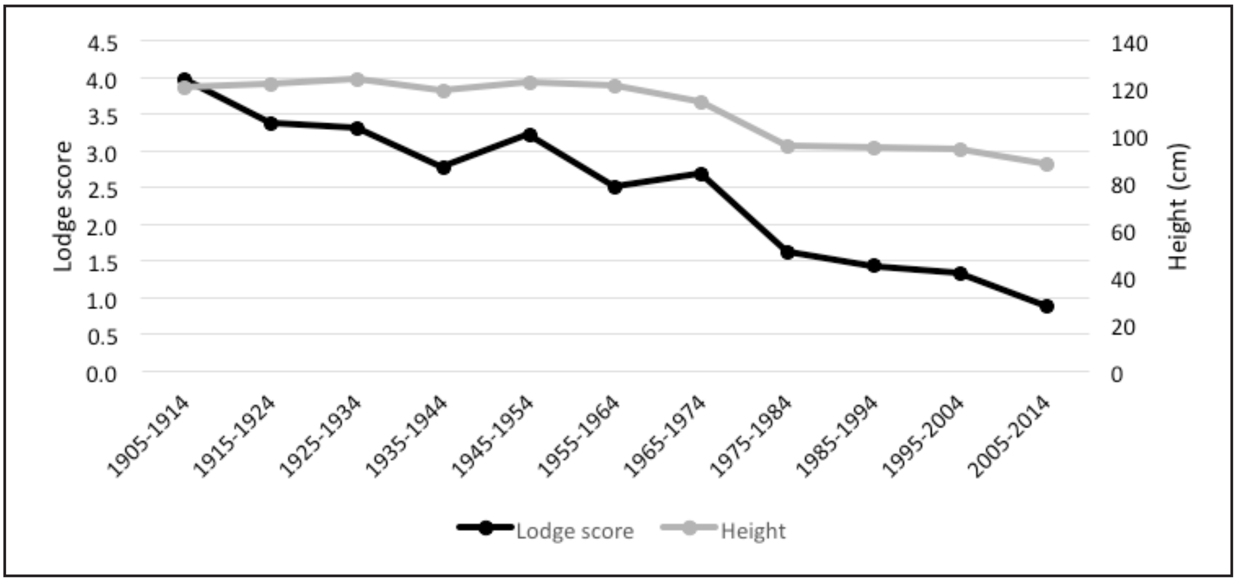


Figure 7 Lodging score and height of wheat varieties averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy. Lodging score: 0 = no lodging, 9 = fully lodged.

What does this mean?

The Roseworthy wheat breeding programme has developed improved varieties with incremental, but measurable improvements to grain yield for South Australian growers. Associated with this improvement in grain yield has been some small reduction in protein concentration and grain size. The lower protein percent has been due to the 'protein dilution effect' of higher yields, while the actual protein production per hectare has increased markedly along with grain yield. Ongoing investigations into management options to address the lower protein concentration are continuing. Recent high selection pressure for larger grain has led to a reversal of the previous trend toward smaller grain.

In this article, we have focussed on grain yield, protein and grain size, without reference to improvements in other important traits such as disease resistance, baking quality or Intervix tolerance. These are other benefits resulting from the breeding programme that can have a high impact on grower profitability. With recent expansion of the Roseworthy based AGT breeding programme, improvements in grain yield, quality and disease resistance are expected to continue to serve Eyre Peninsula growers.

Acknowledgments

This project was funded jointly by AGT and SA Grain Industry Trust Fund (SAGIT).

Intervix and Clearfield are registered trademarks of BASF.

Early sowing in SA – results from 2015 and a summary of two years of trials

James Hunt[1/5], Brad Rheinheimer[1], Tony Swan[1], Laura Goward[1], Rob Wheeler[2], Andrew Ware[2], Leigh Davis[2], John Nairn[2], Amanda Pearce[2], Ian Ludwig[2], Sarah Noack[3], Peter Hooper[3], Mick Faulkner[4], Jeff Braun[4] and Lou Flohr[4]

[1]CSIRO Agriculture, [2]SARDI, [3]Hart Fieldsite Group, [4]AgriLink Agricultural Consultants, [5]La Trobe University

RESEARCH

Try this yourself now

Key messages

- **Across 9 sites in SA in 2014 and 2015 there was an average yield penalty of 28 kg/ha for every day sowing is delayed past the end of the first week in May.**
- **Based on two years of data, Trojan (mid-fast developing) complements Mace (fast developing) in a cropping program and allows growers to sow earlier and achieve higher yields (0.7 t/ha) than they could with Mace alone sown in its optimal window.**
- **Existing slow developing wheat cultivars from other states are poorly adapted to most regions in SA. However, there are winter wheats with better SA adaptation under development and early results are promising.**
- **The value of early sowing with slower developing cultivars to a given farm enterprise is dependent on the duration of wheat sowing program.**

Why do the trial?

In South Australia (SA) the time at which wheat flowers is very important in determining yield. With farm sizes increasing and sowing opportunities decreasing, getting wheat crops established so that they flower during the optimal period for yield is difficult. Whilst no-till and dry-sowing have been used successfully in SA to get more area of crop flowering on time, an opportunity exists to take advantage of rain in March and April to start sowing crops earlier than currently practiced. This is a tactic which complements dry sowing. Earlier sowing is now possible with modern no-till techniques, summer fallow management and cheaper insecticides and fungicides to protect against diseases associated with early sowing.

In the last few decades wheat breeding has focused on mid to fast developing cultivars which are only suited to sowing in late April-May. Sowing earlier than is currently practiced requires cultivars which are not widely grown in SA, and which are much slower to mature, either through having a strong vernalisation/cold requirement (winter wheats) or strong photoperiod/day length requirement (slow developing spring wheats).

Research funded by GRDC in NSW demonstrated that slow developing cultivars sown early yield more than mid-fast varieties sown later when they flower at the same time. This is because early sowing increases rooting depth and water use, reduces evaporation and increases transpiration efficiency. Early sowing slow developing cultivars is a way of increasing yield potential with very little initial investment. A lack of slow developing cultivars adapted to SA is currently limiting grower's ability to take advantage of the water use efficiency (WUE) benefits of early sowing. However, some advances can be made by using mid (e.g. Cutlass) and mid-fast (e.g. Trojan) developing cultivars to open up sowing windows.

How was it done?

The early sowing trials in 2015 were undertaken at four locations (Cummins, Minnipa, Port Germein and Conmurra), each had three times of sowing (aimed at mid-April, late-April, mid-May) and six cultivars. There was seed bed moisture at all times of sowing at all sites and seed germinated shortly after sowing. At Minnipa, a new winter wheat that is being developed by AGT (RAC2341) was also tested.

What happened?

Results from 2015 experiments on EP are presented in Table 1. At all sites Trojan sown in either mid or late April was the highest or equal highest yielding treatment. Trojan sown in its optimal window (late April) out-yielded Mace sown in its optimal window (mid-May) at three out of four sites across SA where the two were grown (mean yield advantage 0.6 t/ha). Slow developing cultivars bred in other states (e.g. EGA Wedgetail, EGA Eaglehawk and Rosella) showed poor adaptation to all sites. This is in part because even when sown early they flower too late in many SA environments (e.g. see Minnipa flowering dates in Table 2).

Table 1 Grain yield (t/ha) of early sowing trial sites on EP in 2015. P-values and LSDs are for TOS x cultivar interactions.

Location	Cultivar	Time of sowing		
		10 April	29 April	14 May
Cummins	Wedgetail	3.3	2.5	3.1
	Rosella	2.8	2.6	2.8
	Eaglehawk	3.3	2.7	2.8
	Cutlass	4.3	3.8	4.0
	Trojan	4.7	4.1	3.9
	Mace	4.0	4.1	4.0
	P-value	0.012		
	LSD (P=0.005)	*0.5*		
Minnipa		13 April	29 April	13 May
	Wedgetail	2.8	2.5	1.9
	Eaglehawk	2.9	2.3	1.8
	RAC2341	3.4	3.6	2.7
	Cutlass	3.5	3.6	2.9
	Trojan	3.3	3.9	3.0
	Mace	2.9	3.8	3.2
	P-value	<0.001		
	LSD (P=0.005)	*0.3*		

The winter wheat RAC2341 showed great promise at Minnipa, where its yield was not significantly different to that of Trojan and Cutlass at all times of sowing, despite flowering much later (Table 2) and therefore taking less frost risk. If released, this cultivar would give SA growers an excellent option for taking advantage of any establishment opportunities arising from March through to late April when it becomes safe to sow currently adapted spring wheats. It would also provide the first ever adapted dual purpose cultivar for SA, which would increase productivity on mixed farms.

Grain quality data were only available for Minnipa at time of writing (Table 3). At this site protein increased due to yield concentration effects with later sowing, but screenings increased and test weight decreased, such that highest paying binned grades (APW and AUH2) were predominantly achieved at the first two times of sowing.

What does this mean?

Based on two years of trials, growers in SA could improve whole-farm yields by including Trojan in their cropping program to complement Mace (Figure 1). Trojan has an unusual photoperiod sensitivity allele inherited from a European parent which is rare in Australian cultivars. This allele seems to delay flowering from an April sowing relative to Mace quite successfully (Table 2).

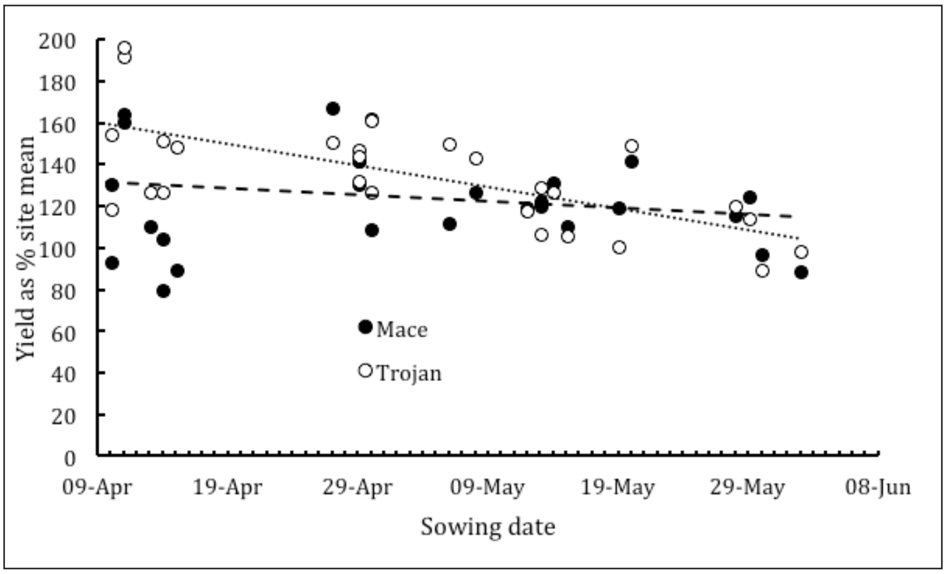
Table 2 Anthesis date for cultivars at different times of sowing at Minnipa in 2015. Values shaded in grey flowered within 7 days of 1 September which is assumed to be the optimal flowering date for Minnipa.

Flowering date Cultivar	Time of sowing		
	13 April	29 April	13 May
Wedgetail	12-Sep	21-Sep	26-Sep
Eaglehawk	13-Sep	23-Sep	3-Oct
RAC2341	3-Sep	14-Sep	21-Sep
Cutlass	20-Aug	8-Sep	18-Sep
Trojan	9-Aug	2-Sep	14-Sep
Mace	26-Jul	24-Aug	8-Sep

Table 3 Grain quality from the experiment at Minnipa in 2015.

Quality parameter	Cultivar	Time of sowing		
		13 April	29 April	13 May
Protein	Wedgetail	11.0	12.9	15.2
	Eaglehawk	10.7	12.7	14.7
	RAC2341	10.8	12.2	14.0
	Cutlass	10.0	11.5	13.1
	Trojan	10.5	11.0	13.3
	Mace	11.0	11.1	12.1
	P-value	<0.001		
	LSD (P=0.005)	*0.8*		
Screenings (%)	Wedgetail	3.3	7.7	15.1
	Eaglehawk	8.4	12.3	21.6
	RAC2341	1.7	6.7	17.2
	Cutlass	2.4	6.5	10.1
	Trojan	2.3	4.1	10.7
	Mace	1.3	3.2	6.2
	P-value	<0.001		
	LSD (P=0.005)	*3.5*		
Test weight (kg/hL)	Wedgetail	71.9	70.1	70.4
	Eaglehawk	77.6	78.2	78.8
	RAC2341	79.6	77.1	75.0
	Cutlass	79.1	76.5	74.9
	Trojan	78.6	78.2	74.5
	Mace	78.8	78.6	75.9
	P-value	<0.001		
	LSD (P=0.005)	*1.5*		
Binned grade	Wedgetail (SA APW)	AGP1	AGP1	Undeliverable
	Eaglehawk (SA APW)	AGP1	FED1	Undeliverable
	RAC2341 (potential AH)	APW1	AUH2	HPS1
	Cutlass (APW)	ASW1	AGP1	FED1
	Trojan (APW)	APW1	APW1	FED1
	Mace (AH)	APW1	APW1	AUH2

a)



b)

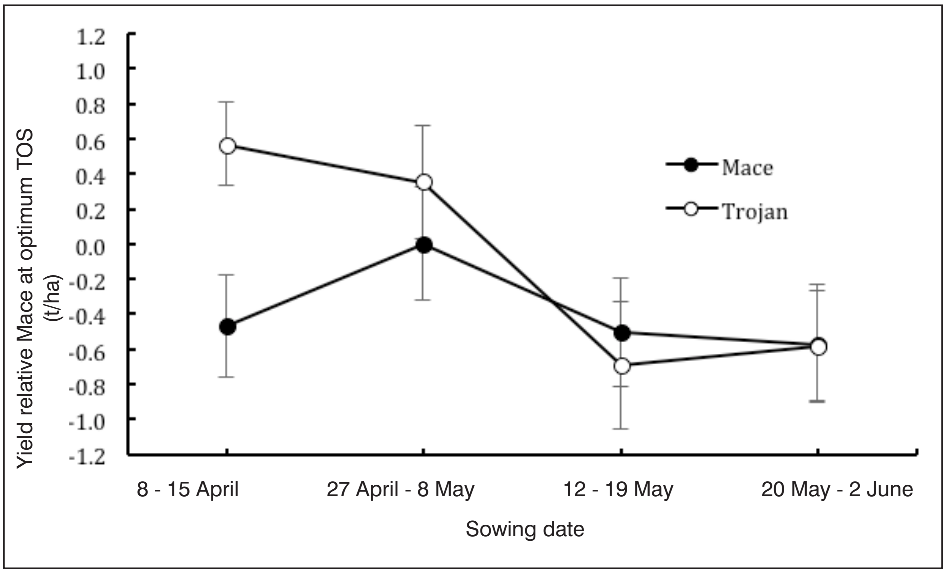


Figure 1 a) *Mean yield (% site mean) of Mace and Trojan at nine SA sites where they were both grown during 2014 and 2015 (Minnipa 14 & 15, Cummins 14 & 15, Port Germein 14 & 15, Hart 14 & 15, Tarlee 14). Linear regressions for both Mace (- - -, R=0.05) and Trojan (····, R=0.47) are significant (P<0.001) and are significantly different from each other in gradient (P=0.045) and intercept (P=0.025).*

Figure 1 b) *Mean yield (t/ha compared to Mace at its optimal time of sowing at each site) for Trojan and Mace from the above sites averaged across different arbitrary sowing periods. Error bars are standard error of means, and points with overlapping bars are unlikely to be significantly different from each other.*

Despite performing strongly from a mid-April sowing in these trials, it is not recommended that Trojan be planted this early in the majority of SA locations as it incurs excessive frost risk. As a rough rule of thumb, it is best suited to being planted approximately ten days earlier than Mace.

For growers in frosty environments who wish to sow earlier than is safe with Trojan or Mace, Cutlass can be sown approximately five days earlier again than Trojan. Sowing earlier than this in frost prone environments requires a winter wheat, and until the release of winter cultivars adapted to SA (e.g. RAC2341) EGA Wedgetail is probably the best option. However, because of its poor adaption to SA even if sown in early-mid April it is unlikely to yield as well as Mace sown in its optimal window. In this set of trials there was an average yield penalty of 0.4 t/ha between EGA Wedgetail sown mid-April and Mace sown in mid-May. Grazing early sown EGA Wedgetail would offset some of the reduction in income compared to mid-May sown Mace.

Two years of trials across multiple environments in SA have shown that yields decline at a rate of 28 kg/ha each day once sowing extends past the end of the first week in May. In order to maximize average yields, growers should aim to finish seeding wheat by mid-May. Growers with longer wheat sowing programs will require multiple cultivars of different development types in order to allow them to start early enough.

Acknowledgements

These trials were run with the financial support of GRDC (Project code: CSP00178, CSP00160)

Understanding the effects of heat stress on grain production

Paul Telfer, James Edwards and Haydn Kuchel

Australian Grain Technologies (AGT), Roseworthy Campus

RESEARCH

Key messages

- **Heat stress is a key limiting factor for cereal production in Southern Australia, including the Eyre Peninsula.**
- **The effects of heats stress on grain yield during flowering cause large negative impacts on grain yield. However, the likelihood of temperature stress occurring during grain filling as late season temperatures rise is greater.**
- **Selecting varieties based on known yield performance and managing the crop using best practice techniques of appropriate sowing time will help limit heat stress effects.**

Why do the trial?

Late season heat stress has been a repeat issue for much of the South Australian (SA) cereal industry, and further afield, in recent seasons. This was particularly the case for the 2015 season. Research into heat stress over a number of years has been multifaceted, using greenhouse based studies to avoid confounding environmental factors as well as working in a number of environments around SA and Australia, to understand variety by environment interactions relating to elevated temperatures during sensitive developmental stages. Flowering and early grain filling have been identified as the more sensitive developmental stages with regard to sensitivity to heat stress, and understanding differences in variety adaptation was the focus of this study.

This research builds on a preliminary study undertaken in 2013 (EPFS Summary 2013, p 36).

How was it done?

Field experiments were conducted at 13 locations over the 2013 and 2014 growing seasons. These trials included 24 wheat lines consisting of Australian varieties and some experimental lines. Each trial was managed as close as possible to local best practice, this includes sowing time, fertiliser, herbicide and fungicide management. The experiment location in each year, along with sowing time, is detailed in Table 1.

In order to characterise the environment that each experiment was conducted in, climatic information was collected through the use of temperature sensors logging atmospheric temperatures at canopy height every 30 minutes throughout the growing season and through local Bureau of Meteorology (BOM) stations. The date of the end of flowering was observed for each plot at Roseworthy in each season, and modelled at the other locations using a degree-day model. This modelling was confirmed with field observations where possible. Flowering date information allowed the climatic environment experienced by each plot to be determined. This was done for the flowering period (300°Cd prior to end of flowering through to 100°Cd post end of flowering) and the grain filling period (100°Cd post end of flowering through to 600°Cd post end of flowering). Climatic variables calculated included average, average maximum and average minimum temperature during both developmental stages as well as the number of days over 30°C, number of days over 35°C, and the number of days below 0°C during both developmental stages.

Grain yield was determined for each experimental unit, as was hectolitre weight (HLW) and percentage screenings. At Roseworthy, Angas valley and Winulta in each season, additional measurements were taken to determine spikelet fertility, thousand grain weight (TGW) and harvest index of the head (HeadHI).

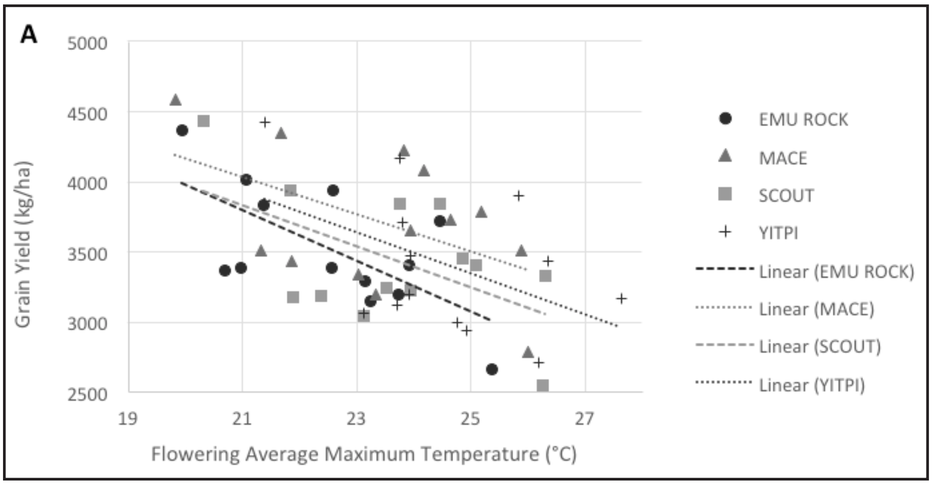
This information allows understanding of the role of heat stress to be determined on a whole of trial or environment level but also allows a more in depth look at individual variety performance under heat stress conditions.

What happened?

Heat stress has been a yield limiting factor in the later portion of the season over the last few seasons on the Eyre Peninsula, which was confirmed in this study where negative interactions of heat stress with grain yield were identified. Large impacts of heat stress were seen during both flowering and grain filling (Table 1). Every 1°C increase in average temperature during flowering across the range of conditions seen in this study resulted in a grain yield reduction of 773 kg/ha (grain filling saw a reduction of 694 kg/ha). Also, for every day over 30°C during flowering a grain yield decline of 302 kg/ha was seen (grain filling saw a reduction of 160 kg/ha).

Table 1 Preliminary analysis of field trials from 2013 and 2014 across seven locations and thirteen experiments in South Australia and the Wimmera, Victoria. For each climatic parameter, the significance of its correlation with site average yield is shown, along with the effect on grain yield for every one unit change in the parameter.

Site	Sowing date	Grain yield (kg/ha)	May-Oct Rainfall (mm)	Av. temp (°C)	Av. max temp (°C)	No. of days > 30°C	Av. temp (°C)	Av. max temp (°C)	No. of days > 30°C	No. of days > 35°C
	2014			flowering	flowering	flowering	grain fill	grain fill	grain fill	grain fill
Angas Valley	16 May	3273	138.8	12.5	23.6	0.1	16.8	28.5	12.4	5.8
Booleroo	19 May	2969	187.8	14.5	25.9	4.7	19.3	31.5	17.3	8.2
Kaniva	21 May	3180	170.2	13.2	24.9	4.5	17.5	29.6	13.8	5.5
Minnipa	7 May	3434	227.4	12.5	21.7	0.5	17.0	26.7	6.0	0.8
Pinnaroo	12 May	2383	103.8	13.0	23.5	1.7	17.6	29.3	13.5	4.0
Roseworthy	13 May	4014	231.6	12.6	23.4	2.4	16.9	28.8	11.5	5.3
Winulta	14 May	3957	192.6	12.6	22.0	0.3	16.9	27.2	11.1	2.4
	2013									
Angas Valley	23 May	1789	165.4	15.2	26.0	6.1	16.1	27.7	8.3	1.9
Booleroo	17 May	3119	292.6	15.2	24.7	2.4	16.1	26.3	7.2	2.0
Minnipa	15 May	2295	196.6	14.4	23.2	4.7	17.0	27.3	9.5	2.4
Pinnaroo	28 May	2318	223.7	14.1	24.1	3.1	16.5	27.4	9.9	3.2
Roseworthy	17 May	3489	302.2	14.2	21.9	2.0	15.9	26.3	8.7	2.5
Winulta	10 May	5222	388.2	13.1	20.2	1.0	15.3	24.8	5.4	0.0
LSD (P=0.05)			*0.0003*	*0.0317*	*0.0054*	*0.0370*	*0.0675*	*0.0012*	*0.0256*	*0.0365*
% variance accounted for			83	37	54	24	22	40	33	34
Effect (kg/ha)			13	-773	-388	-302	-694	-442	-161	-182



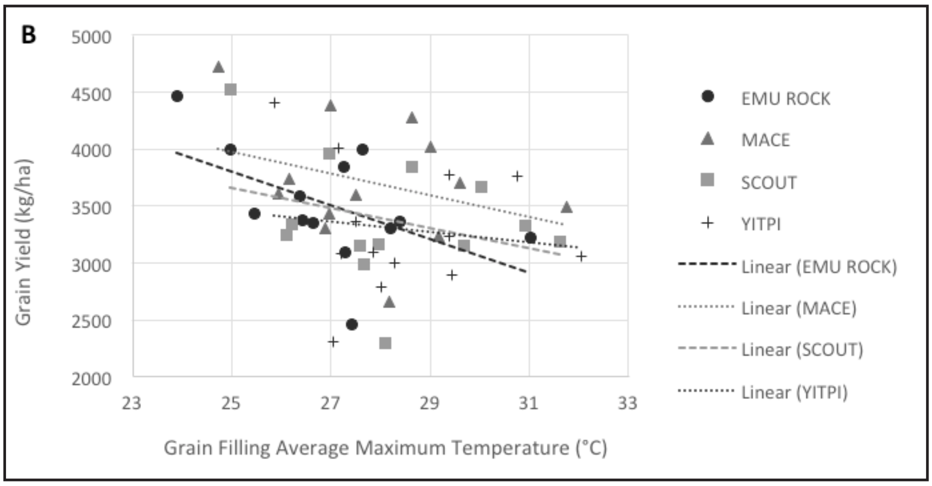


Figure 1 Variety responses to increasing average maximum temperatures during (A) flowering and (B) grain filling for selected varieties.

Experience from this study and similar previous studies have shown that sensitivity to heat stress is greater during flowering with pollen viability reduced under heat stress conditions, subsequently reducing grain number (Dolferus *et al.*, 2011; Wahid *et al*., 2007). However, the impacts during grain filling can be of equal if not greater importance due to the increased frequency of heat stress events. At the grain filling stage, grain number is largely set with negative impacts of heat stress being seen as a reduction in grain size.

Although grain yield is a key driver of productivity and profitability, heat stress can also decrease profitability through its effects on grain quality. HLW was correlated with the number of days above 35°C during flowering, with a reduction of 2 g/hL for every day over 35°C. Surprisingly, a small reduction in grain number was also identified with days over 30°C during flowering.

Identifying how different varieties respond to heat stress is of great value to breeders, assisting in the development of new varieties that are less prone to suffering significant losses under heat stress conditions. Figure 1 shows the interactions between variety and heat stress were observed in this study where heat tolerance can be defined as a lower relative reduction in grain yield under higher temperatures or greater heat stress. Mace showed relatively stable performance in response to increasing heat stress during both flowering and grain fill while Yitpi showed a greater decline in performance in response to heat stress during flowering but was relatively tolerant during grain filling.

What does this mean?

Heat stress is a key limiting factor to grain yield in the Australian environment. Our understanding of how heat stress conditions impact on grain yield is improving, but we still have a lot to learn about the underlying genetics of heat stress tolerance. Such knowledge will aid in the development of genetic tools to aid breeders in developing varieties that are better adapted to the heat stress conditions in our environment, and remains a key research area.

Within the context of current SA wheat varieties, cultivars should still be selected based on performance in NVT and local varieties trials, selecting varieties that demonstrate high yield and good adaptation to the local environment. In addition, matching sowing date to variety flowering date to ensure that crop flowering and maturation occur at the least risk period remains the most effective means of combating heat stress.

Acknowledgements

The authors would like to gratefully acknowledge the South Australian Grains Industry Trust (SAGIT) for funding assistance for this research (Project No. AGT 031). Additional thanks to Cassandra Bell and the rest of the AGT Roseworthy team, for technical assistance in data collection and trial management.

References

Dolferus, R., X. Ji, and R.A. Richards. 2011. *Abiotic stress and control of grain number in cereals.* Plant Science 181:331-341.

Wahid, A., S. Gelani, M. Ashraf, and M.R. Foolad. 2007. *Heat tolerance in plants: An overview.* Environmental and Experimental Botany 61:199-223.

Mechanisms that lead to yield loss after grazing across agro-ecological regions

Jessica Crettenden
SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

Location:
Minnipa Agricultural Centre, paddock South 7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 2.96 t/ha (W)
Actual: 1.72 t/ha (W)
Paddock History
2014: Wheat
2013: Wheat
2012: Medic pasture
Soil Type
Red sandy loam
Soil Test
Organic C%: 0.6
Phosphorous: 2-22 mg/kg
Plot Size
20 m x 24 m x 3 reps
Yield Limiting Factors
Nil
Livestock
Simulated grazing

Key messages

- **The trials across agro-ecological zones have highlighted differences between varieties in their ability to respond to a range of production drivers over varied environments and seasons.**
- **There was no varietal difference between Mace and Trojan at Minnipa with both yielding an average of 1.7 t/ha, and the ungrazed treatment yielded 0.2 t/ha higher than the grazed. There was no difference in grazing response between cultivars.**
- **Nitrogen (N) can provide assistance in plant recovery through higher yields and grain quality with in-season application of N after grazing.**

Why do the trial?

Wheat varieties respond differently to stresses due to genetic and phenological variances. This can impact their production, including plant recovery after grazing. Grazing cereals to growth stage 30, then removing livestock and taking the crop through to yield, is a common practice in low rainfall mixed farming systems. However, with shorter and variable growing seasons the practice carries risk, and can impact negatively on the quantity and/or quality of grain produced from the crop.

An aspect of the Grain and Graze system that is yet to be explored is how different cultivars recover from a stress, such as grazing. Nitrogen (N) is a common yield limiting factor that can assist in the recovery of a crop after grazing, however the optimal N rate required for recovery and efficiency in this system requires further research.

In 2015 a trial was undertaken at the Minnipa Agricultural Centre to determine the ability and drivers of grain yield recovery of two different wheat varieties after grazing. The study also investigated whether N has the ability to assist in grazing recovery of yield and/or quality compensation.

Similar trials were conducted for the GRDC funded Grain and Graze 3 project in 2015 across other agro-ecological regions including Mid-North of South Australia, Wimmera Mallee region of Victoria and Southern Victoria to determine regional and seasonal differences.

How was it done?

The trial site was burnt on 15 April to remove stubble residue. Soil was sampled for pre-sowing soil water content and chemical analysis on 4 May. Sowing occurred on 8 May with a pre-emergent herbicide mix of 1.5 L/ha Roundup + 45 ml/ha Hammer + 1.5 L/ha Triflur X + 800 g/100 L SOA + 500 ml/100 L LI700 sprayed prior to sowing Trojan and Mace @ 50 kg/ha with 57 kg/ha DAP. Drier conditions at the time of sowing caused some unevenness in seeding depth; therefore the site was prickle-chained on 9 May. Plant counts were recorded on 30 June. Biomass cuts were taken prior to simulated grazing (mowing), which occurred on half of all plots on 24 July when plants were approaching GS30. To control grass weeds, 500 ml/ha 2-4-D Ester 680 was applied to wheat on 6 August.

Nitrogen treatments were imposed on the trial on the 10 August in the form of urea broadcast at rates of nil (control), 10, 25, 50 and 75 kg N/ha (equaling urea rates of nil, 22, 54, 109 and 163 kg/ha respectively) on the grazed and ungrazed sections of each plot, which was washed in by 26 mm of rainfall two days later. Yields and grain quality were recorded at harvest, which occurred on 11 November. Sampling for soil water content occurred on 21 December.

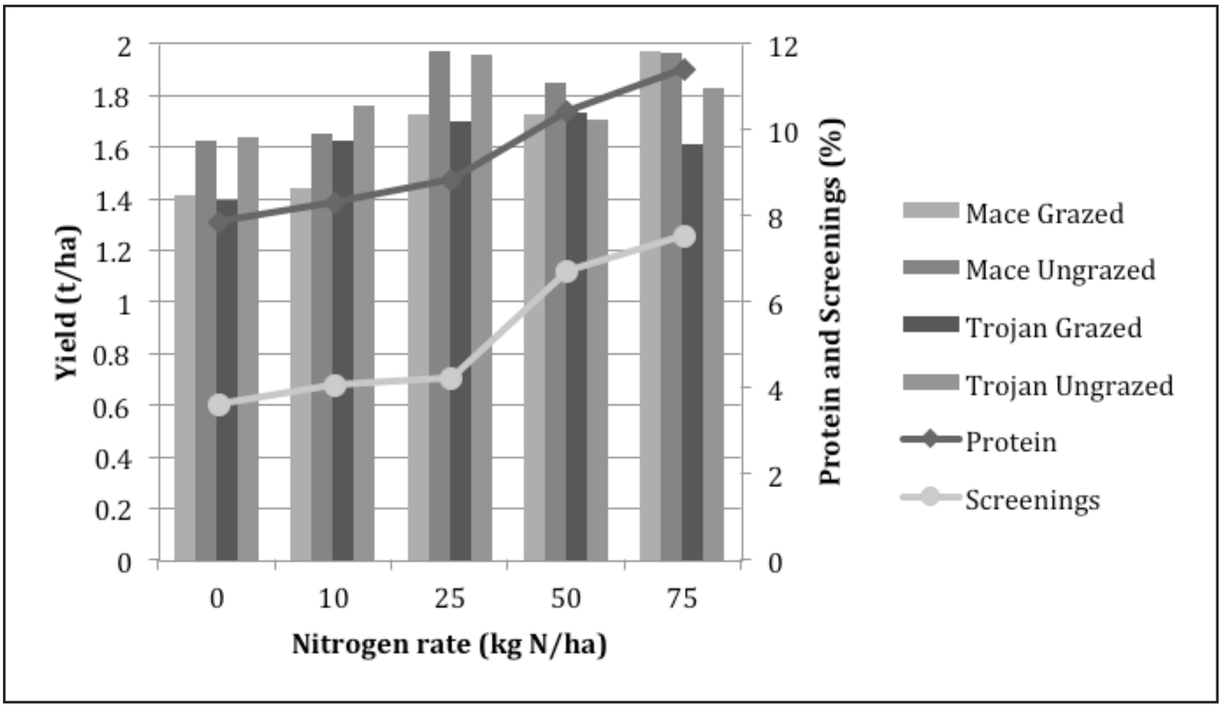


Figure 1 The response to N of grazed versus ungrazed Mace and Trojan in 2015, showing grain quality parameters of protein and screenings percentages.

What happened?

Eyre Peninsula, South Australia trial

Slow and staggered germination was observed due to prickle chaining, however there was no difference recorded in plant numbers after emergence.

At the time of simulated grazing there was on average 1.19 and 1.36 t/ha of biomass in the Trojan and Mace treatments respectively available for grazing. The biomass across the site ranged from 0.91 to 2.19 t/ha, with no varietal difference, and a useful quantity for a grazing opportunity.

Figure 1 presents the cultivar response to N of grazed versus ungrazed Mace and Trojan wheat. Similar to biomass results, there was no varietal difference with both Mace and Trojan yielding an average of 1.7 t/ha. Across varieties the ungrazed treatment yielded 0.2 t/ha higher than the grazed (P=0.003, LSD=0.105), with no difference in grazing treatment between cultivars. The N treatments of 25, 50 and 75 kg N/ha out-yielded the nil and 10 kg N/ha treatments by 0.2 t/ha on average (P=<0.001, LSD=0.166) with higher N application resulting in higher yields and better recovery from grazing as a trend, with the exception of grazed Trojan.

Results from grain quality testing measured no difference in protein percentage in wheat variety or grazing treatment. Figure 1 shows that there was a strong trend for higher protein as a result of higher N rate with averages of 7.8, 8.3, 8.9, 10.4 and 11.4% protein in the nil, 10, 25, 50 and 75 kg N/ha treatments respectively (P=<0.001, LSD=0.714).

Other quality parameters tested showed poorer results from higher N application with trends of lower grain weight, lower test weight and higher screenings regardless of cultivar or grazing treatment. Mace had a higher 1000 grain weight than Trojan in both grazed and ungrazed treatments (P=<0.001) however it had a lower test weight measuring 74.7 and 76.1 kg/hL in Mace and Trojan respectively (P=0.003). Test weight was lower in the higher N treatments (P=<0.001). Screenings were 1.1% higher in Trojan versus Mace (P=0.01) and the grazed treatments measured 0.9% higher screenings than ungrazed (P=0.03), with higher screenings in the higher N rate treatments (P=<0.001).

Mid-north of South Australia trial

The 2015 east SA trial looked at two varieties (Mace and Trojan), two times of sowing (11 and 24 April), seven N treatments (0 to 150 kg/ha N in 25 kg/ha N increments), grazed and ungrazed treatments and also imposed an irrigation treatment of 37.5 mm on 18 September just prior to anthesis. Yields were very high, as expected, as a result of good autumn/winter rains and some carry-over water from 2014.

Key outcomes:

- Grazed Mace out-yielded ungrazed Mace until very high N rates were applied, however the main driver of this response was likely frost of the ungrazed treatment.
- Grazing reduced the yield of Trojan, except at low N rates. High N rates induced haying off of the grazed treatments, but not for ungrazed Trojan.
- There was a yield loss associated with grazing Trojan but not Mace (until very high N rates) in the second time of sowing, however there is inconsistency in the response to N.
- Grazing changed the water use efficiency of applied irrigation (higher irrigation lowered WUE) and there were varietal differences in this response that warrants further investigation.

Wimmera Mallee Region of Victoria trial

The Birchip Cropping Group undertook a similar trial to investigate two varieties (Mace and Trojan), with five N treatments (0, 10, 25, 50 and 75 kg N/ha), and grazed and ungrazed treatments. A second trial imposed three irrigation treatments of 0, 25 or 50 mm/ha on 29 September. Urea was applied at 90 kg/ha on the irrigation trial only at GS25 on 27 July. The amount of biomass available for grazing was low due to the drier season and similar between varieties.

Key outcomes:

- Across grazing treatments Mace (1.03 t/ha) out-yielded Trojan (0.82 t/ha), a result reflective of the variety maturity and the season. Across varieties, grazed treatments yielded only marginally lower (0.90 t/ha) than ungrazed crops (0.95 t/ha).
- There was no significant grain yield effect of increasing rates of post-grazing N, nor were there any interactions between variety, grazing effect and N response.
- In the irrigation trial, Mace (1.30 t/ha) out-yielded longer season variety Trojan (1.07 t/ha). Grazing (average yield 1.1 t/ha) had no significant effect on grain yield compared with ungrazed (1.2 t/ha).
- The finishing rainfall applied at late flowering/early grain fill had a considerable effect on final grain yields, with grazed crops in particular responding to increasing rainfall.

Southern Victoria trial

Southern Farming Systems investigated the two wheat varieties Bolac (high yielding, mid-maturity) and Revenue (high yielding, late maturity, dual purpose), grazed and ungrazed treatments and a 50 mm irrigation treatment (on top of 210 GSR).

Key outcomes:

- There was a significant response between varieties with the irrigation treatment, but not between the unirrigated varieties with Revenue (4.59 t/ha) out-yielding Bolac (4.04 t/ha) in the modified soil water treatments. The irrigated treatments also out-yielded the unmodified soil water with a 1.18 and 0.48 t/ha yield difference in Revenue and Bolac respectively.
- There was no response to grazing treatments with variety or irrigation interactions and no significant difference between grazed and ungrazed treatments.

What does this mean?

Many farmers are unwilling to graze their grain crops due to the potential risks of grain quantity or quality reduction; however the value of feed to the livestock at this crucial period in the season is often left out in the cost-benefit ratio in the mixed farming systems equation. Previous Grain and Graze research has shown that crops have the ability to recover after grazing if grazed early, enough biomass is retained, and there is sufficient soil water and/or rainfall post-livestock removal. This trial shows that nitrogen can provide assistance in plant recovery through higher yields and quality with in-season application of N after grazing, which is a step towards making the practice more attractive to farmers in low rainfall mixed farming systems. Unfortunately, as there often is, there can be a trade-off between grain yield and quality, and the amount of N application required for optimum profitability. Yield results show that it is beneficial to apply at least 25 kg/ha of N in the 2015 season for the best yield of crops left ungrazed. However, to recuperate yields in the grazed crops more N may be required, which could pose a risk to decreasing grain quality, hence delivery grade, depending on the finish of the season.

These trials have highlighted differences between varieties in their ability to respond to a range of production drivers, including grazing, N application and irrigation over varied environments and seasons. Similar trials will be repeated in 2016 to broaden this database in order to gain a greater understanding of these interactions within the mixed farming system.

Acknowledgements

I gratefully acknowledge the technical assistance, support and site management of Leigh Davis and Brenton Spriggs. Thanks to John Kelsh for assistance with site management also. Thanks to Alison Frischke (Birchip Cropping Group), Mick Faulkner (Agrilink Agricultural Consultants Pty Ltd) and Zoe Creelman (Southern Farming Systems) for their guidance and support through trial development and analysis. The Eyre Peninsula Grain and Graze 3 project is funded by GRDC (SFS00028).

Economics of phosphorus applications to wheat and barley varieties at three contrasting field sites

Sean Mason and Glenn McDonald
School of Agriculture, Food and Wine University of Adelaide

Key messages

- **In deficient scenarios phosphorus (P) applications are economically viable at current grain and fertiliser prices.**
- **Highest net returns are achieved with the most suitable variety choice for a particular region in addition to adequate P applications.**
- **Soil types with higher phosphorus buffering index (PBI) values require greater P inputs to maximise yields.**

Why do the trial?

The aim of this project is to quantify the economic benefit to farmers of:

- Applying relatively high application rates of phosphorus on moderate PBI soils across a range of sites with different yield potentials, and
- Growing three or four common wheat and barley varieties that performed well in recent South Australian National Variety Trials to assess their phosphorus use efficiency (PUE).

Phosphorus deficiency still occurs in several regions across SA, with major yield limitations occurring due to inadequate applications of P. In recent years it has been common to measure low soil P test values on soils with moderate to high PBI (PBI> 100) implying that replacement P programs may not be sufficiently maintaining soil P levels for optimal production. In some cases application rates greater than 40 kg P/ha might be required to maximise yields, a fertiliser rate that might not be the most economical in low yielding environments. Identifying optimal P rates for both yield and profit will add vital information to the grains industry.

Wheat and barley varieties may vary in their responsiveness to P either by having root traits that increase access to soil P or by more efficient use of the P that is taken up. In combination with different yield potentials external P requirements and PUE could vary. Identifying varieties that have greater PUE in deficient soil is of great interest to many farmers in SA due to the relatively low soil P levels driven by moderate to high PBI soils in several regions.

This work follows on from similar work which has been outlined in previous articles, EPFS Summary 2014, p 158, EPFS Summary 2013, p 129.

How was it done?

Three replicated field trials using wheat and barley were established at Cummins (lower EP), Pinery (lower Mid North) and Sherwood (upper South East) in SA. Soil P characteristics for the three sites are presented in table 1. Varying PBI and the associated chemistry controlling the P supply to crops along with expected yield potentials meant these three sites provided an excellent opportunity to compare economics of P applications and varietal effects.

On 22 May (Cummins), 26 May (Sherwood) and 2 June 2015 (Pinery), four varieties of wheat and barley were sown at six rates of P: 0, 5, 10, 20, 30 and 50 kg P/ha as MAP while N was balanced with applications of urea to apply 22 kg N/ha to all plots. Each treatment was replicated four times. The varieties sown (wheat – Cobra, Corack, Mace, Trojan; barley – Commander, Compass, Fathom, LaTrobe) were selected from a range of current commercial varieties that have performed best in previous (2-3 years) National Variety Trials (NVT) to build on agronomic significance. Early crop growth was assessed by estimating biomass two-three times during the growing season per site using NDVI values obtained with a Greenseeker™ and calibrating the readings with biomass cuts at each site (data not shown).

The harvested grain was measured from each plot and the PUE for each variety was defined as the yield at 0 P relative to the maximum yield obtained with P application. The P requirement was assessed by fitting a curve through the yield response data and the yield optimising P rate was estimated as the rate that gave 90% of the yield response. The economics of returns from obtained yield vs cost of applied P was calculated based on prices of $260/t for APW wheat and $260/t for Malt barley, and a fertilizer price of $700/t (MAP) (PIRSA Gross margin guide 2016).

Table 1 PBI, Colwell P and DGT P measurements at the three 2015 PUE field sites. Minimum and maximum values for the Cummins site are displayed to show a high level of variability across the reps caused by a soil type transition from gravel loam (low PBI) to ironstone clay (high PBI).

Crop		PBI	Colwell P (mg/kg)	DGT P (µg/L)
Cummins - PBI driven by iron				
Barley	mean	59	25	71
Wheat	mean	43	26	81
Barley	minimum	21	20	21
	maximum	135	35	144
Wheat	minimum	17	20	23
	maximum	112	49	134
Pinery – PBI driven by Calcium Carbonate				
Barley	mean	135	28	17
Wheat	mean	135	31	14
Sherwood - low PBI				
Barley	mean	41	17	25
Wheat	mean	39	11	16

What happened?

Significant ($p < 0.05$) early responses were obtained at all three sites for both wheat and barley as assessed by NDVI (data not shown). These significant responses ($p < 0.001$) translated to grain at all three sites for both wheat and barley. Overall yields varied considerably between the three sites providing an opportunity to assess economic P rates under different yield potentials and response characteristics. Maximum yields at Cummins reached 6.23 and 6.57 t/ha for wheat and barley respectively, 3.29 and 3.69 t/ha for wheat and barley respectively at Pinery and a dry spring reduced yields at Sherwood with wheat at 0.84 t/ha and barley at 1.27 t/ha. There were also significant differences ($p < 0.05$) between grain yields of different varieties at all sites for both wheat and barley with the exception of wheat at the Cummins site. Top performing varieties for wheat were Corack at Pinery and Mace at Sherwood. Compass barley consistently performed well at all three sites and was only matched by LaTrobe at the Pinery site. No significant ($p > 0.05$) variety by P treatment effect was seen at any site for both wheat and barley, meaning that the optimal P rate did not require modification according to cultivar, consistent with the results of similar trials in previous years. As a result calculated PUE % for each variety was very similar, particularly for the Cummins and Pinery sites.

Phosphorus rates at which maximum yields were obtained were highest at the Pinery site reflected by low P fertility (Figure 1) and lower efficiency of applied P fertiliser due to higher P fixation driven by Calcium Carbonate levels of approximately 10%. Trojan, a longer season variety struggled at Pinery due to the relatively late sowing date and the harsh finish generated by a warm/dry spring experienced at the site in 2015. Overall P rates required to maximise yields for Cummins were 17 and 23 kg/ha for wheat and barley respectively which supports previous trials that showed barley requires higher P rates and has lower PUE compared to wheat. Moderate P rates were still required at Sherwood even with the the poor growing rainfall which caused well below average yields.

Calculation of P rates for profit which relates to the P rate at which the greatest gross margin (GM) (GM = profit from grain – cost of fertiliser, Figure 1) is obtained allows for a comparison with GM at P rates required to maximise yield alone (Table 2, Figure 2). For the Cummins site where high yields were observed P rates for yield closely matched P rates for profit and therefore in this situation it was important to overcome P deficiency with sufficient P rates. In comparison at Sherwood P rates for profit were comparatively lower than P rates for yield which were driven by the poor rainfall and yields obtained at this site and therefore the full benefit of P applications in terms of increasing yield was reduced. At Pinery large differences between P rates for yield from P rates for profit with most varieties was driven by higher PBI decreasing the efficiency of P applications. The yield increment per unit of P applied was not sufficient towards the higher end of the response curve to outweigh the cost of the extra fertiliser applied. For these soil types there is a decreased importance of maximising yield through P application but determining profit maximising input levels is important. In terms of P management economic P rates were still significantly higher than typical replacement rates (9-12 kg P/ha) based on 2015 yields.

Table 2 Grain yield results for wheat and barley varieties for the three sites presented as yield at 0P application and maximum yield determined by plotting yields against P rate applied. *PUE %, gross margins (GM) at 0 applied P, P rate for yield and P rate for profit with each variety was determined using the calculations mentioned previously.*

Variety	Yield (Control) (t/ha)	Yield (Max.) (t/ha)	PUE (%)	GM @ 0P ($/ha)	GM @ Yield Max. ($/ha)	GM Maximum ($/ha)
Cummins - wheat						
Cobra	5.07	6.15	82	1396	1646	1660
Corack	5.38	6.35	85	1482	1690	1693
Mace	4.99	6.18	81	1374	1594	1594
Trojan	5.42	6.43	84	1493	1624	1628
Cummins - barley						
Commander	4.30	6.16	80	1306	1548	1547
Compass	5.50	7.09	77	1459	1743	1743
Fathom	5.05	6.38	79	1338	1597	1596
LaTrobe	5.39	6.71	80	1431	1698	1695
Pinery - wheat						
Cobra	2.19	2.99	73	558	624	645
Corack	2.66	3.58	74	720	739	752
Mace	2.45	3.35	73	661	706	720
Trojan	2.50	2.81	89	674	618	674
Pinery - barley						
Commander	2.40	3.20	75	623	753	754
Compass	2.82	3.88	73	738	837	852
Fathom	2.78	3.68	76	727	807	826
LaTrobe	2.94	3.95	74	768	883	886
Sherwood - wheat						
Cobra	0.23	0.74	32	-16	67	67
Corack	0.16	0.87	18	20	155	155
Mace	0.35	1.19	30	74	172	182
Trojan	0.03	0.59	5	41	114	126
Sherwood - barley						
Commander	0.32	1.05	31	63	176	177
Compass	0.59	1.66	36	135	237	251
Fathom	0.76	1.41	54	181	310	310
LaTrobe	0.64	1.23	52	149	232	234

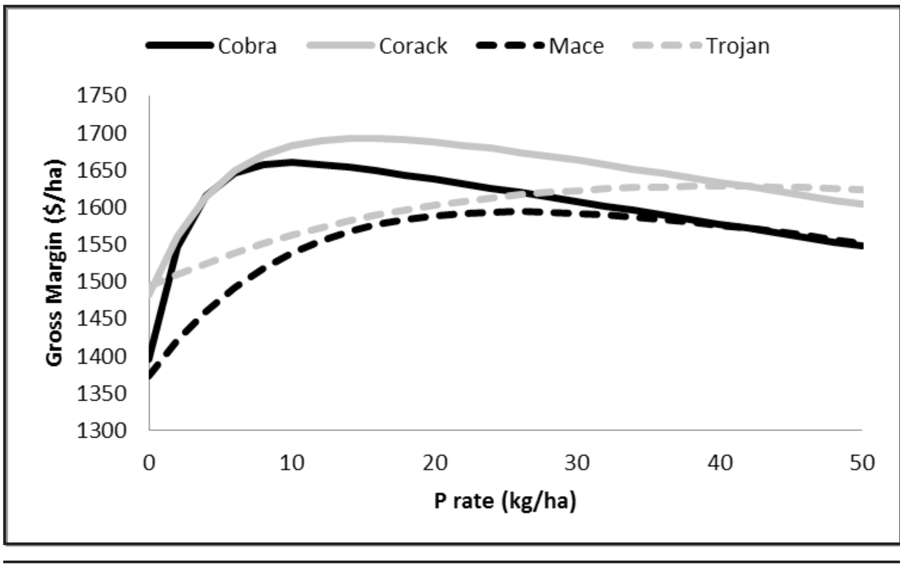


Figure 1 Gross margin curves with P application rates for the Cummins (wheat) site determined by subtracting the cost of the fertiliser applied from the returns from grain yields obtained.

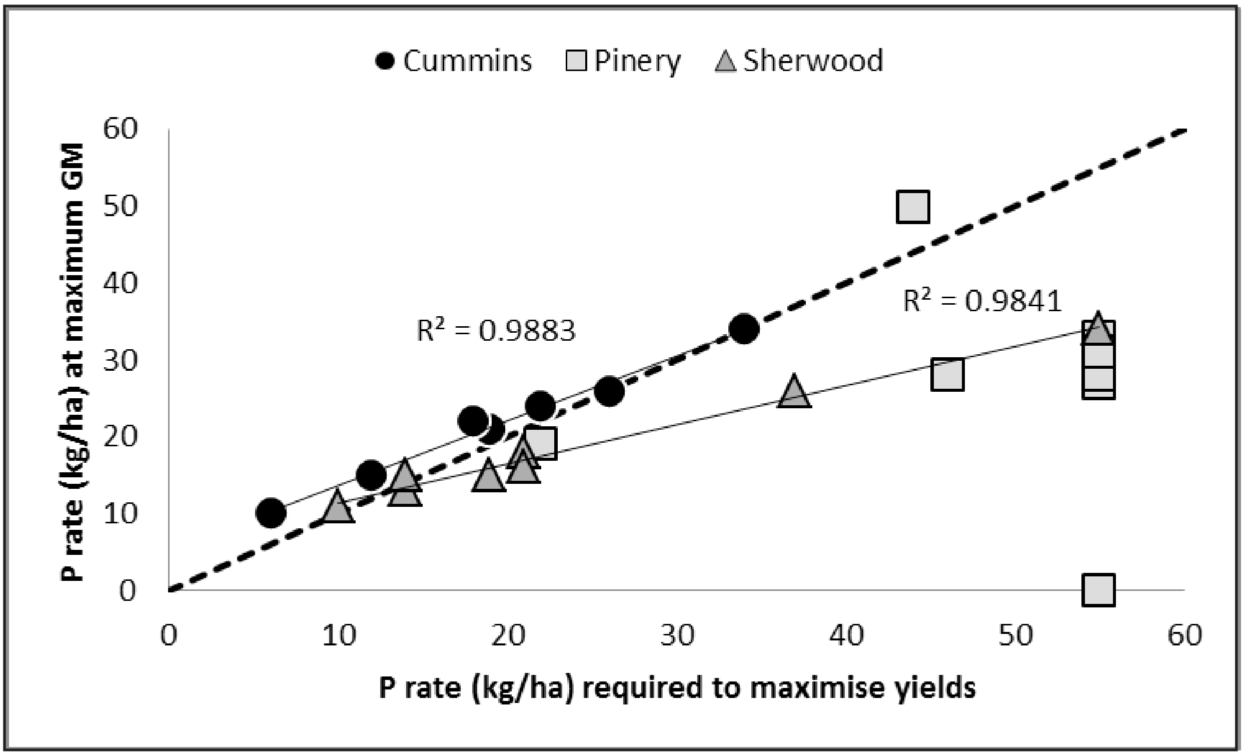


Figure 2 Comparison of calculated P rates required for yield with P rates for profit combining wheat and barley varieties for each of the three sites. P rates required to maximise yield for the majority of wheat and barley varieties at Pinery were > 10% of the highest P rate used (50 kg/ha).

What does this mean?

- Benefits in yield through choosing the most appropriate variety for a particular region outweighs any potential savings through choosing a variety based on higher PUE.
- Overcoming P deficiency on prone soil types (moderate – high PBI) with high P rates will not be the most economical management option but defining economic P rates is important as they are still considerably higher than typical replacement rates.
- We continue to endorse the use of farmer strip type trials where P rates are adjusted accordingly. We further advocate using P rich strips which consist of a P rate at least double typical replacement rates to determine if high P rates are economical for your specific soil type.

Acknowledgements

We would like to acknowledge the efforts of the field teams in particular Willie Shoobridge and Rob Wheeler (SARDI), Patrick Head and Richard May (Landmark, Cummins). The experiments were performed with financial support from SAGIT (Project code UA1115).

SA Wheat variety yield performance *2015 and long term (2011-2015) expressed as t/ha and % of site average yield*

Variety	Upper Eyre Peninsula										Mid and Lower Eyre Peninsula						
	2015 (as % site average)							Long term av. across sites (11-15)			2015 (as % site average)				Long term av across sites (11-15)		
	Kimba	Minnipa	Mitchellville	Nunjikompita	Penong	Poochera	Warramboo	t/ha	as % site av.	# Trials	Cummins	Rudall	Ungarra	Wanilla	t/ha	% site av.	# Trials
AGT Katana	100	95	111	95	98	96	99	2.08	102	33	101	107	106	107	3.94	102	17
Axe	92	94	110	70	72	100	95	1.97	96	33	99	91	98	88	3.67	95	17
Beckom	100	106	103	108	100	101	102	2.20	108	20	104	95	108	112	4.18	108	11
Cobra	104	98	107	83	101	91	109	2.09	102	33	103	108	99	101	4.10	106	17
Corack	116	102	115	88	93	101	110	2.24	110	33	111	114	119	119	4.28	111	17
Cosmick	95	103	108	102	105	92	107	2.17	106	20	106	104	102	100	4.18	108	11
Cutlass	88	91	81	110	104	92	90	-	-	-	110	90	105	106	-	-	-
DS Darwin	-	-	-	-	-	-	-	-	-	-	96	90	97	98	3.83	99	10
Emu Rock	99	93	112	87	95	99	111	2.10	103	33	103	109	111	107	3.93	102	17
Estoc	90	96	84	118	108	92	96	2.04	100	33	100	93	92	100	3.79	98	17
Gladius	92	90	101	97	90	93	96	2.01	99	33	90	90	90	90	3.76	97	17
Grenade CL Plus	91	94	97	89	91	98	98	2.00	98	33	98	98	95	91	3.68	95	17
Harper	-	-	-	-	-	-	-	-	-	-	91	92	86	91	3.72	96	10
Hatchet CL Plus	91	87	115	92	82	111	91	1.94	95	27	98	89	86	83	3.55	92	14
Kord CL Plus	90	98	104	100	91	105	96	2.02	99	26	84	84	87	77	3.73	96	14
Mace	112	112	108	100	100	112	100	2.22	109	33	105	116	114	105	4.18	108	17
Scepter	119	109	119	108	109	101	101	-	-	-	108	115	112	112	-	-	-
Scout	90	96	91	94	92	71	94	2.06	101	33	104	82	102	102	3.97	103	17
Shield	94	95	91	95	95	104	98	2.06	101	33	101	90	88	91	3.81	99	17
Tenfour	114	108	125	94	102	102	112	2.25	111	14	-	-	-	-	-	-	-
Trojan	98	98	93	115	111	93	103	2.16	106	33	108	93	103	94	4.15	108	17
Wyalkatchem	106	102	99	110	110	93	98	2.12	104	33	103	106	103	107	4.04	104	17
Yitpi	86	92	77	115	102	83	92	1.93	94	26	85	74	86	91	3.56	92	13
Site av. yield (t/ha)	***1.93***	***2.96***	***1.50***	***0.75***	***1.29***	***0.98***	***2.76***	***2.03***			**3.83**	**3.16**	**4.33**	**3.28**	**3.84**		
LSD % (P=0.05)	*7*	*7*	*6*	*10*	*7*	*12*	*6*				*8*	*5*	*8*	*10*			
Date sown	14 May	12 May	6 May	7 May	7 May	18 June	13 May				13 May	12 May	15 May	15 May			
Soil type	SL	L	SL	SL	SL	SL	SL				L	SL	SL	SL			
Rainfall (mm) J-M/A-O	49/225	14/258	32/216	0/184	15/170	14/228	38/252				26/299	25/229	20/268	26/299			
pH (water)	8.4	8.8	8.8	8.6	9.3	8.2	8.2				8.2	8.3	6.6	8.2			
Previous crop	Pasture	Pasture	Pasture	Pasture	Pasture	Wheat	Vetch				Canola	Pasture	Canola	Canola			
Site stresses	dl	dl, rh	fr,dl,rh	dl,mice	dl, mice	dl, rh	fr, dl				fr,dl	fr,dl		fr,dl			

Soil type: S=sand, L=loam
Site stress factors: dl=dry post anthesis, fr=frost, rh=rhizoctonia
Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2011-2015)
Data analysis by GRDC funded National Statistics Group

2015 SA Wheat variety performance for grain protein (% at 11% moisture) across NVT sites

Variety	Lower Eyre Peninsula					Upper Eyre Peninsula							
	Cummins	Rudall	Ungarra	Wanilla	*Av.*	Kimba	Minnipa	Mitchellville	Nunjikompita	Penong	Poochera	Warramboo	*Av.*
DS Darwin	11.5	11.9	11.2	12.8	*11.9*	-	-	-	-	-	-	-	-
AGT Katana	12.9	11.7	11.8	14.0	*12.6*	14.9	14.6	10.1	14.0	13.8	12.8	8.8	*12.7*
Axe	12.6	12.2	12.4	14.3	*12.9*	15.0	13.4	10.2	14.3	13.5	13.1	9.3	*12.7*
Beckom	11.7	11.7	11.5	12.2	*11.8*	13.7	13.0	9.7	12.5	11.8	12.4	8.4	*11.6*
Cobra	12.0	11.7	12.0	13.7	*12.4*	14.2	13.3	9.7	13.3	13.0	12.5	8.2	*12.0*
Corack	10.6	10.9	10.9	12.5	*11.3*	13.8	12.2	9.4	12.5	12.8	11.9	8.3	*11.6*
Correll	13.3	12.9	13.2	13.9	*13.3*	16.6	13.4	9.5	12.8	12.7	12.9	8.5	*12.3*
Cosmick	12.6	11.4	11.7	13.1	*12.2*	13.9	12.2	8.9	12.8	11.9	12.0	7.7	*11.4*
Cutlass	11.8	11.7	11.0	13.1	*11.9*	14.9	14.1	10.9	12.5	13.0	12.4	8.8	*12.4*
Emu Rock	12.7	11.5	11.8	14.2	*12.6*	14.9	13.8	9.9	13.4	13.3	12.4	8.7	*12.3*
Espada	12.7	12.1	12.2	13.9	*12.7*	15.5	14.1	10.1	14.3	13.8	13.1	8.5	*12.8*
Estoc	12.7	12.5	12.5	13.7	*12.9*	15.8	14.6	10.8	13.6	13.6	13.3	8.6	*12.9*
Gladius	12.7	13.2	12.7	14.3	*13.2*	15.0	15.1	10.2	14.0	13.9	13.5	8.6	*12.9*
Grenade CL Plus	12.3	11.8	12.4	13.8	*12.6*	15.0	13.3	9.1	13.1	12.8	12.1	8.5	*12.0*
Harper	13.2	12.7	12.6	13.9	*13.1*	-	-	-	-	-	-	-	-
Hatchet CL Plus	13.3	13.2	13.7	15.2	*13.8*	15.8	13.9	9.8	14.1	13.4	13.1	9.6	*12.8*
Justica CL Plus	12.9	13.5	12.9	14.6	*13.5*	15.3	13.9	10.4	13.7	13.8	13.4	9.2	*12.8*
Kord CL Plus	13.1	13.2	12.5	14.3	*13.3*	15.5	13.6	9.3	13.7	13.4	13.2	8.9	*12.5*
Mace	11.7	11.4	10.9	13.4	*11.9*	14.0	11.9	9.3	12.5	12.5	11.7	8.6	*11.5*
Phantom	12.3	12.8	12.1	13.8	*12.7*	15.6	13.2	10.8	13.0	12.7	13.4	8.7	*12.5*
Scepter	11.5	10.8	11.0	12.9	*11.5*	13.6	12.7	8.4	12.4	12.0	11.4	8.0	*11.2*
Scout	11.8	12.0	11.7	13.1	*12.1*	15.0	13.3	9.4	12.2	11.5	12.5	8.3	*11.7*
Shield	12.1	12.2	12.3	13.9	*12.6*	15.8	13.5	10.3	12.9	12.6	12.7	8.7	*12.4*
Tenfour	-	-	-	-	-	14.1	12.3	8.5	13.4	12.4	11.6	8.1	*11.5*
Trojan	11.9	11.6	11.8	13.0	*12.1*	15.2	14.5	10.0	12.5	12.5	12.0	8.1	*12.1*
Wyalkatchem	12.2	11.7	11.7	13.5	*12.3*	14.2	12.5	10.0	12.7	12.5	12.4	9.2	*11.9*
Yitpi	13.4	13.2	12.8	13.8	*13.3*	15.5	13.9	10.9	12.8	13.5	12.8	8.8	*12.6*

2015 SA Wheat variety performance for test weight (kg/hL) across NVT sites

Variety	Lower Eyre Peninsula					Upper Eyre Peninsula							
	Cummins	Rudall	Ungarra	Wanilla	*Av.*	Kimba	Minnipa	Mitchellville	Nunjikompita	Penong	Poochera	Warramboo	*Av.*
DS Darwin	82.7	77.5	81.9	80.2	*80.6*	-	-	-	-	-	-	-	-
AGT Katana	82.6	79.5	82.4	80.1	*81.1*	75.2	75.3	79.0	79.6	80.0	81.3	81.2	*78.8*
Axe	81.5	77.1	79.7	76.3	*78.7*	69.5	76.2	77.8	75.9	76.3	81.1	79.3	*76.6*
Beckom	80.2	75.7	79.7	78.6	*78.6*	71.1	73.5	78.6	78.4	79.6	80.5	79.1	*77.3*
Cobra	78.6	73.9	77.6	74.0	*76.0*	71.2	71.4	76.4	75.5	78.0	78.0	78.6	*75.6*
Corack	82.0	79.7	80.5	77.3	*79.9*	72.6	75.0	77.4	78.7	79.2	80.2	79.6	*77.5*
Correll	78.8	72.1	78.3	74.6	*75.9*	68.3	71.7	76.5	75.9	76.7	78.6	77.7	*75.0*
Cosmick	80.3	77.3	80.8	76.8	*78.8*	69.4	75.3	79.4	78.2	77.8	79.2	79.2	*76.9*
Cutlass	82.2	77.8	82.9	78.5	*80.4*	76.6	75.0	80.7	78.9	76.4	80.3	78.4	*78.0*
Emu Rock	80.6	79.3	81.5	74.8	*79.1*	74.3	75.2	77.3	76.3	76.8	79.6	81.3	*77.2*
Espada	79.4	74.0	78.4	74.1	*76.5*	71.8	72.0	76.7	74.2	76.3	78.6	76.2	*75.1*
Estoc	83.0	79.1	82.9	81.1	*81.5*	76.2	76.6	82.2	78.9	79.3	82.3	82.6	*79.7*
Gladius	80.3	75.1	79.5	76.4	*77.8*	73.8	73.0	77.3	76.4	77.2	79.1	78.3	*76.5*
Grenade CL Plus	81.3	78.5	80.5	77.3	*79.4*	72.5	76.1	79.8	78.6	79.4	79.9	79.3	*78.0*
Harper	81.0	77.2	81.7	78.7	*79.7*	-	-	-	-	-	-	-	-
Hatchet CL Plus	80.6	78.3	79.6	78.9	*79.3*	71.1	75.0	78.9	76.0	77.7	79.1	79.3	*76.7*
Justica CL Plus	78.6	72.8	78.7	72.7	*75.7*	73.3	72.8	77.6	75.1	76.4	77.4	76.4	*75.6*
Kord CL Plus	79.4	74.0	79.6	75.1	*77.0*	71.9	74.2	79.2	77.7	77.6	79.6	78.7	*77.0*
Mace	81.3	78.9	80.9	76.6	*79.4*	73.3	77.8	80.5	79.2	79.9	81.2	79.0	*78.7*
Phantom	81.0	73.5	79.8	75.7	*77.5*	73.5	73.2	77.5	76.1	76.0	79.9	77.0	*76.2*
Scepter	82.0	79.0	80.3	74.2	*78.9*	72.1	75.3	79.7	78.3	79.6	82.1	78.8	*78.0*
Scout	83.2	79.3	83.4	79.6	*81.4*	74.7	78.8	80.6	80.3	81.8	81.7	82.2	*80.0*
Shield	79.8	73.0	76.2	73.1	*75.5*	66.6	71.8	76.9	78.1	79.0	78.2	76.9	*75.4*
Tenfour	-	-	-	-	-	71.0	73.7	75.5	74.9	76.9	79.2	76.8	*75.4*
Trojan	83.6	77.7	83.3	78.9	*80.9*	75.5	72.9	80.9	75.8	78.7	83.1	79.6	*78.1*
Wyalkatchem	79.9	77.4	80.6	75.7	*78.4*	72.9	73.9	77.6	76.9	78.4	79.9	78.9	*76.9*
Yitpi	79.8	77.8	82.4	79.2	*79.8*	76.7	76.8	80.8	79.6	77.5	80.6	80.1	*78.9*

2015 SA Wheat variety performance for screenings (% <2 mm) across NVT sites

Variety	Lower Eyre Peninsula					Upper Eyre Peninsula							
	Cummins	Rudall	Ungarra	Wanilla	*Av.*	Kimba	Minnipa	Mitchellville	Nunjikompita	Penong	Poochera	Warramboo	*Av.*
DS Darwin	1.1	6.8	3.3	3.7	*3.7*	-	-	-	-	-	-	-	-
AGT Katana	4.6	4.7	4.4	6.0	*4.9*	16.5	8.5	4.1	5.0	3.2	5.7	0.4	*6.2*
Axe	0.9	5.2	1.8	2.8	*2.7*	8.5	2.5	0.1	2.8	1.2	3.1	0.2	*2.6*
Beckom	9.2	12.8	9.4	10.8	*10.5*	26.7	11.9	2.0	8.7	3.2	7.2	2.0	*8.8*
Cobra	2.6	8.4	4.4	6.3	*5.4*	9.6	6.9	0.8	4.3	0.1	3.9	0.2	*3.7*
Corack	0.8	6.3	1.9	2.4	*2.8*	8.6	3.7	0.5	3.5	2.4	2.9	0.7	*3.2*
Correll	3.8	12.0	6.9	5.8	*7.1*	18.5	7.7	2.1	5.3	3.9	4.6	1.3	*6.2*
Cosmick	6.4	10.5	7.3	9.9	*8.5*	21.9	9.2	1.5	5.6	2.9	5.7	1.8	*6.9*
Cutlass	2.6	9.0	2.5	6.2	*5.1*	16.2	8.5	3.3	8.0	7.5	3.8	1.0	*6.9*
Emu Rock	3.8	7.5	5.4	7.7	*6.1*	12.7	8.3	1.3	6.2	2.6	4.0	0.4	*5.0*
Espada	3.3	9.7	4.5	7.6	*6.3*	12.2	6.4	1.0	4.2	2.9	3.8	0.4	*4.4*
Estoc	6.4	11.9	7.4	10.3	*9.0*	31.1	17.0	0.7	6.9	7.8	3.9	0.5	*9.7*
Gladius	2.4	7.9	3.0	3.8	*4.3*	8.2	5.7	2.2	4.7	2.7	3.8	0.7	*4.0*
Grenade CL Plus	2.4	6.2	4.4	5.1	*4.5*	14.1	4.3	0.3	2.4	1.0	3.6	0.6	*3.8*
Harper	5.6	12.3	6.1	9.8	*8.4*	-	-	-	-	-	-	-	-
Hatchet CL Plus	1.4	6.1	1.9	3.0	*3.1*	14.1	6.5	0.4	5.6	1.4	3.7	0.2	*4.6*
Justica CL Plus	4.9	8.0	4.9	8.0	*6.5*	11.2	4.2	1.1	5.2	1.9	5.2	1.1	*4.3*
Kord CL Plus	3.2	8.3	3.8	5.4	*5.2*	11.1	3.4	0.1	5.4	1.5	5.2	0.4	*3.9*
Mace	3.0	5.2	3.7	6.7	*4.6*	13.7	4.7	0.8	3.2	1.5	5.6	0.4	*4.2*
Phantom	3.2	13.8	5.6	10.6	*8.3*	16.7	8.5	5.5	6.6	7.5	2.7	2.6	*7.2*
Scepter	2.8	10.0	3.7	5.4	*5.4*	13.0	4.6	1.4	4.2	2.0	4.9	0.1	*4.3*
Scout	1.7	8.3	4.0	5.6	*4.9*	20.7	5.1	1.2	4.7	2.5	2.9	0.6	*5.4*
Shield	3.0	10.9	7.0	8.1	*7.2*	20.2	7.2	1.0	5.0	1.4	6.4	1.2	*6.0*
Tenfour	-	-	-	-	-	10.3	4.0	0.6	5.4	0.9	3.2	0.3	*3.5*
Trojan	3.2	11.6	4.5	8.5	*7.0*	21.2	10.8	0.9	7.3	4.8	3.1	1.0	*7.0*
Wyalkatchem	1.9	5.5	2.5	4.6	*3.6*	6.1	4.0	1.6	3.3	1.4	2.6	0.3	*2.7*
Yitpi	4.8	10.5	3.8	6.5	*6.4*	12.6	6.0	0.8	5.2	5.2	2.5	0.7	*4.7*

SA Barley variety yield performance *2015 and long term (2009-2015) expressed as t/ha and % of site average yield*

Variety	MID AND LOWER EYRE PENINSULA						UPPER EYRE PENINSULA						
	2015 (% site average)			Long term average across sites (2009-15)			2015 (as % site average)				Long term average across sites (2010-2014)		
	Wanilla	Wharminda	Cummins	t/ha	as % site av.	# Trials	Darke Peak	Elliston	Minnipa	Poochera	t/ha	as % site av.	# Trials
Alestar	93	102	99	4.37	106	9	105	93	95	69	2.90	101	16
Bass	92	95	95	4.21	102	17	97	65	91	59	2.88	100	24
Buloke	94	100	91	4.07	99	20	101	98	93	102	2.89	101	28
Commander	90	99	102	4.22	102	20	93	83	93	79	3.01	105	28
Compass	117	112	123	4.66	113	11	105	91	119	120	3.41	119	16
Fathom	115	108	104	4.36	106	17	108	108	112	130	3.18	111	24
Flagship	98	100	-	3.87	94	19	92	74	91	91	2.74	96	28
Fleet	103	93	93	4.25	103	20	98	101	99	105	3.12	109	28
Flinders	98	98	87	4.12	100	17	97	67	91	51	2.80	98	24
Gairdner	85	97	77	3.83	93	18	-	-	-	-	-	-	-
Granger	104	100	101	4.36	105	20	99	94	97	64	2.95	103	28
Hindmarsh	120	104	114	4.45	108	20	102	122	104	120	3.17	111	28
Spartacus CL	117	106	118	-	-	-	100	142	113	157	-	-	-
Keel	111	106	112	4.04	98	20	104	112	111	144	2.99	104	26
LaTrobe	116	101	115	4.52	109	14	103	117	99	142	3.21	112	20
Macquarie	73	90	83	3.84	93	13	-	-	-	-	-	-	-
Maltstar	87	102	89	4.29	104	11	96	93	98	65	2.87	100	12
Maritime	-	-	-	3.89	94	17	98	109	89	121	2.80	98	28
Oxford	81	88	89	4.33	105	20	93	72	84	35	2.86	100	28
Rosalind	122	112	111	4.98	120	6	118	165	117	142	3.44	120	8
Schooner	101	85	-	3.63	88	19	95	81	92	85	2.57	90	28
Scope CL	90	104	94	4.03	98	20	99	84	87	92	2.87	100	28
SY Rattler	105	103	97	4.09	99	10	104	68	86	77	-	-	-
Westminster	74	89	88	4.01	97	15	-	-	-	-	-	-	-
Site av. yield (t/ha)	**3.50**	**4.28**	**4.28**	**4.11**			**3.68**	**1.19**	**4.07**	**1.03**	**2.85**		
LSD % (P=0.05)	*9*	*7*	*9*				*4*	*24*	*8*	*16*			
Date sown	15 May	11 May	13 May				12 May	25 May	12 May	18 Jun			
Soil type	SL	SL	L				SL	S	L	SL			
Rainfall (mm) J-M/A-O	25/328	22/284	26/299				33/281	10/265	14/258	14/228			
pH (water)	6.1	6.5	8.2				6.6	8.6	8.8	8.2			
Previous crop	Lupin	Pasture	Canola				Canola	Pasture	Pasture	Wheat			
Site stress factors	fr, dl	fr, rh, dl	fr, dl				fr, dl	dl,rh	dl	rh, dl			

Soil type: S = sand, L = loam. Site stress factors: dl=dry post anthesis, fr=frost, rh=rhizoctonia

Data source: SARDI/GRDC & NVT (long term data based on weighted analysis of sites, 2009-2015).

Data analysis by GRDC funded National Statistics Group

2015 Barley variety performance for grain protein (%) across NVT sites

Variety	Lower Eyre Peninsula			Upper Eyre Peninsula			
	Cummins	Wanilla	Wharminda	Darke Peak	Elliston	Minnipa	Poochera
Alestar	12.0	13.7	9.6	8.2	11.9	11.5	16.9
Bass	12.9	14.6	10.2	8.5	13.3	13.0	17.9
Buloke	12.3	14.9	9.6	8.5	11.6	12.4	15.4
Commander	11.5	13.9	9.8	8.7	12.1	12.3	15.6
Compass	11.2	13.5	9.2	7.6	11.1	10.8	14.6
Fathom	12.5	13.9	10.0	8.2	12.0	12.4	14.7
Flagship	-	14.7	9.9	8.3	12.4	12.6	16.5
Fleet	12.5	14.9	9.2	8.0	12.4	11.7	16.0
Flinders	13.6	14.5	9.8	8.8	14.0	13.0	17.9
Gairdner	12.8	14.1	9.9	-	-	-	-
Granger	12.5	14.7	9.5	8.5	12.1	12.4	18.3
Hindmarsh	12.1	13.5	9.9	8.3	11.7	12.5	14.6
Spartacus CL	11.9	14.5	9.4	8.3	11.5	11.7	14.1
Keel	11.7	14.1	9.6	8.0	11.4	10.8	14.8
LaTrobe	11.8	13.5	9.6	8.1	11.4	11.6	13.9
Macquarie	13.3	14.4	9.7	-	-	-	-
Maltstar	11.8	13.2	9.0	7.3	11.0	11.2	16.5
Maritime	-	-	-	8.1	12.7	13.0	17.1
Oxford	12.0	14.2	9.6	8.2	12.7	13.2	18.3
Rosalind	11.7	13.9	9.3	8.1	11.0	10.8	13.4
Schooner	-	13.9	10.1	8.2	13.2	13.0	18.4
Scope CL	12.4	14.7	9.4	7.9	12.1	12.7	15.6
SY Rattler	12.5	14.4	9.5	7.7	12.5	12.4	15.7
Westminster	13.1	14.8	10.2	-	-	-	-

2015 Barley variety performance for test weight (kg/hL) across NVT sites

Variety	Lower Eyre Peninsula			Upper Eyre Peninsula			
	Cummins	Wanilla	Wharminda	Darke Peak	Elliston	Minnipa	Poochera
Alestar	63.9	58.0	65.0	62.1	64.9	63.1	64.7
Bass	69.1	64.5	67.4	64.8	63.3	65.8	65.8
Buloke	64.8	59.9	66.0	63.7	63.2	62.3	65.3
Commander	65.8	60.1	63.2	60.8	62.4	60.3	64.6
Compass	67.3	62.0	65.2	64.9	59.7	64.4	63.1
Fathom	65.2	62.3	65.2	65.4	63.6	63.6	63.4
Flagship	-	63.1	67.2	65.9	64.0	64.8	64.8
Fleet	61.9	60.5	63.2	61.4	62.8	61.5	62.1
Flinders	66.5	60.4	65.9	64.3	63.6	63.0	65.9
Gairdner	62.9	57.2	64.6	-	-	-	-
Granger	66.6	61.6	66.3	63.2	65.6	64.3	65.9
Hindmarsh	68.9	63.6	67.7	66.6	62.4	63.7	64.5
Spartacus CL	69.4	64.3	67.3	66.7	65.1	65.2	65.8
Keel	69.2	63.1	68.9	67.1	61.8	67.0	63.0
LaTrobe	69.0	63.6	67.3	67.5	63.1	64.9	64.0
Macquarie	61.2	55.7	64.6	-	-	-	-
Maltstar	62.2	55.0	63.3	60.9	64.0	60.7	67.2
Maritime	-	-	-	64.7	63.2	62.4	64.8
Oxford	64.3	58.4	62.4	60.1	65.6	59.7	67.6
Rosalind	65.6	61.5	68.1	65.1	63.4	63.3	64.0
Schooner	-	63.2	66.5	66.1	65.9	65.8	66.0
Scope CL	66.0	61.0	66.0	64.9	62.4	62.5	65.9
SY Rattler	65.0	60.8	64.6	62.6	63.4	60.7	65.2
Westminster	64.7	55.5	63.8	-	-	-	-

2015 Barley variety performance for screenings (% <2.2 mm) across NVT sites

Variety	Lower Eyre Peninsula			Upper Eyre Peninsula			
	Cummins	Wanilla	Wharminda	Darke Peak	Elliston	Minnipa	Poochera
Alestar	13.8	34.6	1.7	2.4	6.8	6.4	16.3
Bass	4.9	24.4	1.4	0.5	13.4	4.3	11.0
Buloke	37.5	59.3	2.8	3.1	14.8	25.0	17.7
Commander	16.2	45.2	3.6	2.9	9.5	14.9	8.7
Compass	6.0	15.7	1.5	0.3	12.8	2.4	6.3
Fathom	13.3	19.3	2.1	0.9	8.7	4.8	10.6
Flagship	-	43.5	3.9	1.6	22.2	10.3	35.6
Fleet	15.1	23.1	2.1	1.8	12.8	4.3	7.0
Flinders	18.4	39.0	0.8	0.9	11.0	7.7	19.2
Gairdner	43.7	62.8	6.1	-	-	-	-
Granger	13.9	28.1	1.4	2.5	8.1	4.6	19.2
Hindmarsh	15.3	29.5	2.5	1.2	17.1	12.5	10.3
SpartacusCL	11.7	37.9	0.7	1.5	15.3	8.5	8.8
Keel	7.2	23.2	1.7	0.7	13.2	2.2	11.4
LaTrobe	14.4	38.1	1.8	1.0	21.6	15.9	13.8
Macquarie	54.2	71.0	6.9	-	-	-	-
Maltstar	31.1	49.1	4.9	9.7	16.2	16.3	23.0
Maritime	-	-	-	0.3	8.9	4.4	6.4
Oxford	28.3	43.3	5.9	14.5	11.8	32.2	26.5
Rosalind	20.9	29.0	2.0	1.0	18.2	9.6	16.6
Schooner	-	32.5	1.9	2.0	13.5	9.1	21.5
ScopeCL	26.6	42.9	1.7	2.5	23.3	20.3	10.7
SY Rattler	19.5	31.2	2.6	2.7	19.5	13.6	26.4
Westminster	10.1	33.1	2.1	-	-	-	-

2015 Barley variety performance for retention (% >2.5 mm) across NVT sites

Variety	Lower Eyre Peninsula			Upper Eyre Peninsula			
	Cummins	Wanilla	Wharminda	Darke Peak	Elliston	Minnipa	Poochera
Alestar	41.3	22.3	84.5	73.4	65.9	59.8	34.5
Bass	57.2	32.8	87.3	92.1	53.7	69.0	39.3
Buloke	15.0	7.0	73.6	64.1	45.8	29.5	9.3
Commander	45.2	19.4	77.7	79.2	59.7	51.2	44.8
Compass	69.3	42.6	92.0	97.7	58.5	85.0	52.9
Fathom	45.5	31.7	81.8	92.3	58.6	71.4	35.7
Flagship	-	11.2	63.9	81.7	31.9	47.1	9.3
Fleet	30.4	25.5	74.0	82.4	50.2	68.1	53.5
Flinders	28.2	17.0	88.0	87.1	54.5	55.4	25.1
Gairdner	13.0	6.2	60.3	-	-	-	-
Granger	36.4	28.4	87.6	74.3	59.8	62.2	21.0
Hindmarsh	43.1	20.3	79.0	93.2	46.1	51.6	28.6
Spartacus CL	49.8	12.6	90.4	92.7	46.3	62.1	31.1
Keel	73.3	34.4	91.2	97.1	61.2	86.9	38.8
LaTrobe	40.4	12.0	84.1	92.0	37.0	46.2	21.6
Macquarie	8.3	6.4	49.0	-	-	-	-
Maltstar	18.6	13.0	64.6	31.4	36.6	34.4	20.0
Maritime	-	-	-	96.4	62.2	69.8	44.3
Oxford	22.6	14.5	59.6	30.9	42.7	15.5	17.7
Rosalind	35.5	22.5	85.8	93.4	49.2	64.5	24.8
Schooner	-	20.2	84.7	84.9	44.7	53.4	14.2
Scope CL	21.2	13.1	79.9	71.8	39.6	34.8	14.8
SY Rattler	35.0	23.4	81.1	75.6	36.8	44.3	9.7
Westminster	51.9	18.6	79.0	-	-	-	-

Section 2

Section Editor:
Amanda Cook
SARDI, Minnipa Agricultural Centre

Break Crops

Crop estimates by district (tonnes produced) and average yield (t/ha) in brackets in 2015

	Peas	Canola	Lupins	Vetch	Beans	Chickpeas	Lentils
Western EP	4,300 (0.9)	7,500 (1.4)	1,350 (0.9)	1,200 (0.5)	0	0	0
Eastern EP	5,500 (1.0)	11,000 (1.1)	3,000 (0.5)	1,000 (0.5)	250 (0.6)	140 (0.7)	160 (0.8)
Lower EP	5,500 (1.2)	114,000 (1.8)	26,500 (1.0)	1,400 (0.8)	7,800 (1.3)	500 (1.3)	2,500 (1.3)

Source: PIRSA, January 2016, Crop and Pasture Report, South Australia

SA field pea variety trial yield performance 2015
(as a % of site mean) and long term (2011-2015) average across sites (as % of site mean)

	Lower Eyre Peninsula				Upper Eyre Peninsula		
Variety	**2015**		**2011-2015**		**2015**	**2011-2015**	
	Rudall	**Yeelanna**	**% Site mean**	**Trial #**	**Minnipa**	**% Site Mean**	**Trial #**
Kaspa	88	87	95	10	99	105	7
Parafield	71	82	89	8		86	4
PBA Gunyah	88	90	93	10	99	108	6
PBA Oura	84	99	106	10	99	100	7
PBA Pearl	129	116	124	10	103	103	7
PBA Percy	106	102	103	10	101	99	5
PBA Twilight	87	100	89	10	100	107	6
PBA Wharton	99	110	101	10	97	102	7
Sturt					94	91	5
Site mean yield (t/ha)	**1.30**	**1.53**	**1.86**		**1.67**	**1.59**	
LSD (P=0.05)	*14.0*	*9.0*			*10.0*		
Date sown	18 May	20 May			1 May		
Soil type	S	SL			CL		
Previous crop	Wheat	Wheat			Wheat		
Rainfall (mm) J-M/A-O	25/229	36/302			14/258		
pH (water)	5.9	8.3			9.4		
Site stress factors	ht, dl, rh	ht, w			bs, ht		

Soil types: S=sand, L=loam, C=clay
Site stress factors: bs = ascochyta blight (black spot), dl = post flowering moisture stress
ht = high temperatures during flowering/pod fill, rh = rhizoctonia, w = weed competition moderate
Data source: *SARDI/GRDC, PBA & NVT (long term data based on weighted analysis of sites and courtesy National Statistics Program).*

SA chickpea variety trial yield performance 2015

(as a % of site mean) and long term (2011-2015) average across sites (as a % of site mean)

Variety	Lower Eyre Peninsula			
	2015		2010-2014	
	Rudall	Yeelanna	% Site mean	Trial #
Desi trials	No Valid Result - High Variability In Trial			
Ambar		90	101	8
Genesis™ 079		115	98	10
Genesis™ 090		87	90	10
Neelam		97	104	10
PBA Maiden		85	97	10
PBA Slasher		115	105	10
PBA Striker		123	104	10
Site mean yield (t/ha)		**0.39**	**1.38**	
LSD (P=0.05) as %		*0.1*		
Kabuli trials		No Valid Result - High Variability In Trial		
Almaz			99	5
Genesis™ 079			108	5
Genesis™ 090			111	5
Genesis™ 114			87	3
Genesis™ Kalkee			87	5
PBA Monarch			96	5
Site mean yield (t/ha)			**1.23**	
Date sown	18 May	20 May		
Soil type	S	SL		
Rainfall (mm) J-M/A-O	25/229	36/302		
pH (water)	5.9	8.3		
Previous crop	Wheat	Wheat		
Site Stress factors	rh, pe, ht, dl	ht		

Soil type: S=sand, L = loam

Site stress factors: dl=post flowering moisture stress, ht=high temperatures during flowering/pod fill, rh=rhizoctonia, pe=poor establishment

Data source: SARDI/GRDC, PBA & NVT (long term data based on weighted analysis of sites and courtesy National Statistics Program).

EP faba bean variety trial yield performance 2015

2015 and predicted regional performance, expressed as % of site average yield

Variety	Lower Eyre Peninsula				Upper Eyre Peninsula			
	2015	Long term average across sites			2015	Long term average across sites		
	Cockaleechie	t/ha	% Site Mean	# Trials	Lock	t/ha	% Site Mean	# Trials
Farah	No results released	2.15	98	10	91	1.62	97	5
Fiesta VF		2.15	98	10	90	1.60	97	5
Nura		2.14	97	10	85	1.59	96	5
PBA Rana		2.06	94	10	86	1.48	89	5
PBA Samira		2.27	103	4	100	1.66	100	4
PBA Zahra		2.31	105	4	97	1.68	101	4
Site av. yield (t/ha)		**2.20**			**1.13**	**1.66**		
LSD (P=0.05) as %					*11*			
Date sown					7 May			

Data source: SARDI/GRDC, NVT and PBA - Australian Faba Bean Breeding Program.

2008-2015 MET data analysis by National Statistics Program

SA lentil variety trial yield performance 2015

(as % of site mean yield) and long term (2009-2015) average across sites (as a % of site mean)

Variety	Lower Eyre Peninsula		
	2015	2009 - 2015	
	Yeelanna	% site mean	Trial #
Boomer		80	2*
Nipper	95	93	6
Northfield		82	2*
Nugget	103	94	6
PBA Ace	82	99	6
PBA Blitz	110	98	6
PBA Bolt	104	97	6
PBA Bounty		101	2*
PBA Flash	115	103	6
PBA Herald XT	75	86	6
PBA Hurricane XT	98	102	4
PBA Jumbo	105	102	6
PBA Jumbo 2	99	112	4
Site mean yield (t/ha)	**1.09**	**1.70**	
LSD % (P=0.05)	*18.0*		
Date sown	20/5		
Soil type	SL		
Rainfall (mm) J-M/A-O	36/302		
pH (water)	8.3		
Previous crop	Wheat		
Site stress factors	ht, w		

**Varieties have only had limited evaluation at these sites, treat results with caution*
Soil type: L=loam, S=sand
Site stress factors: ht=high temperatures during flowering/pod fill, w=weed competition moderate
Data source: SARDI/GRDC, PBA & NVT (long term data based on weighted analysis of sites and courtesy National Statistics Program)

EP lupin variety trial yield performance 2015

2015 and predicted regional performance (2009 - 2015) expressed as % of site average yield

Variety	Lower Eyre Peninsula					Upper Eyre Peninsula			
	2015		Long term average across sites			2015	Long term average across sites		
	Wanilla	Ungarra	t/ha	% of Site Mean	# Trials	Tooligie	t/ha	% of Site Mean	# Trials
Danja	94	74	1.80	79	9	76	1.36	78	7
Jenabillup	88	105	2.30	101	16	98	1.69	97	12
Jindalee	88	88	1.85	81	16	85	1.37	79	12
Mandelup	104	105	2.24	98	16	81	1.72	99	12
PBA Barlock	106	92	2.39	105	13	106	1.83	106	10
PBA Gunyidi	99	109	2.41	106	14	103	1.80	104	11
PBA Jurien	98	101	2.46	108	9	101	1.85	107	5
Quilinock	97	106	2.24	98	6	108	1.62	94	4
Wonga	92	79	2.08	91	14	68	1.60	93	11
Site av. yield (t/ha)	**1.53**	**1.54**	**2.28**			**0.97**	**1.73**		
LSD % (P=0.05)	*16*	*10*				*21*			
Date sown	1 May	8 May				7 May			

Data source: SARDI/GRDC & NVT and PBA Australian Lupin Breeding Program
2009 - 2015 MET data analysis by National Statistics Program

Eyre Peninsula canola variety trial yield performance 2015

(2015 performance expressed as % of site average yield)

Variety	Lower Eyre Peninsula					Upper Eyre Peninsula						
	2015		Long term average across sites			2015			Long term average across sites			
	Mt Hope	Yeelanna	t/ha	% of site mean	No. Trials	Lock	Minnipa	Mt Cooper	t/ha	% of site mean	No. trials	
AV Garnet	94	96	2.05	104	10	88			1.15	101	5	Conventional
AV Zircon	107	88	1.99	101	10	84	No	No	1.04	91	5	
Hyola 50	-	-	2.13	108	8	-			1.27	112	4	
Nuseed Diamond	85	96	2.19	111	7	119	Trial	Trial	1.48	130	2	
Victory V3002	103	94	2.11	107	6	104			-	-	-	
Site av yield (t/ha)	**2.05**	**2.23**	**1.97**			**1.69**			**1.14**			
LSD % (P=0.05)	*9*	*9*				*8*						
Archer	104	101	2.11	106	6	-	-	95	-	-	-	Clearfield
Banker CL	113	107	2.27	114	2	82	90	-	1.35	104	2	
Carbine	-	-	1.94	98	4	-	-	-	1.35	104	3	
Hyola 474CL	89	99	1.95	98	8	97	105	111	1.38	106	7	
Hyola 575CL	86	94	1.98	99	8	95	100	109	1.38	106	5	
Hyola 577CL	91	99	2.03	102	4	-	-	105	-	-	-	
Pioneer 43C80 (CL)	-	-	-			-	-	83	1.17	90	2	
Pioneer 43Y85 (CL)	-	-	-			-	-	99	1.26	97	4	
Pioneer 44Y87 (CL)	91	102	2.03	102	4	101	92	-	1.32	102	6	
Pioneer 44Y89 (CL)	91	100	2.05	103	3	108	102	-	1.45	111	4	
Pioneer 45Y86 (CL)	97	98	2.07	104	8	-	-	-	-	-	-	
Pioneer 45Y88 (CL)	114	-	2.14	107	5	-	-	-	-	-	-	
Rimfire CL	94	95	2.03	102	3	98	**92**	**102**	1.22	94	4	
Site av yield (t/ha)	**2.13**	**2.12**	**1.99**			**1.46**	**1.63**	**1.01**	**1.30**			
LSD % (P=0.05)	*9*	*9*				*9*	*5*	*21*				
ATR Bonito	102	97	2.01	102	6	100	104	94	1.34	101	5	Triazine Tolerant
ATR Gem	105	105	1.95	99	10	-	-	94	-	-	-	
ATR Mako	94	106	2.02	102	4	-	-	-	-	-	-	
ATR Stingray	-	-	1.84	94	8	95	102	117	1.34	101	6	
ATR Wahoo	110	94	1.99	101	8	-	-	78	-	-	-	
Hyola 450TT	92	92	1.93	98	6	101	102	96	1.43	108	4	
Hyola 559TT	104	102	2.08	105	7	106	103	121	1.46	110	5	
Hyola 650TT	107	112	2.05	104	5	-	-	116	-	-	-	
Pioneer 45T01TT	-	98	2.01	102	3	-	-	-	1.31	98	2	
Pioneer Atomic TT	-	91	2.02	103	2	97	92	92	1.35	101	4	
Pioneer Sturt TT	-	-	-	-	-	-	-	-	1.33	100	4	
Yetna	-	-	-	-	-	-	-	93	-	-	-	
Site av yield (t/ha)	**1.93**	**1.78**	**1.97**			**1.59**	**1.68**	**0.93**	**1.33**			
LSD % (P=0.05)	*10*	*11*				*9*	*5*	*21*				
Date sown	28-Apr	27-Apr				29-Apr	28-Apr	15-May				
Soil type	SL	CL				SL	L	SCL				
pH (water)	5.4	8.0				8.5	8.3	-				
Rainfall (mm) J-M/A-O	284	295				204	249	234				

Soil type: S=sand, C=clay, L=loam

Site stress factors: H=damage on TT and Conv

Data source: SARDI/GRDC, NVT and District Canola Trials. 2010-2014 MET data analysis by National Statistics Program.

Reducing risk in canola

Andrew Ware[1], Leigh Davis[2], Brian Purdie[1], and Brenton Spriggs[2]
[1]SARDI, Port Lincoln, [2]SARDI, Minnipa Agricultural Centre

RESEARCH

Almost ready

Location:
Minnipa Agricultural Centre, paddock S5

Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm

Yield
Potential: 2.0 t/ha (C)
Actual: 1.9 t/ha

Paddock History
2014: Wheat
2013: Barley
2012: Canola

Key messages

- **Canola can be an expensive crop to grow.**
- **Yields can be maximised by planting early in low rainfall environments.**
- **Retained seed from open-pollinated varieties has the potential to match yields of some hybrid varieties.**
- **Delaying nitrogen application until stem elongation (bolting) was not as effective as applying at seeding or early post-emergence.**

Why do the trial?

Canola can be an expensive crop to grow. Seed costs, high requirements for nitrogen and controlling insects can all add to expenses not seen in other break crop options. This is particularly the case for low rainfall areas and can add a high level of risk to growing canola in these areas.

To begin to address the issues of canola being a high risk crop in low rainfall areas two experiments were established in 2015, at Minnipa (upper Eyre Peninsula) and Ouyen (Victorian Mallee). Only Minnipa results are reported here.

This trial is part of the GRDC funded Optimising Canola Profitability Project currently underway across New South Wales, Victoria and South Australia (CSP00187).

How was it done?

The hypotheses for reducing risk were:

1. Can canola be sown on a fixed date (dry or wet) in mid-late April to maximise the growing season rainfall available and completed prior to the 'ideal' wheat planting window? Two seeding times were evaluated: fixed = 21 April and season opening = 6 May.
2. What is the effect on grain yield of using grower retained open pollinated seed compared to purchased, hybrid seed? Two varieties were evaluated: farmer retained Stingray (graded to greater than 1.8 mm) and purchased Hyola 450TT.
3. Can the application of nitrogen be delayed until late in the season when there is a greater certainty of potential yield? Nitrogen applications were planned for sowing at growth stages of 4-8 leaf, bolting and early flowering.

A 29 mm rainfall event occurred between 16-19 April, which resulted in the fixed date seeding (21 April) being planted into moist soil, with the soil drying slightly by the season opening sowing time (6 May). A base application of 100 kg/ha of single superphosphate at seeding helped cover phosphorous and sulphur requirements. All nitrogen applications were able to be made at the correct growth stage with rainfall following shortly after to wash them into the soil.

The trial received 100 kg/ha of single superphosphate at sowing and then received 150 kg/ha urea (69 kg/ha nitrogen), applied either drilled below the seed at seeding, or broadcast around 3 weeks after emergence, or once the stem had started to elongate (bolting) or at the start of flowering. 800 ml/ha Atrazine (500 g/L a.i), 90 ml/ha Verdict and 1.0% Kwicken was applied to control weeds. Multiple products were used during the season to control insects.

What happened?

Results from the Minnipa risk management trial showed that making use of the early sowing opportunity in 2015 produced significantly higher yields (a 19% improvement) than delaying seeding until 6 May, regardless of the variety planted (Table 1). It also showed that there were no differences between the farmer retained open pollinated variety, Stingray, and the purchased hybrid variety, Hyola 450TT, in this trial. This trial showed a yield response with earlier applications of nitrogen applied at seeding and post emergence, before the 8 leaf stage.

Table 1 Grain yield (t/ha) from canola sown at planted at Minnipa, 2015 at two sowing times, and four nitrogen application regimes.

Variety	Time of Sowing (TOS)		
	N Timing	21 April	6 May
Hyola 450	Seeding	1.81	1.45
	Post Em	1.90	1.43
	Bolting	1.69	1.43
	Flowering	1.50	1.38
Stingray	Seeding	1.77	1.55
	Post Em	1.85	1.45
	Bolting	1.60	1.37
	Flowering	1.41	1.28
Average (TOS)		1.69	1.42
LSD (P=0.05)	*0.14*		
CV (%)	6.3		

What does this mean?

Making use of early sowing opportunities will reduce risk, by helping to promote a higher yielding crop, which makes better use of the plant available water. This has been consistently shown over three years by the SAGIT funded Canola Establishment project (see article Maximising canola yield by getting establishment right). It is yet to be determined if similar benefits can be consistently achieved by sowing dry.

Evidence from this research, and supported by a similar trial conducted at Ouyen in Victoria, suggests that delaying nitrogen application, in nitrogen responsive situations, until stem elongation will see a reduction in nitrogen efficacy and yield. This shows that delaying nitrogen applications until later in the growing season for a better idea of yield potential is not the best approach. A better solution may be to plant canola into a paddock with higher levels of residual nitrogen.

Of the two varieties and seed sources (hybrid and open-pollinated) evaluated in this trial there was no significant difference in retaining an open pollinated variety compared to planting a commercial hybrid. This suggests that retaining open pollinated canola seed can be an effective way of reducing costs. It should be noted that in order to compare other varieties in different environments the National Variety Trials (NVT) are a good source of information.

Acknowledgements

Thank you to the Grains Research and Development Corporation (GRDC) for providing the funding. Thank you to Minnipa Agricultural Centre for providing the land for to the trials. ATR Stingray is a registered variety of Nuseed Pty Ltd. Hyola 450TT is a registered variety of Pacific Seeds. Michael Moodie, Moodie Agronomy, Mildura and Dr Therese McBeath, CSIRO, Adelaide, for their direction and input towards the design and input of this trial.

GRDC Grains Research & Development Corporation Your GRDC working with you

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Maximising canola yield by getting establishment right

Andrew Ware[1], **Leigh Davis**[2] **and Brenton Spriggs**[2]
[1]SARDI, Port Lincoln, [2]SARDI, Minnipa Agriculture Centre

RESEARCH

Almost ready

Location:
Minnipa Ag Centre,
Paddock S5
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 2.0 t/ha (C)
Actual: 2.5 t/ha
Paddock History
2014: Wheat
2013: Barley
2012: Canola

Location:
Piednippie/Haslam
Rainfall
Av. Annual: 324 mm
Av. GSR: 220 mm
2015 Total: 204 mm
2015 GSR: 173 mm
Paddock History
2014: Axe wheat
2013: Grass free medic pasture

Key messages

- **Early sowing (22 April) had the largest positive impact on canola yield when comparing a range of treatments trialled in 2015, similar to results observed in 2013 and 2014. Sowing on 22 April improved yields up to 12%, depending on variety, compared to 29 April sowing date.**
- **Different management practices are needed to establish canola on different soil types under marginal moisture conditions. On a loamy soil at Minnipa deeper sowing (to 4 cm) produced the highest yields, whereas shallower sowing (1 cm) produced the highest yields at Piednippie, particularly with the smaller seeded variety Stingray.**
- **Trials at Piednippie in 2015 showed that yields up to 0.8 t/ha are achievable in a below average rainfall season, provided the crop is established early and achieves around 50 plants/m² in open-pollinated varieties.**
- **Results from similar trials in 2013, 2014 and 2015 have all shown that the highest yielding canola has consistently come from plots with plant establishments of over 50 plants/m² for open pollinated varieties and 40 plants/m² for hybrid varieties.**

Why do the trial?

The trials described in this article are part of a South Australian Grains Industry Trust (SAGIT) funded project. It aims to maximise canola productivity through creating soil specific management strategies that improve canola yields, profitability and establishment in field trials on Eyre Peninsula.

In 2015, seven separate trials were conducted as part of this project at Minnipa Agriculture Centre and Piednippie on upper Eyre Peninsula. Three trials will be reported in this article. Further trials were conducted on lower Eyre Peninsula and will be reported in the LEADA results booklet.

How was it done?

Trial 1 – Time of Sowing (Minnipa Agricultural Centre)

Aim: To evaluate the effect of four different sowing times, in combination with two different seeding depths and two different seeding rates, on canola emergence and yield of two triazine tolerant varieties on Minnipa Agricultural Centre.

Treatments: Sowing dates in 2015: Time of Sowing (TOS) 1: 22 April, TOS2: 28 April, TOS3: 18 May, TOS4: 21 May. Two varieties were sown each time: ATR Stingray (open pollinated) and Hyola 559TT (hybrid). Sowing depths were: Normal (2 cm) and Deep (4 cm). Sowing Rates (calculated allowing for an establishment rate of 70% with the small seed Stingray and 85% with the larger seeded Hyola 559TT): 40 plants/m² (equivalent to 1.9 kg/ha Stingray and 3.0 kg/ha Hyola 559TT) and 60 plants/m² (equivalent to 2.9 kg/ha Stingray and 4.4 kg/ha Hyola 559TT). Seed size: Stingray = 0.34 g/100 seeds and Hyola 559TT = 0.64 g/100 seeds.

Table 1 Grain yield (t/ha) for ATR Stingray and Hyola 559TT with four sowing times Minnipa in 2015.

Variety	TOS			
	22 Apr	29 Apr	18 May	21 May
ATR Stingray	2.56	2.28	1.52	1.38
Hyola 559	2.34	2.12	1.43	1.35
LSD (P=0.05)	*0.10*			
CV (%)	7.7			

Management: The trial received a total of 69 kg/ha 19:13:0 S9% + 57 kg/ha urea fertiliser, applied at seeding and a further 50 kg/ha of urea and 52 kg/ha sulphate of ammonia broadcast during the season (total of 72 kg/ha of nitrogen). 800 ml/ha Atrazine (500g/l a.i), 90 ml/ha Verdict and 1.0% Kwicken was applied to control weeds. Multiple products were used during the season to control insects.

What does this mean?

- Time of sowing had a large impact on yield, where the earliest sowing time (22 April) produced the highest yield and each subsequent time of sowing producing significantly lower yields (Table 1).
- There was no penalty from seeding an early maturing variety such as ATR-Stingray in mid-late April in 2015. It managed to utilise the maximum soil moisture available very effectively, and wasn't compromised by seasonal conditions. A similar result was achieved in 2014.
- TOS 1 and 2 had higher average plant establishment (TOS1: 46 plants/m^2 and TOS 2: 48 plants/m^2) than times of sowing 3 and 4 (TOS3: 35 plants/m^2 and TOS4: 34 plants/m^2) (Table 2).
- Interestingly TOS3 and TOS4 were sown three days apart, where TOS3 was sown into relatively dry soil just before 7 mm of rainfall and TOS4 just after. There was no significant difference in plant establishment, but the yield of Stingray was 0.14 t/ha higher in TOS3.
- Other treatments such as sowing depth and seeding rate while significantly affecting plant establishment, did not significantly affect grain yield within the same time of sowing (i.e. all treatments sown on the same day, regardless of sowing rate and sowing depth didn't yield significantly different to each other).

Trials 2 & 3 – Triazine Tolerant Canola Emergence Trials

Aim: To evaluate the effect of two triazine tolerant varieties, sown at three different seeding rates and three different depths, on emergence and yield at Minnipa Agricultural Centre and at Piednippie.

Treatments: The Minnipa trial was sown on 28 April 2015 and the Piednippie trial was sown on 27 April 2015. The varieties; ATR Stingray, a small seeded open pollinated variety, (seed size 0.34 g/100 seeds) and Hyola 559TT, a large seeded hybrid variety, (seed size 0.63 g/100 seeds) were used in all treatments. The trials were planted at three depths (1 cm, 2 cm, and 4 cm) and at three seeding rates (1.5 kg/ha, 3 kg/ha and 4.5 kg/ha).

Management: The Minnipa trial received a total of 65 kg/ha 19:13:0 S9% and 41 kg/ha urea fertiliser, applied at seeding and 50 kg/ha of urea and 120 kg/ha sulphate of ammonia (SOA) broadcast during the season (total of 78 kg/ha nitrogen). The Piednippie trial received 65 kg/ha 19:13:0 S9% and 41 kg/ha urea fertiliser, applied at seeding and 50 kg/ha urea during the season (total of 54 kg/ha nitrogen). The trials received knockdown herbicide of Sprayseed plus pre-emergent 1.5 L/ha Trifuralin 480 prior to sowing. Multiple applications of insecticides were applied at both sites throughout the season to control a range of insects.

Table 2 Grain yield and establishment rates for ATR Stingray and Hyola 559TT sown on four sowing times Minnipa in 2015.

		Grain yield (t/ha)				Emergence (plants/m^2)			
Variety	Rate TOS/ Depth	40		60		40		60	
		Deep	Normal	Deep	Normal	Deep	Normal	Deep	Normal
ATR Stingray	TOS1	2.54	2.58	2.49	2.63	33	50	49	71
	TOS2	2.28	2.24	2.35	2.24	39	55	60	71
	TOS3	1.47	1.47	1.54	1.60	25	35	40	50
	TOS4	1.32	1.34	1.43	1.44	27	33	42	43
Hyola 559TT	TOS1	2.31	2.41	2.34	2.32	27	41	33	62
	TOS2	2.06	2.15	2.15	2.14	27	44	42	48
	TOS3	1.39	1.37	1.46	1.49	22	32	31	43
	TOS4	1.28	1.35	1.37	1.40	25	30	31	42
LSD (P=0.05)	*TOS x rate x depth*	*0.18*				*10*			
CV (%)		*7.7*							

Table 3 Grain yield and establishment rates for ATR Stingray and Hyola 559TT sown at Minnipa in 2015.

Variety	Rate (kg/ha)	Grain yield (t/ha)			Emergence (plants/m²)		
		1 cm	2 cm	4 cm	1 cm	2 cm	4 cm
Hyola 559TT	1.5	1.45	1.40	1.43	13	17	16
	3.0	1.47	1.58	1.53	24	30	19
	4.5	1.57	1.67	1.62	42	44	50
ATR Stingray	1.5	1.36	1.46	1.51	23	29	24
	3.0	1.52	1.58	1.62	52	58	50
	4.5	1.56	1.56	1.63	75	78	61
LSD (P=0.05)	*depth x rate*	*0.08*			*13*		
CV (%)		4.8					

Table 4 Grain yield and establishment rates for ATR Stingray and Hyola 559TT sown at Piednippie in 2015.

Variety	Rate (kg/ha)	Grain yield (t/ha)			Emergence (plants/m²)		
		1 cm	2 cm	4 cm	1 cm	2 cm	4 cm
Hyola 559TT	1.5	0.63	0.75	0.57	23	27	14
	3.0	0.75	0.80	0.64	22	56	37
	4.5	0.81	0.81	0.66	60	61	45
ATR Stingray	1.5	0.53	0.66	0.45	28	41	27
	3.0	0.68	0.73	0.53	59	58	30
	4.5	0.69	0.80	0.59	71	74	60
LSD (P=0.05)	*depth x rate*	*0.17*			*7*		
CV (%)		8.1					

What does this mean?

The highest yielding treatments were sown at 3.0 kg/ha and 4.5 kg/ha, this gave significantly higher yields than treatments sown at 1.5 kg/ha (Table 3). The cost of 1.5 kg/ha of open pollinated seed is approximately $18.75/ha, lower if retained on farm, and $37.50/ha for hybrid varieties (PIRSA Gross Margin Guide 2015). Using a canola price of $480/t, yields of the open pollinated variety would need to lift from 1.40 t/ha to 1.44 t/ha to cover the expense of an extra 1.5 kg/ha of seed and would need to lift from 1.40 t/ha to 1.48 t/ha to cover the expense of an extra 1.5 kg/ha of hybrid seed.

Sowing 1 cm deep in marginal moisture conditions (almost 10 days after significant rainfall) produced lower yields at Minnipa than treatments sown at 2 cm or 4 cm.

What does this mean?

The canola yields from the Piednippie site reached 0.8 t/ha, which given that May, June and July rainfall for this site was Decile 1 (lowest ever) showed that if canola can be established early it is quite hardy and can still offer reasonable returns (Table 4).

On this soil both varieties yielded significantly lower when sown at 4 cm. Sowing depth appeared to be more critical than sowing rate. Seeding to a depth of 2 cm produced the highest yields.

Acknowledgements

Thank you to the South Australian Grains Industry Trust (SAGIT) for providing the funding (S1113). Thank you to Minnipa Agricultural Centre and Dion Trezona for providing the land to the trials. ATR Stingray is a registered variety of Nuseed Pty Ltd. Hyola 559TT is a registered variety of Pacific Seeds.

Nitrogen applications to maximise canola yield

Leigh Davis[1], Brenton Spriggs[1] and Andrew Ware[2]

[1]SARDI, Minnipa Agricultural Centre, SARDI, Port Lincoln

Location:
Minnipa Ag Centre
Paddock S5
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 258 mm
2015 GSR: 333 mm
Yield
Potential: 2.22 t/ha (C)
Actual: 1.85 t/ha (Best bet treatment)
Paddock History
2014: Wheat
2013: Barley CL
2012: TT Canola
Soil Type
Red loam
Plot Size
1.5 m x 10 m x 3 reps
Yield Limiting Factors
Dry conditions after sowing

Key messages

- **Canola yields of 2 t/ha are possible in an average growing season (decile 5) at Minnipa Agricultural Centre.**
- **The total application of 85 kg/ha N and 108 kg/ha N exceeded the 2 t/ha target, producing 2.13 t/ha and 2.22 t/ha respectively, and 62 kg/ha N very nearly achieved 2 t/ha (1.96 t/ha).**
- **Soil tests determined that 70-80 kg/ha N was available in the soil, including mineralisation, which predicted a potential yield of 1 t/ha.**

Why do the trial?

Canola varieties have advanced in the last 5-10 years in terms of maturity and adaptability, allowing canola to be successfully grown in lower rainfall areas. The aim of this trial was to push the nitrogen inputs at Minnipa Agricultural Centre to achieve a target yield of 2 t/ha.

How was it done?

A nitrogen application trial was established in 2015 with six treatments (Table 1). The replicated trial was sown on the 29 April using Stingray TT canola. 2 L/ha Sprayseed, 1.5 L/ha Triflur X was used as a knockdown and 1 L/ha Lorsban was applied post sowing, pre emergence for insect control. Grassy weeds were controlled 25 June with 0.18 L/ha of Elantra Xtreme, 1 L/100L Kwicken and further insect control with 0.5 L/ha Astound Duo. No triazine herbicides were used or needed for broadleaved weeds. Plant emergence, vigour, start and end of flowering, yield and seed oil content were measured. The trial was harvested on 26 October.

All trials were sown with 59 kg/ha of DAP (18:20:0:0) and weeds and pests were controlled as required in line with standard field pea management.

What happened?

There was a distinct relationship between yield and nitrogen rate, regardless of what method was used and application timing of nitrogen. An initial soil test showed there was 80 kg/ha of nitrogen in the soil with potential to produce around 1 t/ha of canola. Therefore another 70-80 kg/ha of nitrogen was required to reach the target of 2 t/ha of canola grain yield (Table 2). All treatments received 8 units of phosphorus.

The gross margins were calculated for each treatment using the PIRSA Farm Gross Margin Guide 2015. The grain price used was $550/t to undertake the economic analysis (Table 2).

Table 1 2015 nitrogen application treatments.

	Total units nitrogen	Treatment
Opportunistic	108	65 kg/ha 19:13:0 S9% + 57 kg/ha urea @ sowing + 50 kg/ha urea @ 4 leaf, 9 leaf & budding
N++	85	65 kg/ha 19:13:0 S9% + 57 kg/ha urea @ sowing + 50 kg/ha urea @ 4 leaf & budding
N+	62	65 kg/ha 19:13:0 S9% + 57 kg/ha urea @ sowing + 50 kg/ha urea @ 4 leaf
Best Bet	53	Best bet 40 kg/ha DAP + 50 kg/ha urea @ 4 leaf & budding
Standard N	39	65 kg/ha 19:13:0 S9% + 57 kg/ha urea @ sowing
Control	7	40 kg/ha DAP

Table 2 Nitrogen rate, timing and gross margins of treatments.

Treatment	Sowing N	Extra N as urea				Total N	Cost of Fert	Yield	Gross Margin
		Sowing	4 leaf	9 leaf	Budding				
	19:13 or DAP	kg/ha N	kg/ha N	kg/ha N	kg/ha N	kg/ha N	$/ha	t/ha	$/ha
Opportunistic	12	26	23	23	23	108	137	2.22	834
N++	12	26	23	0	23	85	113	2.13	821
N+	12	26	23	0	0	62	90	1.96	766
Best Bet	7	0	23	0	23	53	75	1.85	715
Standard N	12	26	0	0	0	39	66	1.65	621
Control	7	0	0	0	0	7	27	1.14	396
LSD (P=0.05)								*0.26*	
CV (%)								7.9	

What does this mean?

The opportunistic treatment yielded 2.22 t/ha with the highest application of N (108) and achieved the best gross margin, significantly out yielding all other treatments apart from the N++ and N+ treatments.

This trial demonstrates the potential of canola to yield 2 t/ha in an average (or decile 5) growing season at Minnipa. It has also shown that canola needs to have access to 150 kg/ha of nitrogen to achieve a 2 t/ha yield.

In this trial, where approximately half of the crop's requirements needed to be applied through artificial fertiliser, the cost of fertiliser required to reach a yield potential of 2 t/ha was approximately $100/ha. This increased the risk of growing canola in this environment.

A lower risk option may be planting the canola into a soil with higher levels of plant available nitrogen after a productive legume based pasture. Regardless, a good knowledge of plant available soil nitrogen will assist in targeting nitrogen application to a canola crop.

Acknowledgements

This trial was done in conjunction with the SAGIT S1113 – Improving canola establishment project.

Registered products: see chemical trademark list.

Break Crops

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

SAGIT

Evaluating alternative pulse options for low rainfall regions

Sarah Day[1], Larn McMurray[1], Christine Walela[1] and Leigh Davis[2]
[1]SARDI, Clare; [2]SARDI Minnipa Agricultural Centre

RESEARCH

Almost ready

Location:
Minnipa Ag Centre
Paddock S5
SARDI Pulse Breeding Australia
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: Pulses 1.96 t/ha
Actual: Peas 1.6 - 1.95 t/ha
Paddock History
2014: Canola
2013: Wheat and barley
2012: Wheat
Soil Type
Clay loam
Plot Size
1.5 m x 10 m x 3 reps
Yield Limiting Factors
Limited soil moisture prior to sowing, late season moisture stress

Key messages

- **Field peas have proven to be the most reliable pulse option on the upper Eyre Peninsula with yields remaining the most stable across seasons.**
- **Under favourable conditions there is potential for alternative pulse crops to be successful.**
- **Paddock selection, soil type, time of sowing, pulse agronomy, marketing and storage options all need careful consideration when looking at growing alternative pulse crops.**
- **New varietal options offer earlier maturity as well as improvements in harvestability, disease resistance and herbicide tolerance over older commercial standards, aiding production and profitability.**
- **Higher value alternatives, such as lentils, may be a high risk option and pulse crops better suited to the region could still prove to be the most profitable option in the long term.**

Why do the trial?

There has been increasing interest from growers and agronomists in low rainfall farming regions to evaluate alternative break crop options to field peas. Field peas are generally well suited to low rainfall farming systems and have historically been the main pulse option for the upper Eyre Peninsula region. However, record high prices and new varieties with improved agronomic characteristics has renewed interest in alternative pulse options. This is the second consecutive year for this trial and alternative pulse crops to field peas performed poorer in the 2015 season compared to the 2014 season. 2014 saw yields well above the long term averages due to favourable conditions and above average rainfall. Crop means for 2014 have been included for reference.

How was it done?

A field pulse demonstration trial was set up at Minnipa in 2015 to compare newly released faba bean, chickpea, field pea and lentil varieties. Five varieties of faba beans, chickpeas and lentils and six varieties of field peas were selected for comparison. Included in the variety selection were Nura faba bean, Genesis™ 090 chickpea, Kaspa field pea and Nugget lentil as commercial standards. Chickpea, field pea and lentil seed was treated with P-Pickle-T seed treatment prior to sowing. All crops were sown on 13 May with 60 kg/ha of MAP. The different crop types were sown as individual trials for ease of crop management and harvest. Faba beans were sown with Group F inoculum at 24 plants/m^2, field peas with Group E at 55 plants/m^2 and lentils with Group F at 120 plants/m^2. Chickpeas were sown with Group N inoculum. Desi chickpeas were sown at 50 plants/m^2 and kabuli chickpea varieties were sown at 35 plants/m^2.

Throughout the growing season pests and weeds were controlled as required in line with standard pulse crop management. Emergence, flowering, lodging, and pod drop scores were recorded during the growing season and grain yields were taken at harvest. Field peas were harvested on 29 October, faba beans and lentils on 30 October, and chickpeas on 30 November.

What happened?

Annual rainfall (332 mm) and growing season rainfall (258 mm) in 2015 was close to average at Minnipa. However, a dry start to 2015 meant there was marginal soil moisture at time of sowing. Following good winter rainfall, October recorded well below average rainfall as well as above average day time temperatures, causing moisture stress during pod fill and maturity. October also saw three consecutive days with temperatures above 35 degrees and very strong winds, which is likely to have reduced yields and grain size.

Field peas performed on par with the long term average grain yield and were also the only pulse crop to yield higher than the 2014 season, which saw above average grain yields under favourable conditions. Field peas achieved the highest crop mean of 1.8 t/ha, followed by faba beans (1.5 t/ha), lentils (1.4 t/ha), and chickpeas (0.7 t/ha) in 2015 (Table 1).

Table 1 Faba bean, chickpea, field pea and lentil variety performance, Minnipa 2015 (listed in descending order of grain yield).

Faba bean variety	Yield (t/ha)	Flower day (Julian)	Maturity rating	Chickpea variety	Yield (t/ha)	Flower day (Julian)	Maturity rating
Farah	1.51	216	Early-mid	PBA Striker	0.88	253	Early
PBA Samira	1.49	227	Early-mid	PBA Slasher	0.73	254	Mid
AF09167	1.47	219	Early	Genesis™ 079	0.66	255	Early
Fiord	1.40	217	Early	PBA Monarch	0.62	255	Early
Nura	1.38	225	Early-mid	Genesis™ 090	0.45	255	Mid
Crop mean (t/ha)	**1.45**			**Crop mean**	**0.67**		
LSD (P=0.05)	*0.04*			*LSD (P=0.05)*	*0.10*		
2014 Crop Mean	**1.89**			**2014 Crop Mean**	**1.30**		
Field pea variety	**Yield (t/ha)**	**Flower day (Julian)**	**Maturity rating**	**Lentil variety**	**Yield (t/ha)**	**Flower day (Julian)**	**Maturity rating**
PBA Pearl	1.95	231	Early	PBA Blitz	1.60	243	Early
Kaspa	1.94	242	Mid	PBA Bolt	1.52	255	Early-mid
PBA Twilight	1.90	225	Early	PBA Jumbo2	1.37	252	Early-mid
PBA Oura	1.89	227	Early	PBA Hurricane XT	1.21	254	Mid
OZP1101	1.69	240	Mid-late	Nugget	1.12	256	Mid-late
PBA Wharton	1.64	239	Early				
Crop mean	**1.83**			**Crop mean**	**1.36**		
LSD (P=0.05)	*0.24*			*LSD (P=0.05)*	*0.09*		
2014 Crop Mean	**1.79**			**2014 Crop Mean**	**1.43**		

Field peas were the highest yielding pulse crop in this trial for 2015, yielding 20% higher than faba beans. PBA Pearl, Kaspa, PBA Twilight and PBA Oura were equal highest yielding, and yielded higher than the potential new release OZP1101 and PBA Wharton. PBA Wharton was the lowest yielding variety, 15% lower than Kaspa. Although it was the highest yielding variety in 2014 under more favourable conditions, long term yield performance at Minnipa suggests that PBA Wharton is in fact lower yielding than Kaspa and its performance has been variable across seasons in these environments. It is important to note that PBA Pearl is a white pea and therefore cannot be delivered to bulk export markets with dun peas. Growers are advised to secure markets before deciding to grow white peas.

Farah, PBA Samira and AF09167 were the equal highest yielding faba bean varieties, followed by Fiord which was the highest yielding variety in 2014. The newly released disease resistant variety PBA Samira yielded 8% higher than the commercial standard Nura.

The early maturing variety PBA Blitz, and PBA Bolt, a line with improved salt and boron tolerance, were the highest yielding lentil varieties. The newly released herbicide tolerant variety PBA Hurricane XT was the lowest yielding along with Nugget. Lentil grain yields were similar to 2014 yields but lower than field pea yields, most likely due to their slightly later flowering and maturity timing. With no significant rain falling from mid-September until early November, as well as high temperature events in October, lentil and faba bean appeared to be more affected than field pea during this critical grain filling period, particularly the later maturing varieties, PBA Hurricane XT and Nugget.

Overall chickpeas were the lowest yielding of the pulses evaluated, due to the combined effects of their later maturity with the late season moisture and temperature stresses. PBA Striker was the highest yielding chickpea variety, yielding 20% higher than PBA Slasher and almost doubling the yield of commercial standard Genesis™ 090. PBA Striker has performed well in low rainfall areas due to its early flowering and maturity, as well as very good early vigour. The early maturing kabuli types Genesis™ 079 and PBA Monarch had similar yields, both yielding higher than Genesis™ 090.

What does this mean?

In 2014 under favourable conditions all pulse types performed well at Minnipa and there was little separation in grain yields between them. However, hotter spring conditions in 2015 affected the performance of chickpeas, faba beans and to a lesser extent lentils more adversely than field peas, leading to lower yields than in 2014. The hot and dry finish to the growing season limited soil moisture availability through maturity, particularly impacting on chickpeas, with a 50% reduction in yields from 2014. The late season moisture stress is also expressed in the lentil results, where early maturing variety PBA Blitz was on top, while the latest maturing variety Nugget was the lowest yielding.

Field peas performed relatively well at Minnipa in 2015 and were not only the highest yielding pulse crop for the year, but also performed on par with long term yields and their 2014 performance. Field peas remain agronomically the best suited pulse crop to low rainfall farming regions, proving to be the most reliable and stable across seasons. They are better suited to low rainfall seasons over alternative pulse crops due to their relatively early maturity, high levels of winter biomass production and broader adaptation to different soil types.

Although alternative pulse crops did not perform as well as field peas in an average season, the 2014 figures in Table 1 show that under favourable conditions with a good season break, other pulse crops can be grown successfully. If opportunity arises with a good season outlook and break there are a number of things that growers need to consider for growing an alternative pulse crop. This includes paddock selection and soil type (particularly flat, free draining paddocks free of sticks and stones to improve harvestability), time of sowing, pulse agronomy, marketing and storage. Growers need to be aware of specific market requirements and in some cases on farm storage is required. Time of sowing is critical to maximise success. Previous studies have emphasised the importance of early sowing in the upper Eyre Peninsula region, as field pea yields have shown to be reduced by up to 0.2 t/ha for every week that sowing is delayed. Correct variety choice is also an important factor to consider, with newly released varieties offering earlier maturity and improvements in harvestability, disease resistance, and tolerance to herbicides. Selections should be based upon all available information.

High commodity prices in alternative pulse crops, such as lentils, continues to drive interest and area sown to these crops in South Australia. Lentils are well suited to production on the Yorke Peninsula and to the lesser extent the lower Mid North region, however further expansion is possible provided that all essential criteria for successful production is met. Be mindful that the current very high prices for lentils are unlikely to be sustainable. Despite lower prices in field peas, often their increased ease of production combined with higher yields may still make them a lower risk and more profitable pulse break crop option than lentils in low rainfall areas.

Southern PULSE Agronomy

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Assessment of alternative fungicides for improved blackspot control in field peas

Larn McMurray[1], Christine Walela[1], Jenny Davidson[2], Rohan Kimber[2] and Leigh Davis[3]

[1]SARDI Clare; [2]SARDI Waite; [3]SARDI Minnipa Agricultural Centre

RESEARCH

Almost ready

Location:
Minnipa Agricultural Centre, (site details)
Paddock S5
Hart and Pinery
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: Peas 1.96 t/ha
Actual: Peas 1.60 t/ha
Paddock History
2014: Canola
2013: Wheat/barley
2012: Wheat
Soil Type
Clay loam
Plot Size
1.5 m x 10 m x 3 reps
Yield Limiting Factors
Limited soil moisture prior to sowing, late season high temperatures and moisture stress, blackspot disease infection

Key messages

- **The optimum agronomic sowing window for field pea coincided with high blackspot risk in many districts of South Australia in 2015.**
- **Under such high disease risk situations, growers in low rainfall areas may be best suited to choose alternative break crop options to field pea to avoid significant yield losses through delayed sowing or disease infection.**
- **Experimental fungicide treatments with greater efficacy than Mancozeb showed improved blackspot control and significant yield increases over the Nil and Mancozeb treatments in 2015. Further assessment and application approval is still required.**

Why do the trial?

Blackspot or ascochyta blight, remains one of the most economically important diseases in field peas often resulting in significant yield losses either directly through infection or indirectly through delaying sowing time to minimise infection. The use of fungicides to control blackspot disease can be an important component of disease management and also assist in maintaining yield potential through enabling agronomically acceptable sowing times. Research in the Mid North of SA has shown that a fungicide application strategy, using P-Pickel T® and two foliar Mancozeb applications (9 node and early flowering) at 2 kg/ha suppresses blackspot and is generally economical in crops yielding 1.5 t/ha or greater. The aim of this project was to test the efficacy of a range of experimental (unregistered) foliar fungicides against the above strategy in controlling blackspot in field pea in three major production areas of South Australia.

How was it done?

Field pea blackspot fungicide management trials were conducted at three sites at Hart and Pinery, which represented medium rainfall zones, and Minnipa which represented the low rainfall zone. Trials were designed as Randomized Complete Block Design (RCBD), replicated three times with eight fungicide treatments and a Nil treatment. Fungicide treatments and application timings are presented in Table 1. The dual purpose (grain/forage) field pea type PBA Coogee was sown at 55 plants/m^2 at all sites due to its increased biomass production, lodging and blackspot susceptibility over Kaspa. The plot sizes were 10 m by 1.35 m with six rows sown on 12 inch (30 cm) spacings. Trial sowing dates were 30 April at Hart, 1 May at Minnipa and 7 May at Pinery. The Hart sowing date corresponded to a medium blackspot risk sowing window while Pinery and Minnipa sowing dates were within high blackspot risk sowing windows as forecasted by the Blackspot Manager, DAFWA Crop Disease Forecasts, May 2015.

Blackspot disease was assessed visually at 9 to 10 node (early bud development) and the mid to late flowering stage. Assessment at 9 to 10 node was done as percentage blackspot severity per plot while the final assessment was conducted on five individual plants selected at random from the centre of each plot and scored for the number of girdled nodes. A disease index (DI) was further developed from these scores. Only data from the 9-10 node rating has been presented in this report.

What happened?

Low summer rainfall followed by high rainfall during the month of April led to relatively late release of black spot spores in 2015 and all trials were sown into medium or high risk disease situations. The wet winter climatic conditions favoured plant growth and disease progression, and black spot infection was apparent at all sites. The Minnipa trial was spread with infected pea stubble from the previous year post sowing but prior to emergence and disease onset occurred earlier at this site. The interaction between fungicide treatment and site was significant for blackspot disease infection as measured by percentage plot disease severity at the 9-10 node stage (Table 2).

Table 1 Foliar fungicide treatments and application timings.

Treatment	Product#	Rate	Timing
Nil	Nil		
PPT	P-Pickle T®*		
Mancozeb PPT	PPT* + 2x Mancozeb (750 g/kg)	2 kg/ha	8 weeks after sowing (WAS) and early flowering
Chlorothalonil PPT	PPT*+Fortnightly Chlorothalonil (720 g/L)	2 L/ha	Fortnightly in front of rain fronts from 8 WAS
Fluid Flutriafol	Fluid injection: Flutriafol (500 g/L)	400 ml/ha	seeding
Fluid Uniform	Fluid injection: Uniform® (325 g/L Azoxystrobin & 125 g/L Metalaxyl-M)	400 ml/ha	seeding
Aviator Xpro PPT	PPT* + 2x Aviator® Xpro (75 g/L Bixafen & 150 g/L Prothioconazole)	600 ml/ha	8 WAS and early flowering
Amistar Xtra PPT	PPT *+ 2x Amistar® Xtra (200 g/L Azoxystrobin & 80 g/L Cyproconazole)	600 ml/ha	8 WAS and early flowering
Cabrio PPT	PPT* + 2x Cabrio® (250 g/L Pyraclostrobin/L)	200 ml/ha	8 WAS and early flowering

**PPT = P-Pickle T® seed treatment @ 200 ml/100 kg seed (360g/L Thiram & 200g/L Thiabendazole)*
#All treatments were treated with Apron® (350 g/L Matalaxyl-M) seed dressing to control downy mildew

Minnipa had the highest level of disease infection and it was thought that the timing of the first foliar fungicide spray occurred too late for effective control at this site. Similar levels of infection were observed at Hart and Pinery. The fluid injection Uniform and PPT treatments showed similar levels of disease infection to the Nil at all sites. Disease severity levels were lower in the Mancozeb and fluid Flutriafol when compared with the Nil, however this reduction in the Mancozeb treatment was only significant at Hart. Fortnightly Chlorothalonil treatments reduced disease infection over the Nil at Hart and Minnipa but not at Pinery, while the Amistar Xtra treatment reduced infection levels at Hart and Pinery but not at Minnipa. The Cabrio and Aviator Xpro treatments showed the highest level of disease reduction over the Nil. Further, Cabrio was also improved over Mancozeb at Hart and Aviator Xpro improved over Mancozeb at Hart and Pinery. At Hart Aviator Xpro showed an improved level of blackspot control over all other treatments.

Grain yields of field peas at all sites were reduced greatly by a very hot and windy day on 4 October which led to rapid maturity and dry down. There was no site by fungicide treatment effect for grain yield. The Hart and Minnipa sites had similar grain yields (1.6 t/ha) and Pinery was lower yielding (1.2 t/ha). Grain yields showed a very similar response to the mid flowering disease index scores (data not shown) with similar responses obtained in the Nil, Mancozeb, PPT and fluid treatments. All these treatments had both a higher disease index score and a lower grain yield than the remaining four treatments (Figure 1).

Table 2 Blackspot severity assessed at 9 to 10 node as percentage plot severity PBA Coogee under different fungicide treatments at Hart, Pinery and Minnipa, 2015.

Treatment	Hart		Minnipa		Pinery	
Nil	23.7	a.....	36.6	a...	21.1	a....
Amistar Xtra PPT	5.8	....e.	29.7	abc.	13.1	.bcd.
Aviator Xpro PPT	3.6	.....f	19.1	..cd	7.9	....e
Cabrio PPT	6.8	...de.	21.1	.bcd	12.2	..cde
Chlorothalonil PPT	9.3	..cd..	17.1	...d	14.4	abcd.
Fluid Flutriafol	15.0	.b....	22.9	.bcd	10.4	...de
Fluid Uniform	28.0	a.....	30.0	ab..	19.6	ab...
Mancozeb PPT	12.2	.bc...	29.7	abc.	16.5	abc..
PPT	28.2	a.....	26.2	abcd	18.2	abc..
Site mean	11.8		25.1		14.2	

**log base 10 back transformed data; letters indicate significance within a site only*

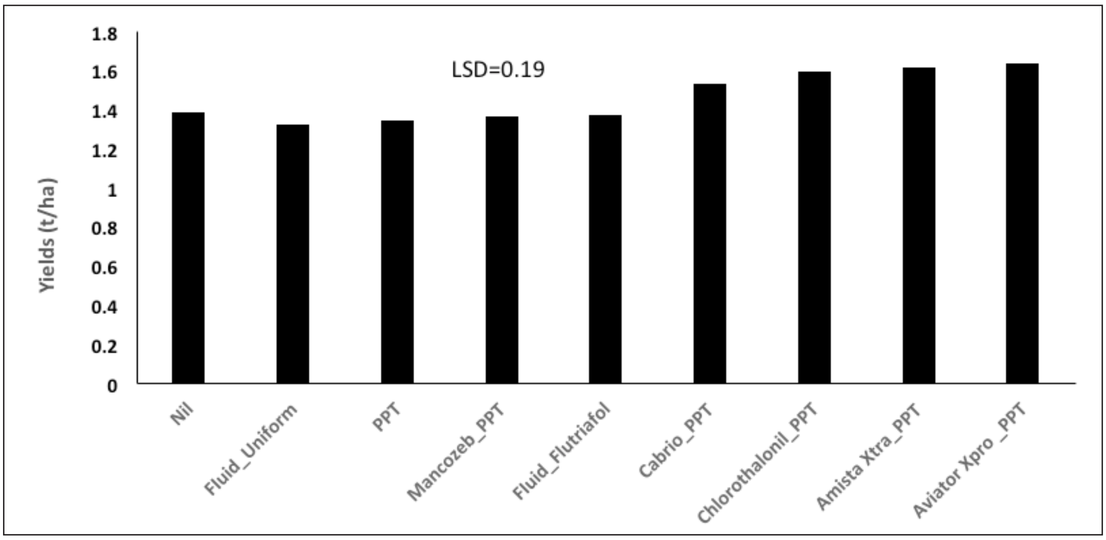


Figure 1 Mean yield (t/ha) of field pea (PBA Coogee) under different fungicide treatments averaged across three field sites, 2015.

***Some of the fungicide treatments in this research contain unregistered fungicides, application rates and timings and were undertaken for experimental purposes only. The results within this document do not constitute a recommendation for that particular use by the author or author's organisation.*

What does this mean?

Several experimental fungicides in field pea were effective in both reducing blackspot levels below and increasing grain yields above that achieved in the Nil and Mancozeb treatments at multiple field sites in SA in 2015. Disease progression and grain yield were both reduced by dry and hot spring conditions in early October at all sites and further evaluation is warranted in years and environments with more favourable spring conditions. Earlier application timings than the 8 week treatment used in these experiments may also be warranted along with additional 'spring' treatments in longer more favourable seasons.

Weather patterns experienced early in 2015 resulted in growers in many districts being advised by DAFWA's Blackspot Manager Prediction model to delay sowing of field peas in SA. This timing was often out of alignment with optimal sowing times based on best agronomic practice for some districts. Growers in these districts had to decide whether to choose an alternative crop, sow field pea into high blackspot-risk situations, or delay sowing date past the optimal window for successful production. Under these circumstances, growers could also revise their blackspot management strategy and consider recommended fungicide applications to manage this disease. This is more feasible while grain prices are high. If going against the Blackspot Manager recommendations, and choosing to sow into periods where a high risk of blackspot spore showers are predicted in your region, growers should consider an alternative break crop to field pea. However, if field peas are preferred it is important to consider the following to reduce the risk of blackspot outbreaks:

- Apply P-Pickle T seed treatment (PPT) to seed prior to sowing and follow up with current recommended fungicide strategies of two applications of Mancozeb, one at 8 weeks after sowing and one at early flowering.
- Select paddocks with no history of field pea, or paddocks with a long break period from field pea and history of a low incidence of blackspot.
- Avoid close proximity to previous field pea stubbles, particularly downstream to prevailing wind direction.
- Delay sowing as long as possible.

A number of industry support groups have reported the economic benefit of using fungicide in controlling blackspot in field pea. Results in 2015 showed the current fungicide application strategy, using PPT and two Mancozeb applications, suppressed blackspot at most sites, but previous yield benefits reported from this treatments were not realised due to the dry spring experienced in 2015. However, new fungicide actives and formulations being evaluated showed significant increases in efficacy for controlling blackspot compared to both untreated plots and those treated with Mancozeb. Furthermore, a significant yield benefit (approx. 15%) were also identified in these treatments this year. Further trials are planned in 2016 to explore these results.

Acknowledgements

Funding for this work was provided through GRDC project DAV00113 (Southern Pulse Agronomy) and their support is greatly appreciated. We also acknowledge the support of research colleagues from the SARDI teams at Clare and Minnipa. Much gratitude also goes to the land owners/managers of the different farms where the trial sites were located and to Rob Griffith Bayer CropScience Pty Ltd for providing Aviator Xpro.

SARDI

Southern PULSE Agronomy

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Improving herbicide tolerance in pulse crops

Dili Mao[1], Jeff Paull[2], Chris Preston[2], Shi Ying Yang[2], Tim Sutton[1], Simon Michelmore[1] and Larn McMurray[1]

[1]SARDI; [2]University of Adelaide

RESEARCH

Key messages

- **Germplasm with improved levels of herbicide tolerance have been successfully developed in faba bean, lentils and chickpeas.**
- **Faba bean lines are the most advanced and new varieties with tolerance to Group B herbicides are expected to be released in 3-5 years.**
- **Future work could explore the development of multiple herbicide tolerance traits in each crop, and be extended into other crops such as field pea.**

Why do this work?

Pulse crops play an important role in sustainable farming systems however the lack of safe or suitable weed control options limits their use in Australian production. Herbicides are the main method of weed control in broadacre farming systems, however with fewer new herbicides being developed, there is an increasing need to maximise the use of available products.

The aim of this project is to improve weed control options in pulse crops through the development of herbicide tolerance (HT) traits. The recent release and rapid adoption of the first HT XT lentil varieties demonstrates the likely demand for HT traits in other pulse crops, particularly faba bean where there are no in-crop broad leaved weed control options available. Further, the development of multiple herbicide tolerances, particularly for different modes of action, is important to ensure robust and sustainable weed control options into the future.

How was it done?

The GRDC funded project DAS00131 explored a number of different strategies to develop lines with improved tolerance to a number of key herbicides.

The first strategy looked at screening differences in herbicide tolerance in existing material to improve current tolerance levels. Pulse crops currently have a narrow safety margin to many of the registered herbicides in pulses, such as metribuzin, and varietal differences in HT have been observed in seasons conducive to damage. Field trials were conducted in faba bean, field pea and lentil lines to evaluate varietal differences for metribuzin tolerance using a range of rates applied post-emergent at the five node growth stage. In parallel, high throughput, rapid and repeatable screening methods were developed in controlled environment conditions to screen over 1000 diverse accessions of lentil (from the Australian Grains Genebank and PBA breeding material), and 200 lines of field pea and faba bean, for improved levels of metribuzin tolerance. Selections were validated in dose response studies to compare tolerance levels against the current best performing varieties.

The second strategy looked at generating large scale diversity using mutagenesis methods to develop novel herbicide tolerances. Mutagenesis methods have been successfully used in the development of novel herbicide tolerance traits in a number of commercialised crops. In this project, mutagenized populations of lentil, faba bean and chickpea were screened for tolerance to a range of herbicides. Selections with putative tolerance were multiplied in following seasons and validated in progeny screens, dose response studies and field trials.

What happened?

Genotypic variation for metribuzin tolerance was observed across all crops tested when evaluating varietal tolerance. In Faba beans, lines AF03109 and Nura showed no significant yield loss while Farah and 1952/1 showed significant yield loss across all rates when compared to the untreated controls (Figure 1). Similarly, in field pea lines, PBA Oura and Yarrum performed significantly better than Kaspa and Sturt at all rates (Figure 2), and the same differences were seen again in lentil with 99-088L performing significantly better than 96-047L. A number of selections were made in each crop from screening diverse accessions, and dose response studies confirmed low levels of improved tolerance in two lentil (Figure 3) and four faba bean lines. While these low levels of improved tolerance are unlikely to be sufficient for new or novel herbicide applications, they will increase current safety margins and are being incorporated into PBA breeding programs.

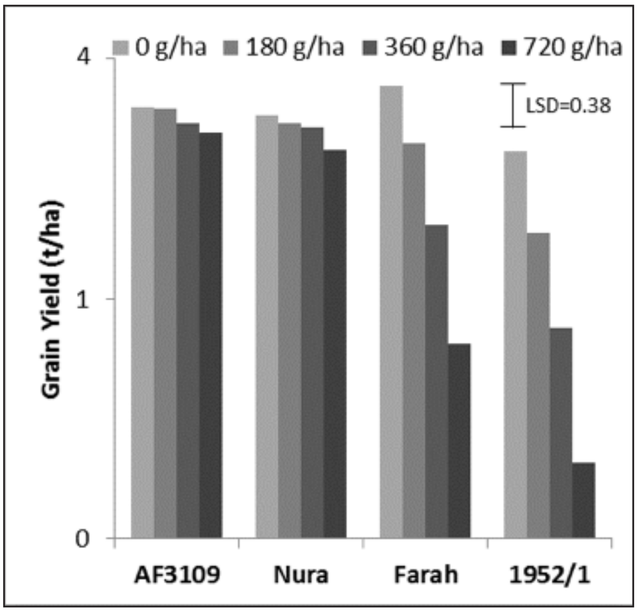


Figure 1 Yield response of faba bean lines with increasing rates of metribuzin, Turretfield 2012.

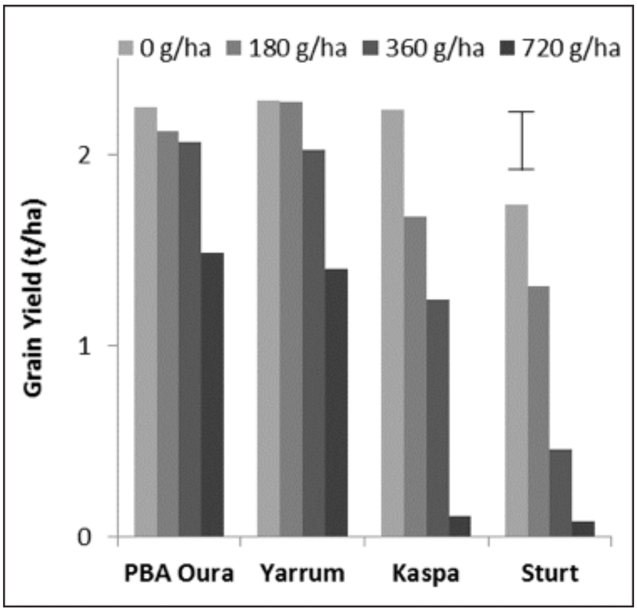


Figure 2 Yield response of field pea lines with increasing rates of metribuzin, Kybunga 2013.

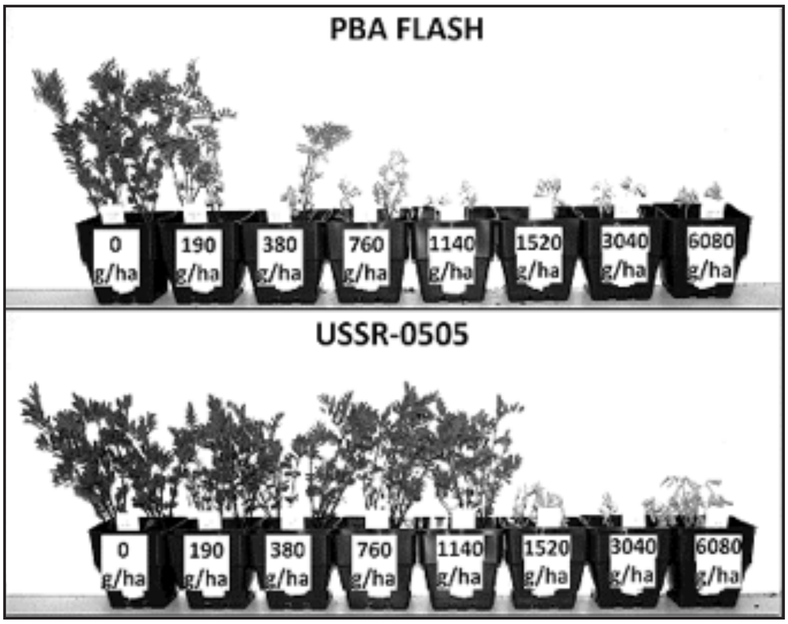


Figure 3 Lentil selection USSR-0505 showing a low level of improved tolerance compared to control cultivar PBA Flash.

Mutagenesis methods were successful in developing selections with improved herbicide tolerance in faba bean (Group B), lentil (Group C) and chickpea (Group I) as summarised below (Table 1). Dose response and field studies confirmed high levels of tolerance to imazapyr in faba beans, and metribuzin in lentils (Figures 4, 5). Preliminary dose response trials have also shown a high level of tolerance to clopyralid in chickpea selections (Figure 6).

Table 1 Summary of herbicide tolerant germplasm developed through mutagenesis methods.

	Faba Bean	Lentil	Chickpea
Mutated Cultivar	Nura	PBA Flash	PBA Hatrick
Herbicide	imazapyr	metribuzin	clopyralid
Year/s screened	2011	2011, 2012	2014
Population size screened	1.5 million M2 seeds	22 million M2 & M3 seeds	5 million M2 seeds
Field selections collected	6 M2 plants	95 M2 & M3 plants	67 M2 plants
Lines progressed with herbicide tolerance trait	4 lines	2 lines	50 lines
Level of improved tolerance developed	High	High	High
Current status of validation	Dose response experiments 2013 Field validation 2014	Dose response experiments 2014 Field validation 2015	Dose response experiments 2016

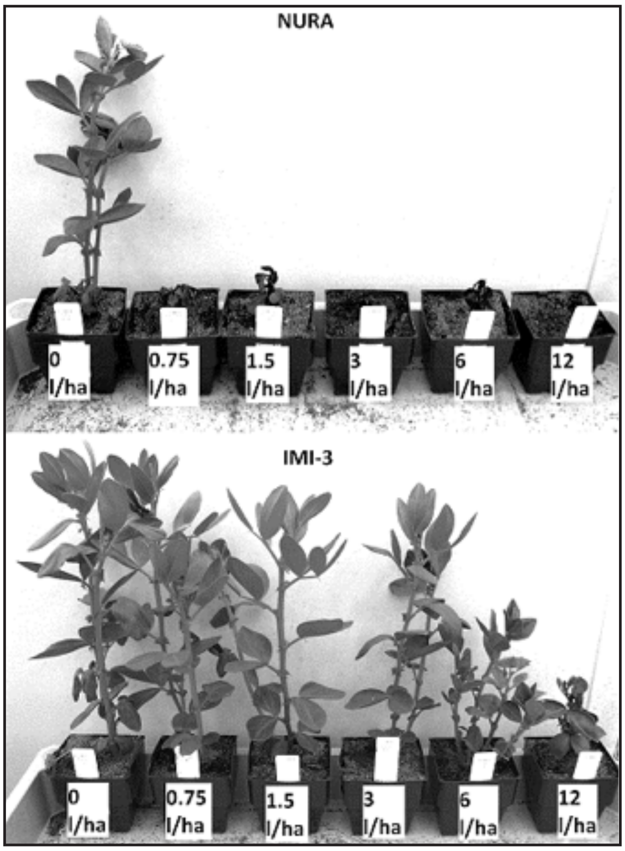


Figure 4 Tolerance of faba bean selection IMI-3 compared to control cultivar Nura with increasing rates of imazapyr from controlled environment dose response studies.

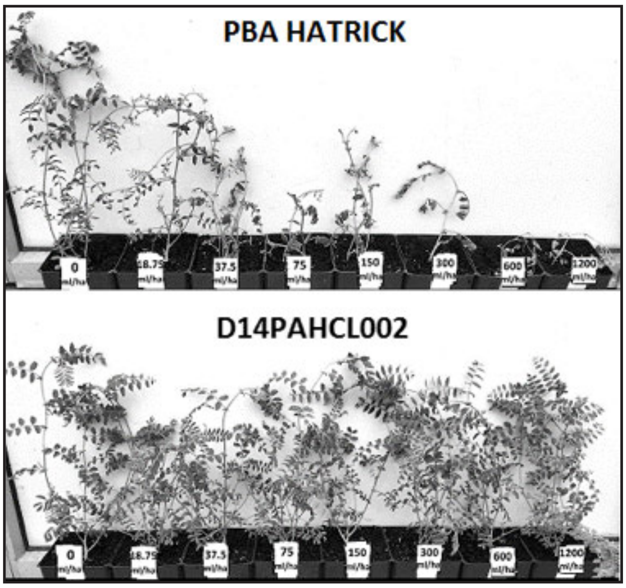


Figure 6 Photo from a preliminary dose response showing improved tolerance of chickpea selection D14PAHCL002 compared to control cultivar PBA Hatrick at increasing rates of clopyralid.

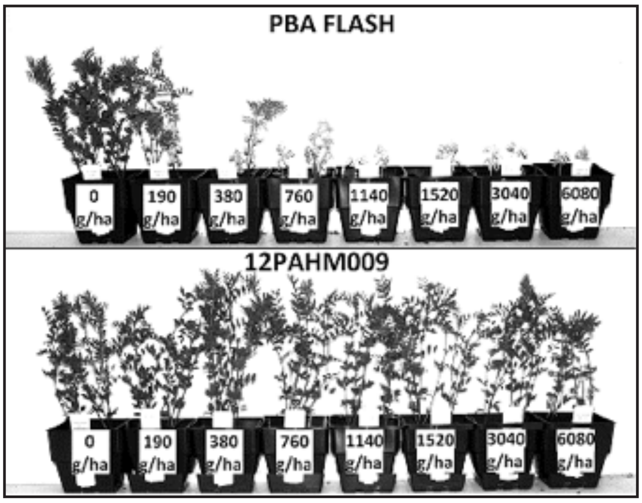


Figure 5 Tolerance of lentil selection 12PAHM009 compared to control cultivar PBA Flash with increasing rates of metribuzin from controlled environment dose response studies.

Table 2 Comparison of the relative tolerance levels of novel faba bean selections and lentil XT varieties from independent lab and field trials conducted as part of this and Southern Pulse Agronomy projects.

Crop/line	Mutation Event	Molecular Marker Developed	Imazapyr	Imazapic	Imazamox	Imazapyther	Flumetsulam	SU Soil residuals
Lentil								
PBA Hurricane	197	Yes	IT	IT	IT	IT	IT	IT
PBA Herald	197	Yes	=H	=H	=H	=H	=H	=H
Faba bean								
IMI-1	653	Yes	>H	=H	=H	=H	S	S
IMI-2	205	Yes	*	*	*	*	*	*
IMI-3	205, ?	Yes	>H	=H	=H	=H	=H	=H
IMI-4	205	Yes	*	*	*	*	*	*

*IT = improved tolerance; =H = equal to PBA Hurricane; >H = greater than PBA Hurricane; S = sensitive; * = unknown/ not yet tested*

Laboratory and field trials evaluating tolerance across Group B chemistries were compared in faba bean selections and XT lentil varieties (Table 2). Independent results suggest that Group B tolerant faba bean IMI-3 has a similar level of cross tolerance to the XT lentil varieties with improved tolerance to imidazolinone herbicides and flumetsulam, as well as a low level of improved tolerance to soil residues of some sulfonylurea (SU) herbicides (Table 2). On the other hand, while IMI-1 also shows improved tolerance to imidazolinone herbicides, it remains sensitive to flumetsulam and SU herbicides (Table 2).

PBA faba bean, lentil and chickpea are rapidly incorporating these novel herbicide tolerance traits into their elite breeding lines, including with other HT tolerant traits (e.g. PBA Hurricane XT) to develop dual HT lines where possible. The most advanced of these new traits is the Group B tolerant faba beans, with breeding material incorporating the IMI-1 and IMI-3 tolerance evaluated in South Australian field trials during 2015. The best of these lines showed average yields comparable to, if not slightly better than, the variety Nura and will be progressed to more widespread evaluation in 2016, with further multiplication undertaken in parallel for potential commercialization in 2018 or 2019.

What does this mean?

The development of lines with improved levels of herbicide tolerance will help to improve grower confidence, expand weed control options and reduce the rotational limitations of pulse crops. All traits are being progressed in PBA breeding programs and new traits will continue to be evaluated in dose response and field trials as seed becomes available. Molecular markers will continue to be developed for all traits wherever possible, however this may be difficult in selections from existing germplasm with low levels of tolerance as they are likely to be complex (multi-gene) traits. Selections from novel germplasm can potentially carry deleterious genes and further work may be required to understand any limitations associated with these new traits. Further characterization of these traits, such as evaluation of tolerance levels to other herbicides with the same mode of action, is also required to allow the best registration opportunities to be pursued. Additionally, future work in developing tolerance to different herbicides with different modes of action is also required in lentils and faba bean, and could also be extended to other crops such as field pea, to ensure robust and sustainable weed control options into the future.

Acknowledgements

Funding for this work was provided through GRDC project DAS00131 - Improving weed management in pulse crops through herbicide tolerance—Part B (previously DAS00107) and their support is gratefully acknowledged. We also gratefully acknowledge the ongoing help and support of the many research colleagues and farming collaborators whom without this work would not be possible, including the SARDI team at Clare, the University of Adelaide faba bean and weed science research groups, Yorke Peninsula grower Mark Schilling, and many others.

Break Crops

Comparing break crop performance in the SA Mallee

RESEARCH

Michael Moodie[1], Nigel Wilhelm[2] and Ray Correll[3]

[1]Mallee Sustainable Farming, Mildura; [2]SARDI, Waite Campus; [3]Rho Environmetrics Pty Ltd, Adelaide

Almost ready

Location:
Loxton and Waikerie -
Northen South Australian Mallee
Brenton Kroehn (Waikerie) and
Bulla Burra (Loxton)
Mallee Sustainable Farming and
Lowbank Ag Bureau
Rainfall
Av. Annual: 260 mm
Av. GSR: 170 mm
2015 Total: 193-220mm (Nov - Mar)
2015 GSR: 133-145mm (Apr - Oct)
Paddock History
Waikerie
2014: Wheat
2013: Medic pasture
2012: Wheat
Loxton
2014: Wheat
2013: Wheat
2012: Juncea canola
Soil Type
Loxton Flat: Red loam
Loxton Sand: Deep yellow sand
Waikerie Sand: Red sandy loam
Waikerie Flat: Shallow red-grey clay loam
Diseases
Nil
Plot Size
2 m x 15 m x 4 reps
Yield Limiting Factors
Frost, heat, drying spring

Key messages

- **Break crops faced a range of tough environmental conditions in the Mallee in 2015 including multiple frost and heat shock events.**
- **Timely rainfall in April and hence early sowing resulted in excellent biomass production with most crop options producing on average more than 2 t DM/ha and several break crop options producing greater than 2.5 t DM/ha.**
- **The highest grain yields tended to be crops with the quickest maturity such as lentils (0.73 t/ha), vetch (0.64 t/ha) and field peas (0.63 t/ha).**
- **High value crops such as lentils and vetch were highly profitable due to both excellent prices and reasonable grain yields.**
- **Break crop productivity and profitability was very different between common Mallee soil types.**

Why do the trial?

Mallee farmers are looking to increase the proportion and diversity of broadleaved break crops in their paddock rotations, however very little localised information is available to support break crop selection and management in low rainfall environments. Furthermore, there is extreme soil type variability between Mallee paddocks, which adds additional complexity when selecting an appropriate break crop for these farming systems. To address these knowledge gaps, Mallee Sustainable Farming Inc, with funding from SAGIT, commenced a three-year project in 2015 to compare broadleaved break crop performance across four soil types in the northern Mallee of South Australia (SA). The aim of these trials is to provide farmers with information on the relative productivity of legume break crops in this low rainfall Mallee region.

How was it done?

The trials were located at Waikerie and Loxton in the northern Mallee of SA with one trial located on each of two contrasting soil types within the same paddock. A brief description of each of the four trial sites is provided below:

- Loxton Flat: Red loam located in a swale
- Loxton Sand: Deep yellow sand located on the top of an east-west dune
- Waikerie Flat: Heavy red-grey soil with limestone from 20-30 cm below the surface
- Waikerie Sand: Red sandy loam located mid-slope

Each trial had nine different broadleaved crop options replicated four times. Table 1 shows the crop type, variety, target plant population and seeding rate used for each treatment. Each treatment at each site was managed independently to ensure that it had every opportunity to reach its potential. Agronomic management differences included herbicide choice, fertiliser rates and fungicide and pesticide applications.

The Loxton sites were sown on 28 April 2015 and the Waikerie site on 1 May 2015. All plots received 100 kg/ha of single super phosphate banded below the seed and all legumes were inoculated just prior to seeding with their specific Rhizobian strain using a peat inoculant. All canola received an additional 100 kg/ha of urea applied immediately prior to sowing and incorporated by the sowing operation. Pre-emergence herbicide packages and rates were specific for each treatment and soil type. Grass weeds were controlled with an application of clethodim and haloxyfop on 26 June. Broadleaved weeds were controlled to an acceptable level by the knockdown and pre-emergence herbicide applications. Cowpea aphids at the Loxton trial sites were controlled by an application of omethoate on 9 July. Cabbage aphids and native budworm were controlled at all sites on 12 September using a mixture of pirimicarb and alpha-cypermethrin.

Crop performance was assessed by measuring establishment, peak crop biomass and grain yield. The trials were machine harvested across three dates from late-October to mid-November to ensure grain yield was measured soon after crops matured. Rainfall was recorded at both locations using automatic rain gauges and temperature was recorded at hourly intervals using iButton temperature loggers. One logger was placed at a height of 1.2 m above ground level (similar to official met gauges) and the other at 0.5 m to reflect crop canopy height.

Gross margins were calculated for each treatment using the Rural Solutions Farm Gross Margin and Enterprise Planning Guide 2015. The January grain prices from the 2016 guide were used to undertake the economic analysis (Table 1).

Table 1 Break crop treatment details for Loxton and Waikerie trial sites.

Crop	Variety	Target (plants/m^2)	Seeding rate (kg/ha)	Price ($/t)
Field pea	PBA Wharton	45	90	550
Vetch	Rasina	60	40	850
Narrow-leaved lupin	PBA Barlock	50	90	380
Albus lupin	Luxor	35	120	380
Faba bean	PBA Samira	20	140	560
Lentil	PBA Hurricane	120	50	1340
Desi chickpea	PBA Striker	45	100	950
Kabuli chickpea	Genesis 090	35	120	1050
Canola	Stingray	40	2.5	530

What happened?

Seasonal Conditions

Rainfall in 2015 was below average at both sites with 193 mm recorded at Loxton and 220 mm recorded at Waikerie from November 2014 to October 2015. Growing season rainfall was also below average with Loxton receiving 145 mm and Waikerie 133 mm. However, both sites received timely rainfall of approximately 40 mm in mid-April and a further 30-40 mm in the month of September.

Both trials were impacted by extremely low and high temperatures during the flowering and grain filling period (mid-August to mid-October) (Table 2). The coldest temperatures were recorded on 30 and 31 August when minimum temperatures were between -4 and -5°C at the Waikerie and Loxton flat sites respectively. There were fewer frost events at both sand sites due to their higher elevation within the paddock with minimum temperatures of -1 and -2.4°C recorded at the respective Waikerie and Loxton sites at the end of August. Both sites were also subject to a number of heat events during the flowering and grain fill period (Table 2) with three consecutive days of near or above 40°C at the beginning of October.

Biomass production

Field pea produced the greatest biomass with an average of 3.1 t DM/ha across all four trial sites and no less than 2.7 t DM/ha at any one site (Table 3). Canola, vetch and lentil produced similar levels of biomass with 2.5 – 2.7 t DM/ha on average while desi chickpea, narrow leaved lupin and faba bean produced 2.1 – 2.3 t DM/ha across all sites. The lowest levels of biomass were produced by kabuli chickpea and albus lupins. Each crop produced its greatest biomass at the Loxton flat site with the exception of narrow leaf lupin and canola which performed best on the Loxton sand. The biomass produced by vetch was least on the Waikerie flat (<2.5 t DM/ha) than at the other three sites.

Table 2 Number of days between 15 August and 15 October 2015 with a minimum temperature below 0°C or a maximum temperature above 30°C and 35°C at each trial site.

Site	Days<0°C	Days>30°C	Days>35°C
Loxton Flat	12	17	9
Loxton Sand	3	15	5
Waikerie Flat	9	16	8
Waikerie Sand	4	14	5

Note: Temperature loggers were placed at 50 cm from ground level to reflect crop canopy height.

Table 3 Peak biomass (t DM/ha) for each trial site and as an overall average across all sites.

Treatment	Loxton Flat	Loxton Sand	Waikerie Flat	Waikerie Sand	Overall
Albus lupin	1.62	1.22	1.28	1.59	1.43
Kabuli chickpea	2.17	1.30	1.48	1.58	1.63
Desi chickpea	2.74	1.57	1.85	2.19	2.09
Narrow-leaved lupin	2.56	265	1.97	1.71	2.22
Faba bean	3.01	2.09	2.20	1.94	2.31
Lentils	3.28	2.62	2.10	2.19	2.55
Vetch	3.41	2.97	1.80	2.55	2.68
Canola	2.49	2.96	2.94	2.40	2.70
Field pea	3.57	3.30	2.67	3.00	3.14
P value	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
LSD (P=0.05)	*0.54*	*0.63*	*0.46*	*0.42*	*0.50*

Grain yield

Across all sites (Table 4), lentils had both the most consistent and the highest average grain yield (0.73 t/ha). Field peas only averaged 0.64 t/ha despite having the highest individual yield at any one site of 1.2 t/ha at the Waikerie sand. Field pea yields were particularly affected by frost on the Loxton and Waikerie flat sites. Vetch grain yields were also good with 0.63 t/ha while narrow leaf lupins, canola and faba bean yielded similarly at 0.5 – 0.53 t/ha. The later maturing crops, chickpeas and albus lupins, performed the worst in 2015 with average yields below 0.5 t/ha. Very low yields were obtained from these crops on the soils with the lowest water holding capacity at each site; Loxton sand and Waikerie flat.

Table 4 Grain yield (t/ha) for each trial site and as an overall average across all sites.

Treatment	Loxton Flat	Loxton Sand	Waikerie Flat	Waikerie Sand	Overall
Albus Lupin	0.28	0.14	0.02	0.30	0.18
Kabuli Chickpea	0.43	0.22	0.05	0.45	0.29
Desi Chickpea	0.55	0.30	0.09	0.77	0.43
Narrow-leaved Lupin	0.71	0.60	0.20	0.49	0.50
Canola	0.52	0.69	0.20	0.66	0.52
Faba bean	0.83	0.55	0.29	0.46	0.53
Vetch	0.77	0.86	0.19	0.69	0.63
Field Pea	0.58	0.71	0.16	1.21	0.66
Lentils	0.96	0.64	0.48	0.82	0.72
P value	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*0.001*
LSD (P=0.05)	*0.12*	*0.19*	*0.09*	*0.09*	*0.23*

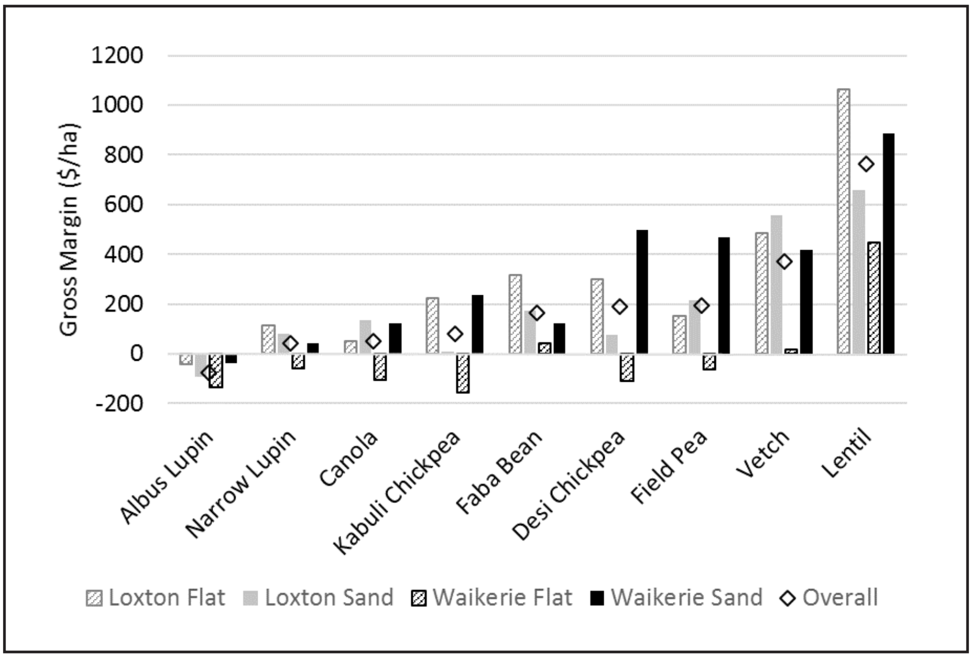


Figure 1 Gross margin for each break crop at the four trial sites and for the overall average yield across all sites.

Profitability

Lentils were the most profitable break crop option on all soil types in 2015, and averaged nearly $800/ha profit across all sites (Figure 1). This is a reflection of the extremely high price of $1340/t and high and constant yields across all sites relative to the other break crops. Vetch grain which also had a relatively high price was also a profitable option on all soils except the Waikerie flat. Field pea, faba bean and chickpeas returned $75 - $200/ha across all sites while canola and narrow leaf lupins usually broke even. Albus lupins were not a profitable option at any site.

What does this mean?

In 2015, break crops faced a range of tough environmental conditions in the Mallee, however some options still proved to be both productive and profitable. Timely rainfall in April and hence early sowing resulted in excellent biomass production with most crop options producing on average more than 2 t DM/ha and many break crop options producing greater than 2.5 t DM/ha. This is an important consideration where farmers are looking to increase nitrogen levels in their soil because every tonne of above ground legume dry matter is likely to result in 15-25 kg N/ha added to the soil (where legumes are well nodulated). The highest grain yields tended to be crops with the quickest maturity such as lentils, vetch and field pea which handled the hot dry finish to the season better than later crops such as chickpea and lupins.

High value crops such as lentils and vetch were highly profitable due to excellent prices and reasonable average grain yields. A high grain price also helped both chickpea crops (desi and kabuli) to be profitable despite poor grain yields (although quality was not considered and may have been an issue at some sites). Field pea and chickpea have been the most profitable break crop options in recent trials in the Victorian Mallee where they were the highest yielding treatments in kinder seasons (Moodie *et al*., 2015).

These trials highlight significant variability in the productivity and profitability between the break crop options that may be considered by Mallee farmers. Furthermore, there was large variation in break crop productivity and profitability between the soil types commonly found in Mallee paddocks. Trials are continuing at all four sites in 2016 and 2017 to evaluate break crop performance across seasons and provide Mallee farmers with greater confidence when selecting break crops for inclusion in their farming system.

References

Moodie, M., Wilhelm, N and McDonald, T (2015). *Productive and profitable pulse crops in the Northern Victorian Mallee.* Mallee Sustainable Farming Results Compendium 2013. http://msfp.org.au/wp-content/uploads/2015/02/Moodie_Pulse-Crops-in-Vic-Mallee.pdf

Rural Solutions SA (2015 and 2016). *Farm Gross Margin and Enterprise Planning Guide.* http://www.grdc.com.au/FarmGrossMarginGuide

Acknowledgements

South Australian Grain Industry Trust (SAGIT) for providing funding for this project, Adopting profitable crop sequences in the SA Mallee (MSF115). Matt Whitney (Dodgshun Medlin) for providing advice on trial management. Todd McDonald (MSF) and Peter Telfer (SARDI) for their technical assistance on the trial. Brenton Kroehn and the Lowbank Ag Bureau for assistance in selecting and setting up the Waikerie site and Bulla Burra staff for assistance at the Loxton site.

SAGIT

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

MALLEE SUSTAINABLE FARMING INC.

Vetch for grain and hay on EP

Stuart Nagel[1], Gregg Kirby[1] and Leigh Davis[2]

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

RESEARCH

Almost ready

Location:
Minnipa Agricultural Centre, paddock S5
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential:
Grain: 2-2.5 t/ha
Dry matter: 5-6 t/ha
Actual:
Grain: Site mean 1.4 t/ha, highest 2.1 t/ha
Dry matter: Site mean 4.1 t/ha, highest 4.3 t/ha
Paddock History
2014: Wheat
2013: Barley
2012: Canola
Soil Type
Red Loam
Diseases
No disease was observed
Plot Size
1.5 m x 10 m x 3 reps
Yield Limiting Factors
None

Location:
Piednippie/Haslam - Trezona
Rainfall
Av. Annual: 324 mm
Av. GSR: 220 mm
2015 Total: 189 mm
2015 GSR: 147 mm
Yield
Potential: 2-3 t/ha dry matter
Actual: site mean 1.1 t/ha, highest 1.5 t/ha
Paddock History
2015: Canola
2014: Axe wheat
2013: Grass free medic pasture
Soil Type
Grey calcareous sand
Diseases
No disease was observed
Plot Size
1.5 m x 10 m x 3 reps
Yield Limiting Factors
Poor sub moisture at sowing, with no significant follow up rainfall event until mid June

Key messages

- **Vetch grain and dry matter yields were very good at Minnipa in 2015, the grain trial mean was 1.4 t/ha with the top lines achieving 2.1 t/ha, mean dry matter yields were 4.1 t/ha with the top line achieving 4.3 t/ha.**
- **The Piednippie SAGIT trial was poor, suffering from moisture stress post emergence which stunted growth and limited the potential once the crop received rain in mid-June, the site mean was only 1.1 t/ha of dry matter.**
- **Early sowing (mid-April) can achieve good results but is heavily reliant on either good subsoil moisture or follow-up rain.**
- **The new varieties, Volga and Timok continue to out yield all existing varieties in both grain and hay production on the EP.**
- **Herbicide choices for vetch are very dependent on local conditions so talk to your local agronomist about the best options for your conditions.**

Why do the trial?

The vetch trials on Eyre Peninsula in 2015 were expanded to include a primary trial of breeding material funded by GRDC, at Minnipa, to investigate advanced common vetch lines with specific traits best suited to this region, and enable comparison with other sites in the southern cropping region.

SAGIT trials looking at vetch for a genuine legume break crop option for cereal and mixed farmers in the marginal cropping areas of South Australia were conducted at Piednippie and Minnipa. Other trials were conducted at Morchard, Loxton and Kingsford research centre.

How was it done?

The objective of this research is to investigate material bred in GRDC funded projects, which may not have been suitable for broad scale release, but may be locally adapted to these areas with the potential to be used as new varieties specifically for the local area.

For the best weed control, particularly for broadleaved weeds, it can be most economical and effective to control pre-sowing by allowing time for a germination and kill with appropriate chemicals pre-sowing, combined with the use of IBS or PSPE chemicals (like diuron, simazine and metribuzine) This is not always practical when dry sowing or taking advantage of an early break, however it is very effective when the season permits as there is no currently registered chemicals for in-crop broadleaved weed control in vetch. As mentioned above talk to your local agronomist for the best options for your conditions.

What happened?

An excellent early rain in April at Minnipa saw sowing commence on 22 April, earlier than traditional planting times but there was excellent soil moisture. This allowed good early establishment, and the strong early vigour produced the very good grain and dry matter yields achieved in 2015 (Table 3). There had been some reports of rust at the Minnipa Agricultural Centre in 2014 but there were no major disease problems in 2015.

Table 1 Trial details for Minnipa 2015.

Sowing date	SAGIT Vetch GRDC Primary Vetch	22 April 23 April
Fertiliser	No fertiliser	
Pre sowing chemicals	2.0 L/ha Sprayseed +1.5 L/ha TriflurX	22 April
Post sowing, pre- emergent	300 g/ha Diuron + 100 g/ha Lexone + 1.0 L/ha Lorsban PSPE	23 April
Insecticides	200 ml/ha Lemat	11 June
	500 ml/ha Asound Duo + 200 ml/ha LeMat	13 July
	1 L/ha Astound Duo + 200 ml/ha Dimethoate	7 Sept
Grass herbicides	180 ml/ha Elantra Xtreme + 1 L/100L Kwicken + 500 ml/ha Astound Duo	25 June
Hay cut	SAGIT Vetch, cut for hay	9 Sept
Desiccation	2 L/ha Gramoxone	20 Oct
Grain harvest	GRDC Primary Vetch	30 Oct

Table 2 Trial details for Piednippie 2015.

Sowing date		27 April
Fertiliser	No Fertiliser	
Pre sowing chemicals	1.5 L/ha Sprayseed + 1.5 L/ha TriflurX + 400 g/ha Diuron + 100 g/ha Lexone + 1.5 L/ha Lorsban (IBS)	27 April
Grass herbicides	185 ml/ha Elantra Xtreme + 500 ml/ha Astound Duo+1 L/ha/100L Kwicken	25 June
Hay cut	Cut for hay	8 Sept

Table 3 Mean dry matter yields for Minnipa and Piednippie 2015.

Genotype	Minnipa			Piednippie		
	Rank	Dry matter (t/ha)	% Timok	Rank	Dry matter (t/ha)	% Timok
34559	8	4.12	96.7	18	1.02	88.1
34748	13	4.01	94.1	5	1.28	110.0
34822	4	4.23	99.3	17	1.03	88.5
34831	9	4.11	96.6	9	1.22	104.8
34842	1	4.37	102.6	8	1.22	105.2
34876	7	4.14	97.2	12	1.15	99.3
34883	16	3.98	93.4	3	1.32	113.3
34885	2	4.29	100.8	6	1.26	108.7
35019	19	3.82	89.8	15	1.08	92.6
35036	18	3.85	90.4	14	1.08	93.1
35122	10	4.07	95.5	2	1.33	114.8
37003	11	4.05	95.1	16	1.07	91.9
37058	6	4.15	97.5	10	1.22	104.7
37107	20	3.69	86.7	13	1.09	93.5
37457	17	3.96	93.0	4	1.30	111.9
34823-2	5	4.20	98.5	7	1.23	106.1
35427-1	14	3.99	93.7	20	1.02	87.6
Rasina	15	3.98	93.5	19	1.02	87.7
Timok	3	4.26	100.0	11	1.16	100.0
Volga	12	4.01	94.1	1	1.51	129.5

Table 4 Grain yield of selected lines from Minnipa GRDC primary trial, 2015.

Genotype	Grain Yield (t/ha)	% Timok
37731	2.16	122.4
37670	2.09	118.7
35444-3	2.04	115.9
37695	2.03	115.2
37654	2.02	114.7
35427-1	1.94	109.9
37102	1.91	108.2
Volga	1.86	105.7
Timok	1.76	100.0
34876	1.72	97.3
37107	1.62	91.7
Rasina	1.51	85.5
Blanchefleur	1.35	76.3
Morava	1.15	65.0
Site Mean	**1.41**	

The trial at Piednippie was sown after a false break in mid-April. It did not receive any further significant rainfall until mid-June. The trial emerged well but this prolonged period of moisture stress severely set back the vetch potential and it never fully recovered. Weed control was good early but the June rains enabled a good germination of medics. The medic competed with the vetch as the season progressed, due to a lack of sufficient competition/ canopy in the vetch, affecting the vetch yields. The vetch and medic mix would have produced a productive pasture.

Of the existing and new varieties trialled in 2015 Timok and Volga again performed well, both out yielding all other current varieties in both grain and dry matter production. In both trials at Minnipa a number of lines out yielded these new varieties, with some of the newer crosses showing impressive grain yields. These lines were not in the dry matter trials, so their performances for dry matter production will need to be assessed.

The rainfall during July (35 mm) and August (80 mm) at Minnipa meant the later lines and varieties yielded well in the SAGIT trial. In previous years later lines suffered yield penalties due to lack of late winter/early spring rainfall (in 2014 Minnipa only received 6 mm in August). This good rainfall produced contrasting results from 2014, where SA 37107 and SA 34748 were the highest yielding lines. In 2015 these lines were among the lower yielding. Over the 2 years of trials SA 34876 and SA34823-2 achieved more consistent yields of dry matter and SA 34876 in particular showed impressive early vigour and winter growth across both years.

Disease screening of the lines in the SAGIT trials is ongoing as trials conducted in 2015 were inconclusive. Recommendations on material suitable for release from this project will be made after the conclusion of the 2016 season.

What does this mean?

These trials demonstrate vetch can yield well in both grain and dry matter on Eyre Peninsula. The yields combined with the recognised benefits vetch provides to the cropping rotation of nitrogen fixation, a disease break, especially Rhizoctonia, and chance to control grass weeds, show vetch can be an integral part of a profitable farming system.

For more information on the value of vetch in crop rotations see an article by Dr Chris McDonough http://msfp.org.au/vetch-maximises-n-advantage/

The new varieties Volga (Heritage Seeds) and Timok (Seed Distributors) were available for purchase in 2016. Both companies report that they have sold out of seed this season, so for access to seed for next season order now.

The trials have shown that there is some promising material in the breeding program that can out yield existing varieties.

2016 will be the final set of SAGIT trials to identify lines with the potential to fit into the cropping system on western EP. There are lines which have shown excellent early vigour and winter growth which would benefit a mixed farming system.

The GRDC trials have shown impressive yield potential of several new lines, that have performed well both on EP and across the state. These lines require further research to validate their potential.

Acknowledgements

The National Vetch Breeding Program would like to thank SAGIT (project code S914), GRDC (DAS 00149), RIRDC and SARDI for funding this program and acknowledge the ongoing support and interest provided by Australian farmers. Farmers and not for profit farmer groups and organisations provide trial sites, feedback, advice, recommendations and their wish lists for future varieties to the program all of which are gratefully received and appreciated.

Green Cumin – is it a new break crop for the Eyre Peninsula?

RESEARCH

Nigel Wilhelm, Leigh Davis and Naomi Scholz
SARDI, Minnipa Agricultural Centre

Searching for answers

Location:
Minnipa Agricultural Centre, paddock S5
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Paddock History
2015: Vetch
2014: Wheat
Soil Type
Calcareous red sandy loam
Plot Size
2 m x 10 m x 4 reps x 4 ha block

Location:
Piednippie
Rainfall
Av. Annual: 290 mm
Av. GSR: 230 mm
2015 Total: 254 mm
2015 GSR: 212 mm
Paddock History
2015: Canola
2014: Wheat
2013: Grass free medic pasture
Soil Type
Grey highly calcareous sandy loam
Plot Size
2 m x 10 m x 4 reps

Location:
Port Kenny
Rainfall
Av. Annual: 400 mm
Av. GSR: 300 mm
2015 Total: 284 mm
2015 GSR: 241 mm
Paddock History
2015: Canola
2014: Barley
2013: Wheat
Soil Type
Calcareous loamy sand
Plot Size
2 m x 10 m x 4 reps

Key messages

- **Green cumin (*Cuminum cyminum*) is a tap-rooted herb grown extensively in India and the Middle East for its grain.**
- **It survived trials on Eyre Peninsula in 2015 sufficiently well to encourage another look.**
- **Alternaria fungal disease is a major threat.**
- **Its low and slow growth will complicate harvesting and weed control.**

Why do the trial?

Cumin is a herb in the parsley and carrot family which is grown in northern India and the Middle East. The seed is used as a traditional spice ingredient of kormas, masalas, and soups, and forms the basis of many other spice blends. Global production is estimated at around 600,000 tonnes. Elite cumin varieties are being evaluated across a range of Australian locations because of its high value (up to $2,000 per tonne). SARDI were approached by Blue Ribbon Seeds and Pulse Exporters Pty Ltd to investigate its viability in southern Australian environments. It is also being tested in Western Australia. Regional site selection is based on conditions that best replicate where cumin is already grown in India and the Middle East, including the following characteristics:

- Neutral to alkaline sandy loams over heavier subsoils.
- Regions with a well-defined and reliable early break to the winter season. Ideally cumin prefers most of the in-crop rainfall in the first half of the season and then a dry finish.
- Dry spring conditions to minimise Alternaria fungal infection.

The attraction of cumin as a potential new crop for upper Eyre Peninsula is that it has a reputation for being drought tolerant, is unrelated to other current crops or pastures, produces a high value commodity, a market is already established and, although an entirely new plant for southern Australia, has some herbicides and pesticides already suitable for use. Its weaknesses are that it is not a tall crop (typically only 30-50 cm high) and is a poor competitor with weeds.

The agreement with Blue Ribbon Seeds was for SARDI to undertake initial evaluation of an elite cumin line at a range of locations on the upper Eyre Peninsula. Blue Ribbon would also undertake assessment of cumin quality (oil quality) attributes within their international markets.

How was it done?

Four replicated trials were established, three on the upper EP (Minnipa Ag Centre, Piednippie, Port Kenny) and one on lower EP (as a high rainfall comparison). While cumin has a reputation for being a tough crop which requires few inputs, we know little of the agronomic needs of this crop under EP conditions. For this reason, each trial was set up with 3 treatments (low, medium and high input). Medium input was a package of 23 kg/ha of pelleted seed and 50 kg/ha of DAP applied with the seed which was recommended by Blue Ribbon Seeds for a crop yielding 1 t/ha. The low input package was 15 kg/ha of seed and 25 kg/ha of DAP while the high input was 33 kg/ha of seed with 50 kg/ha of DAP plus 50 kg/ha of urea in season. Trials were sown in late April (Piednippie and Minnipa) and mid May (Port Kenny) at 1-2 cm.

Weed control was achieved with a pre-seeding application of a knock down (Sprayseed or glyphosate), 1.5 L/ha of Triflur X, in crop application of Select for grass control and 1.2 L/ha of Linuron (a horticultural herbicide) for broad leaved weeds.

Table 1 Strengths and weaknesses of green cumin.

Strengths	Weaknesses
Very high value product	Yields in 2015 were low
Unrelated to current crops and pastures so should have different disease and pest profiles	Very vulnerable to *Alternaria burnsii* foliar disease
Survived some pretty tough periods during 2015	
Grew extremely well in some patches and looked very healthy despite calcareous soils	Despite its strong aroma, can be a target for pests late in the season
Despite being short, seeds are held near the top of the plant and stems are quite tough	It is a short crop so harvesting low enough can be an issue
Established well despite some very marginal and rough seeding conditions	Performance over a range of local seasons and soil types still unknown
There are herbicides available which will control broadleaved and grassy weeds	Slow to establish and grow so a poor competitor with weeds
A market already exists. Cumin is the second largest traded spice in the world, behind pepper	

Early pest control was achieved with a pre-seeding application of 1 L/ha of Lorsban and for Piednippie, an in crop application of 185 ml/ha of Elantra Xtreme plus 500 ml/ha of Astound Duo was also used.

A broadacre strip of cumin was also set up and managed on Minnipa Agricultural Centre by the farm staff. This strip was approximately 3 hectares in size and was sown with the Horwood Bagshaw precision bar on 24 April. The strip was sown with 15 kg/ha of pelleted seed and 60 kg/ha of DAP after a knockdown spray of 1.2 L/ha of Gramoxone 250 and 1 L/ha of Triflur X. In crop weed control was Clethodim for grasses and 1.2 L/ha of Linuron for broad leaved weeds.

What happened?

For the two sites which were sown under reasonable conditions (MAC broadacre and Wanilla), plants emerged and established well, but for the other sites emergence was slow and patchy. An even stand of plants eventually developed in the Minnipa small plot trial, but early growth at all sites was slow.

Wet conditions during August triggered an epidemic of *Alternaria burnsii* (a fungal disease which attacks the canopy and flowers) in the cumin stands. This disease is well known in cumin overseas but was not expected on EP given that this was the first time that cumin had been grown in the area. While patchy in the broad acre strip, this epidemic decimated most of the small plot trial and only one replicate was harvested.

While slow, the remaining healthy cumin plants developed to budding at Minnipa by the beginning of September. Late in grain filling, seed in the broadacre strip was extensively chewed by a pest (SARDI entomologists are confident it was earwigs) but in the better areas cumin yielded 400 kg/ha of uncleaned seed (current contract prices for cumin are $1,800 per tonne). The remaining replicate of the small plot trial yielded 200-300 kg/ha of un-cleaned seed.

Despite the poor season at Port Kenny (GSR of 241 mm), cumin survived (just) and yielded about 150 kg/ha of uncleaned seed, regardless of management package.

The Piednippie site was always severely drought-stressed and was not harvested. The cumin at least survived the very tough conditions up until maturity.

The Wanilla trial was severely damaged by herbicide spray drift early in the season and was not continued.

A sample of grain from our trials will be assessed for quality by Blue Ribbon Seeds.

What does this mean?

Our impressions from this first year of experience with cumin is that it showed sufficient promise to justify further testing of its performance under upper EP conditions. We are currently negotiating with Blue Ribbon Seeds for another programme of testing in 2016 and we are optimistic that further work will occur.

In summary, the strengths and weaknesses of cumin as a break crop for upper EP, including experiences from 2015 are listed in Table 1.

If work were to continue into 2016, we would improve our management based on 2015 experiences by:

- Rolling after seeding to allow lower and smoother harvesting.
- Late April planting to set up sufficient growth to support yields of 0.8-1.0 t/ha.
- Applying preventative fungicides during wet periods in August-September to minimise Alternaria impacts.
- Close monitoring during flowering and grain fill for pests.

Acknowledgements

Thank you to MAC farm staff for the broadacre strip and to Brenton Spriggs & Andrew Ware for technical support of the small plot trials. Also thanks to Mike Lucy (Alliance Agricultural Consulting) for coordinating the work with Blue Ribbon Seeds.

Section Editor:
Andrew Ware
SARDI, Minnipa Agricultural Centre

Section
3

RESEARCH

Disease

Cereal variety disease guide 2016

Hugh Wallwork and Pamela Zwer
SARDI, Waite

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 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 article 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.

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

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Wheat	Rust			*Septoria tritici* blotch	CCN Resistance	Yellow leaf spot	Powdery mildew	Root lesion nematodes		Crown rot	Common root rot	Flag smut	Black point ‡	Quality in SA
	Stem	Stripe	Leaf					*P. neglectus*	*P. thornei*					
Adagio	SVS	RMR	MS	MRMS	S	MRMS	MR	MS	MS	SVS	MS	MS	–	Red feed
Axe	MS	RMR	S	SVS	S	S	MS	MSS	MS	S	MSS	S	S	AH
Beckom	MR	MRMS	S	SVS	R	MSS	–	MSS	MS	S	MSS	MR	–	AH
Cobra	RMR	MSS	MR	MSS	MS	MRMS	MRMS	MSS	MSS	S	MSS	S	MS	AH
Corack	MR	MS	SVS	SVS	RMR	MR	SVS	MSS	S	S	MS	S	S	APW
Cosmick	MS	MS	SVS	S	S	MRMS	MS	MSS	MSS	S	MSS	SVS	–	AH
Cutlass	R	MS	RMR	MSS	MR	MSS	–	–	–	–	–	–	MS	APW
Darwin	MR	MR	SVS	SVS	MSS	S	–	MSS	S	S	MSS	MR	MR	AH
Emu Rock	MRMS	MRMS	S	SVS	S	MRMS	S	MSS	S	MS	MSS	MS	MS	AH
Forrest	RMR	RMR	MSS	MSS	S	MRMS	MS	S	SVS	SVS	MS	MR	MR	APW
Grenade CL Plus	MR	MRMS	S	SVS	MR	S	MS	MSS	S	S	MRMS	MR	MS	AH
Harper	MRMS	MS	S	MSS	MR	S	MS	S	MSS	S	MRMS	RMR	–	APW
Hatchet CL Plus	MS	MRMS	SVS	SVS	MR	S	MS	MS	MS	S	MS	R	–	AH
Impala	MR	MR	SVS	SVS	S	MSS	RMR	SVS	S	S	MSS	SVS	MRMS	Soft
Kiora	RMR	RMR	MR,MS	S	MSS	MSS	MRMS	MSS	MRMS	S	MS	MRMS	MS	AH
Kord CL Plus	MR	MRMS	MS	S	MR	MSS	MSS	MSS	MS	S	MRMS	MR	MRMS	AH
Mace	MR	SVS	MSS	SVS	MRMS	MRMS	MSS	MS	MS	S	MS	S	MRMS	AH
Manning	MR	RMR	RMR	MR	MS	MRMS	MR	MSS	S	VS	SVS	R	–	Feed
Orion	MR	MSS	R	MSS	S	MSS	MS	MS	MSS	S	MSS	S	S	Soft / Hay
Revenue	RMR	R	S	MS	S	MS	MR	MSS	MSS	S	SVS	S	MS	Feed
Scepter	MR	MSS	MSS	S	MRMS	MRMS	–	–	–	–	–	–	–	AH
Scout	MR	MS	MS	MSS	R	SVS	MS	S	MS	MSS	S	MR	SVS	AH
Shield	RMR	MR	R	S	MRMS	MSS	MRMS	MS	MSS	S	MRMS	S	MS	AH
Tenfour	S	SVS	MSS	SVS	MRMS	MRMS	–	MSS	MS	MSS	MS	RMR	–	Feed
Trojan	MRMS	MR	MRMS	MSS	MS	MSS	MSS	MSS	MS	MS	MS	SVS	MRMS	APW
Wyalkatchem	MS	S	SVS	S	S	MR	SVS	MRMS	MS	S	MSS	SVS	MRMS	APW
Yitpi	S	MRMS	S	MSS	MR	SVS	MRMS	MSS	S	S	MS	MR	MS	AH

‡ - Black point is not a disease but a response to certain humid conditions. Tolerance levels are lower for durum receivals
R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible
, = mixed reaction, ^ = some susceptible plants

Disease

Durum	**Rust**			***Septoria tritici* blotch**	**CCN Resistance**	**Yellow leaf spot**	**Powdery mildew**	**Root lesion nematodes**		**Crown rot**	**Common root rot**	**Flag smut**	**Black point ‡**	**Quality in SA**
	Stem	**Stripe**	**Leaf**					***P. neglectus***	***P. thornei***					
Aurora	RMR	RMR	R	MS	MS	MRMS	MR	MS	RMR	VS	MRMS	R	MS	Durum
Caparoi	RMR	MR	RMR	RMR	MS	MR	–	MSS	MR	VS	MS	R	MSS	Durum
Hyperno	RMR	MR	R	MRMS	MS	MRMS	MR	MS	RMR	SVS	MS	R	MS	Durum
Saintly	MR	MR	MRMS	S	MS	MRMS	MSS	MS	MR	VS	MS	R	MS	Durum
Tjilkuri	MR	MR	R	MSS	MS	MRMS	MRMS	MS	MR	VS	MS	R	MSS	Durum
WID802	RMR	MR	R	MS	MS	MRMS	MRMS	MS	MS	VS	MS	R	MSS	Durum
Yawa	RMR	MR	R	MR	MS	MRMS	MS	MRMS	RMR	VS	MRMS	–	MRMS	Durum

Triticale	**Rust**			***Septoria tritici* blotch**	**CCN Resistance**	**Yellow leaf spot**	**Powdery mildew**	**Root lesion nematodes**		**Crown rot**	**Common root rot**	**Flag smut**	**Black point ‡**	**Quality in SA**
	Stem	**Stripe**	**Leaf**					***P. neglectus***	***P. thornei***					
Astute	RMR	RMR	RMR	R	R	MRMS	R	R	MRMS	MSS	–	R	–	Triticale
Bison	RMR	RMR	MR	R	R	MR	R	MR	RMR	MSS	MRMS	R	–	Triticale
Bogong	RMR	MRMS	R	R	–	MR	R	MR	S	MSS	MSS	–	–	Triticale
Chopper	MRMS	MRMS	R	R	R	MR	R	MRMS	MSS	MSS	S	–	–	Triticale
Fusion	R	RMR	R	R	R	MRMS	R	RMR	MS	MS	S	R	MSS	Triticale
Goanna	R	MR ^	MR	R	R	MR	R	MRMS	SVS	–	–	–	–	Triticale
Hawkeye	RMR	MR ^	R	R	R	MR	R	MR	MS	MS	MSS	–	–	Triticale

R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible
Tolerance levels are lower for durum receivals.
^ - Some susceptible plants in mix, , = mixed reaction
‡ Black point is not a disease but a response to certain humid conditions.

Barley	Leaf rust*	Net form net blotch*	Spot form net blotch*	Scald*	CCN Resistance	Powdery mildew	Barley grass stripe rust	Covered smut	Common root rot	Root lesion nematodes		Black point
										P. neglectus	*P. thornei*	
Buloke	MS-SVS	MR	MS-S	MS-S	S	R-MR	RMR	MS	MS	MRMS	MS	MS
Charger	MR-MS	VS	SVS	VS	R	R-MR	RMR	MS	MS	MR	MRMS	MRMS
Commander	MS-S	MS-S	MSS	S-SVS	R	MRMS	R	RMR	MS	MRMS	MRMS	MSS
Compass	MR-VS	MR-MRMS	MR-MSS	MS-SVS	R	MR	R	R	MS	MRMS	MR	MS
Fathom	MRMS-S	MR-MS	RMR	R-MS	R	MRMS	R	MR	MSS	MRMS	MRMS	S
Flagship	MS-S	MR	MRMS	MS-SVS	R	S	RMR	MRMS	MSS	MRMS	MRMS	MSS
Fleet	MRMS-S	S-VS	MR	MR-SVS	R	MRMS	RMR	MR	MSS	MRMS	MRMS	MS
GrangeR	MR-MS	MR-MSS	S	MS-SVS	S	R	R	MR	S	MR	MR	MS
Hindmarsh	MRMS-S	MR	S	R-VS	R	R-S	MR	MS	S	MRMS	MRMS	MSS
Keel	VS	MS	MR	MS-SVS	R	S	MRMS	R	S	MR	MRMS	SVS
La Trobe	MRMS-S	MR	MSS	R-VS	R	MR-S	RMR	MS	S	MRMS	MRMS	MSS
Macquarie	MR-S	MRMS	SVS	R-S	S	S	RMR	MS	MS	MR	MS	MR
Maritime	MRMS-S	R-VS	MRMS	MS-S	R	SVS	S	MS	S	MR	–	MSS
Navigator	VS	MR-MS	MR	R-S	R	R	RMR	MSS	MS	MRMS	MRMS	MSS
Oxford	R-MR	MR-SVS	MSS	MS-SVS	S	R	R	MRMS	MSS	MRMS	MRMS	MR
Rosalind	MR-MS	MR	MSS	MR-S	R	RMR-S	–	MRMS		MS	MR	–
Schooner	S-VS	MR	MS	MS-S	VS	SVS	RMR	MR	S	MS	MRMS	MS
Scope	MS-SVS	MR	MS-S	MS-S	S	R-MR	RMR	MS	MS	MRMS	MRMS	MSS
Shinestar	MR-MS	MR	MRMS	MS-S	–	MRMS	–	–	–	MS	–	–
Spartacus	MR-S	MR-MS	MSS	R-VS	R	R-S	RMR	MS	S	MS	MRMS	MSS
Westminster	R-MRMS	MR	S	R-S	–	R	R	RMR	MRMS	MRMS	MS	MRMS

* Due to multiple strains of these pathogens, the table provides a range of reactions that may be observed. Different ratings are separated by a -

R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible

Oats	**Rust**		**CCN**		**Stem nematode**		**Bacterial blight**	**Red leather leaf**	**BYDV***	***Septoria avenae***	***P. neglectus* Nematodes**
	Stem*	**Leaf***	**Resistance**	**Tolerance**	**Resistance**	**Tolerance**					
Bannister	MR-S	R	VS	I	–	MI	MR-S	MS	MS	S	–
Brusher	MS-S	MS-S	R	MI	MS	I	MR-MS	MS	MS	MS	MR-MS
Dunnart	MR-S	MR	R	MT	–	MT	MR-S	MS	MR	MR-MS	–
Forester	R-S	MR-MS	MS	MI	S	I	MS-S	R-MR	MR-S	MR	–
Glider	MR-S	MS-S	MS	I	R	T	R	R	MR-S	MR	–
Kangaroo	MS-S	MS-S	R	MT	S	MI	MR-MS	MS	MR-S	MR-MS	–
Mitika	MR-S	MS-S	VS	I	S	I	MR	S	MS-S	S	–
Mulgara	MS	MR-MS	R	MT	R	MT	MR	MS-S	MS	MS	–
Numbat	MS	S	S	I	S	I	S	MS	S	MR	MR
Tammar	MR-S	MR-MS	MR	MT	R	T	MR	R-MS	MS	MR	–
Tungoo	MS-S	MS	R	MT	R	T	MR	R	MR-MS	MR	–
Wallaroo	S	S	R	MT	MS	MI	S	MS	MS	S	MR
Williams	MR-S	R	S	I	–	I	R	MS	MR-MS	MR-MS	–
Wombat	MS-S	MS	R	T	MR	MT	MR-MS	MS	MR	MS	–
Wintaroo	S	S	R	MT	MR	MT	MR-MS	MS	MR-MS	MR-MS	MR-MS
Yallara	S	MS	R	I	S	I	MR-MS	MS	MS	MS	–
WA02Q302-9[1]	S	R-S	R	MI-MT	–	I	MR-S	MS	MS-S	S	–

* Due to multiple strains of these pathogens, the table provides a range of reactions that may be observed. Different ratings are separated by a -
R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible
T = tolerant, I - intolerant, MI - moderately intolerant, - = uncertain
[1]This breeding line will be named in 2016

Crown rot management in-crop in bread wheat

Margaret Evans and Hugh Wallwork
SARDI, Plant Research Centre, Urrbrae

RESEARCH

Searching for answers
Almost ready

Location:
Anthony and Paul Kaden
Franklin Harbour Ag Bureau
Rainfall
Av. Annual: 281 mm
Av. GSR: 192 mm
2015 Total: 320 mm
2015 GSR: 216 mm
Paddock History
2014: Grass free pasture
2013: Oats
2012: Wheat
Soil Type
Light sandy clay loam
Diseases
Crown rot
Plot Size
1.8 m (6 rows) x 12 m x 4 reps

Key messages

- **Emu Rock yielded better than Mace in the presence of low levels of crown rot in a late sown (25 May) trial at Mitchellville.**
- **Pyramiding crown rot management options (seed treatment, low plant density, low N application at seeding and 2 fungicide applications in-crop) reduced crown rot incidence in both varieties.**
- **Reduced crown rot incidence due to pyramiding management options was associated with a yield improvement over district practice only in Mace. This seems to imply that pyramiding management options may not assist varieties such as Emu rock which have some level of crown rot resistance.**
- **Emu Rock generally had a higher incidence of crown rot symptoms than Mace, which is unexpected and needs to be further explored.**
- **Lowering plant densities from 180 per m² to 90 per m² reduced yields in both varieties and could not be recommended.**
- **More work is required to support or refute these findings and what has been learned in 2015 will be valuable in selecting a revised suite of treatments. Future work should include improving our understanding of the relationship between visual crown rot symptoms and yield in low rainfall environments.**

Why do the trial?

Management options available for in-crop control of crown rot have only a limited effect but it is sometimes necessary to sow bread wheat into a paddock with medium to high risk of yield loss from crown rot. This work will contribute to understanding the effects of crown rot management options used singly or in combination in-crop in the low rainfall environment of upper Eyre Peninsula.

PreDicta B results for the Mitchellville NVT trial site showed there were high levels of crown rot present at the site, as is common in this area. Andrew Ware and the Franklin Harbour Agricultural Bureau saw this as an opportunity to assess options for managing crown rot when bread wheat must be sown into a paddock with this disease. Best management practice options were selected on the basis that they were suited to the area and its agricultural practices. Options were used alone or in combination to quantify effects, with the "control" being based on NVT trial protocols and district practice.

How was it done?

The trial was sown late in the sowing window (25 May 2015) to encourage crown rot expression in plots 12 m long x 6 rows wide using completely randomised block design with 4 replicates. Apart from crown rot (medium to high risk), PreDicta B results showed that Rhizoctonia barepatch (medium risk), take-all (low risk), common root rot (low level) and root lesion nematode (low risk) as well as yellow leaf spot and white grain disorder inoculum were present in the trial area.

Treatments were based on:

- Varietal resistance (locally adapted varieties: S - Mace; MS - Emu Rock)
- Seed treatment (for crown rot suppression)
- Plant density (reducing crop bulk to improve moisture availability during grain fill)
- Nitrogen rates (reducing crop bulk to improve moisture availability during grain fill)

Varieties, plant densities and N levels were chosen as being easy to manipulate in a commercial setting and treatment details are provided in Table 1. Phosphorus applied was at the same level for both of the nitrogen treatments. Rancona Dimension (registered for suppression of crown rot) was applied to seed @ 320 ml/100 kg. Seed treatment products not registered for crown rot management were also used as a treatment – one product on Emu Rock and another on Mace. Prosaro 420 SC @ 300 ml/ha was applied at early tillering and at anthesis, targeting the base of the plants.

Disease

Table 1 Treatments applied to Mace (susceptible rating for crown rot) and Emu Rock (moderately susceptible rating for crown rot) at Mitchellville in 2015.

	Seed dressing	Plant density (per m²)	N at seeding (kg/ha)	In-crop sprays	Abbreviation
1	None	180	14.4	Nil	District practice
2	None	90	14.4	Nil	Low density
3	None	180	7.3	Nil	Low N
4	Rancona Dimension	180	14.4	Nil	Rancona D
5	New products	180	14.4	Nil	Seed trt 1 and 2
6	Rancona Dimension	90	7.3	Prosaro	Best CR* practice

** CR = crown rot*

Plant samples were collected at early grain fill for assessment of plant density, head density, whitehead expression and browning on main stem bases. Plot yield was recorded.

Crown rot severity on main stem bases was scored visually using a 0-5 scale:

0 = 0%	No yield loss
1 = 1-10%	Possibility of minor yield loss
2 = 10-25%	Possibility of some yield loss
3 = 25-50%	Probably some yield loss
4 = 50-75%	Significant yield loss likely
5 > 75%	High yield loss likely

What happened?

The trial established well and weeds, other diseases and pests were adequately controlled. None of the diseases (other than crown rot) detected by PreDicta B analysis pre-seeding were seen to cause issues in the trial. Rainfall was good early in the season, but during grain fill there was significant moisture stress.

Mace had slightly higher plant densities than Emu Rock and the two treatments targeting low plant density had only slightly lower densities than seen in the other treatments (Figure 1). Mace treated with Rancona Dimension had the highest plant density and this may have been enough to influence yield. Head densities were slightly higher for Emu Rock than for Mace and generally did not appear to have been influenced by plant density (Figure 2). The exception was for the Mace treatments targeting low plant density, which had the lowest head densities.

Crown rot incidence was relatively low, ranging from 19% to 46% (Figure 3). Mace generally had a lower incidence of crown rot than Emu Rock (Fig. 3). The best crown rot practice treatment had the lowest ranking of crown rot incidence of all treatments for both varieties (Fig. 3). Crown rot expression was very low, ranging from 0.29-0.77 across all treatments (data are not presented here). White heads ranged from 37%-43% across all treatments, with no significant differences between treatments (data are not presented here).

Emu rock yielded better than Mace for most of the treatments, however, yields for both varieties were similar for the Best CR practice treatment (Figure 4). For Mace, the Best CR practice treatment out yielded the District practice treatment, but both these treatments had similar yields for Emu Rock (Fig. 4). For both varieties, yields were lowest for the Low density treatment (Fig. 4). Rancona Dimension treatments yielded well, as did Seed trt 1 for Emu Rock (Fig. 4).

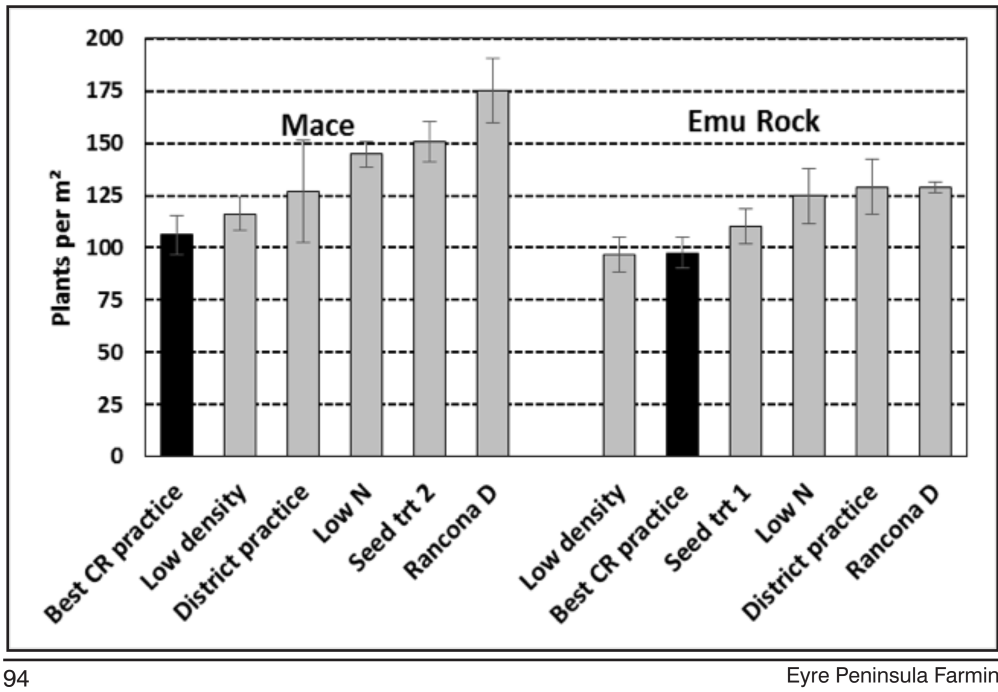


Figure 1 Effects of crown rot management treatments on plant density at early grain fill, Mitchellville 2015. District practice – plant density 180; 14.4 kg N. Best CR practice – plant density 90, 7.3 kg N; Rancona Dimension on seed; Prosaro in-crop.

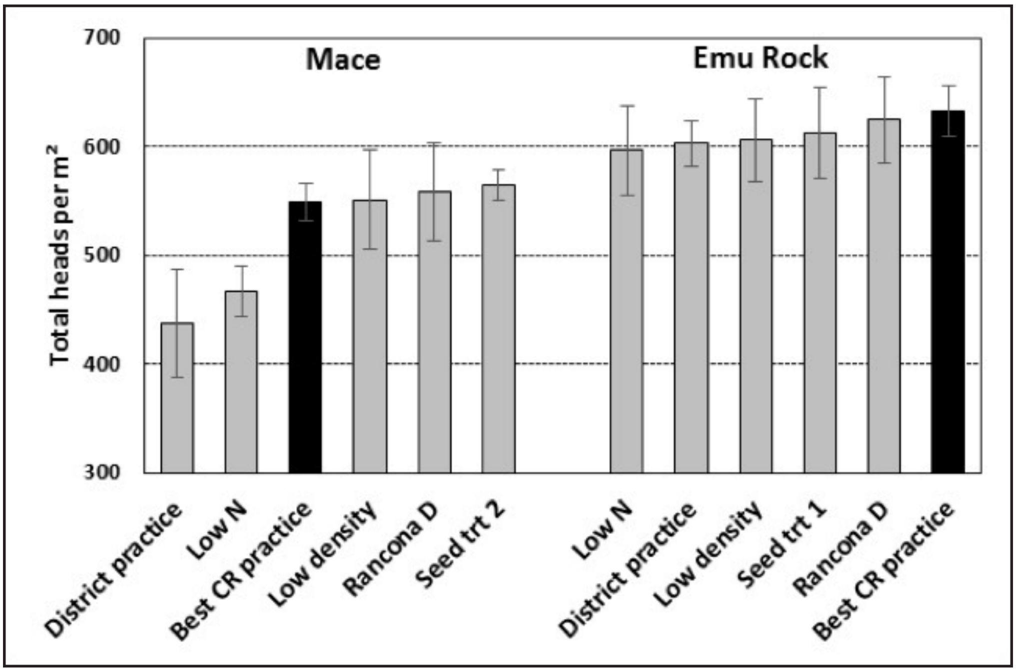


Figure 2 Effects of crown rot management treatments on head density at early grain fill, Mitchellville 2015. District practice – plant density 180; 14.4 kg N. Best CR practice – plant density 90, 7.3 kg N; Rancona Dimension on seed; Prosaro in-crop.

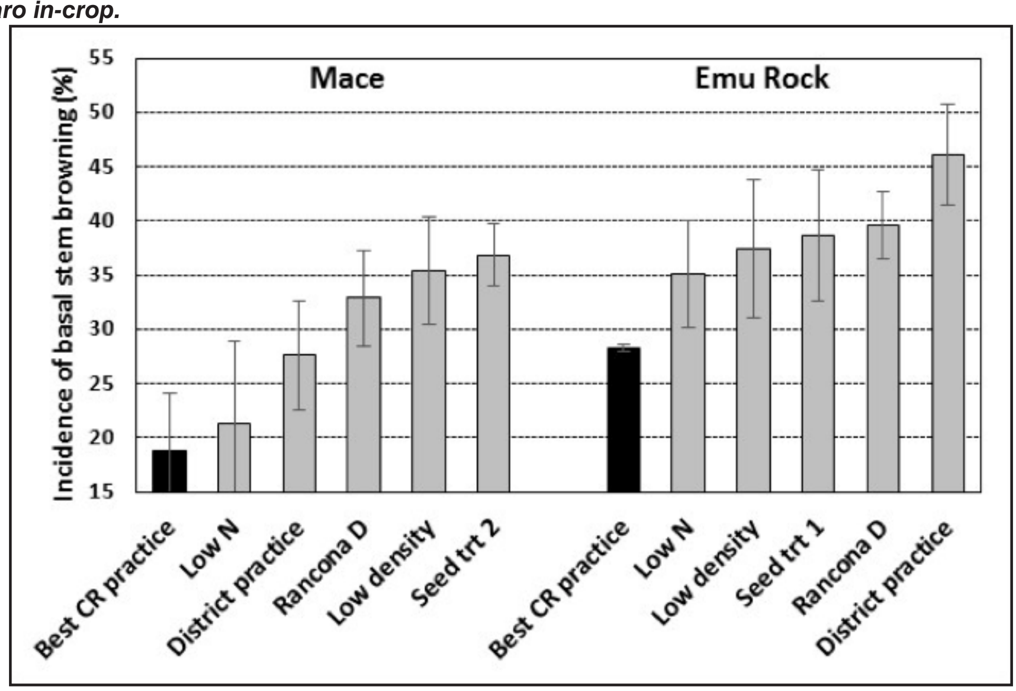


Figure 3 Effects of crown rot management treatments on incidence of crown rot on main stems at early grain fill, Mitchellville 2015. District practice – plant density 180; 14.4 kg N. Best CR practice – plant density 90, 7.3 kg N; Rancona Dimension on seed; Prosaro in-crop.

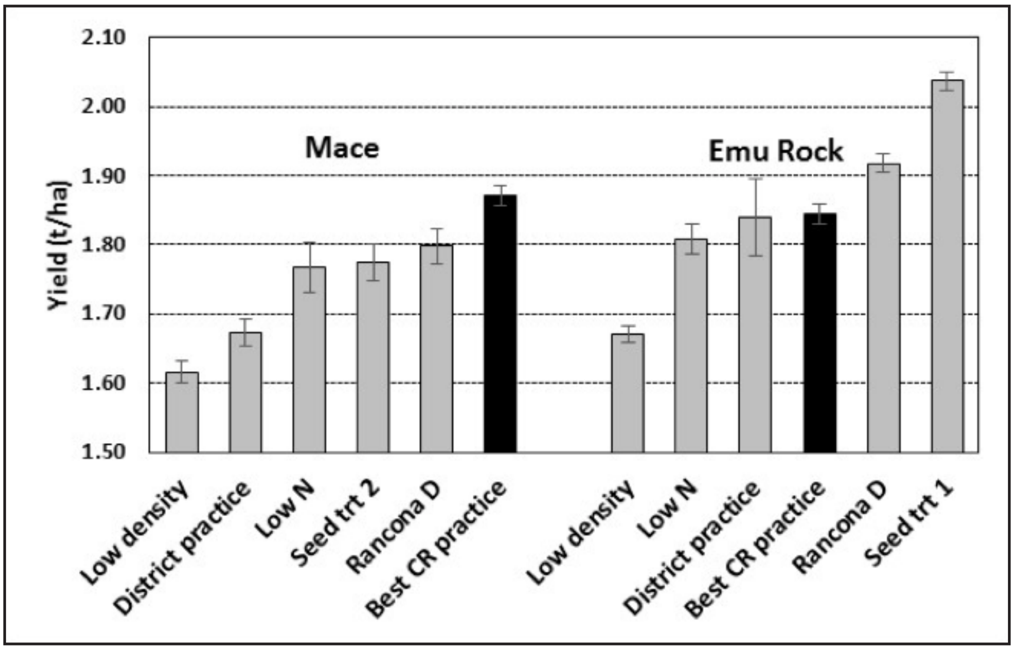


Figure 4 Effects of crown rot management treatments (including varietal resistance) on yields of bread wheat, Mitchellville 2015. District practice – plant density 180; 14.4 kg N. Best CR practice – plant density 90, 7.3 kg N; Rancona Dimension on seed; Prosaro in-crop.

What does it mean?

Crown rot is a widespread problem and often appears to be present in yield limiting amounts at this site, but crown rot expression was low in the 2015 trial and would not normally be expected to affect yield. However, there did appear to be some relationship between reduced crown rot incidence and yield in the best treatments in this trial which suggests more work is needed to quantify the relationship between crown rot symptoms and yield in low rainfall areas such as Mitchellville. Inclusion of a treatment in future trials which was artificially inoculated with crown rot would assist in this.

In the NVT trial (sown 6 May), Mace yielded 1.62 t/ha and Emu Rock 1.68 t/ha and in the crown rot management trial (sown 25 May), Mace yielded 1.67 t/ha and Emu Rock 1.84 t/ha. As Emu Rock is a fast maturing variety, it is not surprising that it out yielded Mace in both trials, but particularly in the later-sown trial. Emu Rock also out yielded Mace in NVT trials in this area in 2014 and 2012, but not in 2011. These findings alone support sowing Emu Rock in the Mitchellville area.

The Best CR practice treatment noticeably decreased crown rot incidence for both varieties but only for Mace was there a yield improvement over District practice. It is possible that in-crop management options for crown rot may not assist varieties with some level of crown rot resistance.

Emu Rock in general had a higher incidence of crown rot than did Mace. This was unexpected as Mace is susceptible to crown rot while Emu Rock has a moderately susceptible rating for crown rot. More work to assess the relationship between crown rot symptoms and yield may produce an explanation for this.

Low plant density (half that of district practice) did not greatly affect crown rot incidence, head density or white head expression, but it was the lowest yielding treatment for both varieties. The effect of low plant density may have confounded results from this trial and such a reduction in plant density would not be included in future trials. This magnitude of reduction in target plant density could not be recommended for crown rot management on upper Eyre Peninsula.

Seed treatments did not reduce crown rot incidence or severity, but they did improve yields and it is not clear why that improvement occurred. As treatments in 2015 did not include a standard seed dressing, that would also need to be included in future trials to assist in interpretation of results.

Results from the 2015 trial are encouraging and provide the base for planning further work to assess the effects of in-crop management options for crown rot in low rainfall.

Acknowledgements

This project was funded by GRDC through DAN00175 "National crown rot epidemiology and management program". Thanks to Anthony and Paul Kaden for providing a trial site on their property. Thanks to Andrew Ware who suggested doing this trial and assisted in selection of treatments, the Port Lincoln Crop Improvement team who sowed, managed and harvested the site and particularly to Blake Gontar who took soil samples and applied the in-crop fungicide treatments.

Registered products: see chemical trademark list.

GRDC Grains Research & Development Corporation
Your GRDC working with you

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Eyespot – variety tolerance and fungicide efficacy

Margaret Evans and Hugh Wallwork
SARDI, Plant Research Centre, Urrbrae

RESEARCH

Disease

Searching for answers
Almost ready

Location:
Edillilie
Joe and Tracy Dahlitz
Rainfall
Av. Annual: 424 mm
2015 Total: 360 mm
2015 GSR: 303 mm
Paddock History
2014: Bread wheat
Soil Type
Sand over clay
Plot Size
2 m (6 rows) x 8 m (variety) x 3 reps (fungicide)

Key messages

- **Eyespot has the potential to cause significant yield losses on lower Eyre Peninsula in a susceptible variety such as Mace. Losses in the range of 22-27% (1.11-1.36 t/ha) or more might be expected from eyespot lesions alone and the more harvest is compromised by crop lodging due to weakened stems, the higher the yield losses are likely to be.**
- **Findings from 2014 and 2015 indicate that where eyespot is a problem, avoid the varieties Scout, Mace, Axe, Shield, Cobra, Corack, Cosmick and Wyalkatchem. In preference select Trojan or Emu Rock.**
- **Findings for barley varieties are less clear, but generally they have a lower incidence of eyespot than bread wheat varieties and La Trobe and Hindmarsh are most affected while Compass is least affected. There is also some indication that barley with stems weakened by eyespot might be more at risk of yield losses due to harvest difficulties caused by lodging than bread wheat.**
- **Fungicide application resulted in significant yield improvements where high levels of eyespot inoculum was present. Remember that no fungicides are currently registered for eyespot control in Australia.**
- **Plant growth regulants assisted in reducing lodging due to eyespot, but the economics of using these products will need to be considered carefully.**
- **It is anticipated that at least two fungicides will be registered/have label extensions for eyespot control in cereals in Australia in 2016.**

Why do the trial?

These variety and fungicide efficacy trials have assisted in identifying resistance sources for eyespot and have provided data to support chemical companies acquiring label extensions to register fungicides for use against eyespot in cereals in Australia.

Eyespot is an increasing problem in the higher rainfall grain growing areas of SA such as lower Eyre Peninsula, the Cleve Hills, the mid North, the Adelaide Plains and the South East. This increase is mainly due to farming systems moving to stubble retention, direct drill and more cereals in rotations. In Australia, eyespot in cereals is caused by the fungus *Oculimacula yallundae* (previously known as *Pseudocercosporella herpotrichoides*) which infects stem bases causing the eye-like lesions which gives eyespot its name. Yield losses from this disease occur as a direct result of the stem lesions and, secondarily, from plants lodging due to weakened stem bases which can make it difficult or impossible to harvest affected plants. Overseas, eyespot control includes fungicide application and the use of partial resistance in varieties. As eyespot has had a very restricted distribution in Australia, no fungicides have been registered for control of eyespot in cereals and little has been known about resistance levels in Australian varieties.

GRDC has funded a two year program to assess fungicide efficacy and varietal resistance in Southern Australian germplasm. Information presented here is from the second year of the research and follows on from an article which can be found in EPFS Summary 2014, p 119-121.

How was it done?

The Edillilie site was located in a paddock which had eyespot problems in the 2014 wheat crop and had significant cereal residues and medium levels of eyespot inoculum (19,875 copies of eyespot DNA per g of soil) present at the start of 2015. To encourage eyespot expression, the trial was sown early in the seeding window (14 May 2015) at a high plant density (250 plants/m^2) and with high nitrogen inputs (190 units of N). Trials were sown, managed and fungicide treatments applied by Cummins Agricultural Services. Plots were 5 rows (2 m) wide by 8 m long. The variety trial had 3 replicates and the fungicide trial had four replicates.

Variety screening. Twelve bread wheat, 4 barley and 1 triticale varieties as well as 7 breeders' lines were screened for resistance to eyespot. Entries were chosen to represent a range of genetic backgrounds (including genes for resistance to crown rot) and maturities.

Fungicide efficacy. The variety Mace was used in the fungicide trial and products assessed were all registered for use in cereals in Australia, but not for eyespot control. Twelve products (including plant growth regulants) were represented in the fungicide trial, which was done in collaboration with Adama Agricultural Solutions Ltd, BASF Australia Ltd, Bayer CropScience Australia and Syngenta Australia Pty Ltd. Details of fungicides assessed cannot be presented here as they are not registered for control of eyespot in cereals in Australia. Fungicide treatments were applied using a hand boom on 17 July 2015 early in stem elongation (GS31), before canopy closure.

Stem samples were assessed for eyespot expression on 23 October 2015, when plants were at late grain fill. A total of 25 stems were assessed in each plot, with 8-9 stems taken from each of the 3 inner rows of the plot. A scoring scale of 0-3 was used, where:
0 = no lesions.
1 = slight eyespot – small lesion(s) on less than half the stem circumference.
2 = moderate eyespot - lesion(s) on at least half the stem circumference.
3 = severe eyespot – lesion(s) girdling the whole stem; tissue softened, lodging would occur readily.

This scale was taken from Scott and Hollins (1974) and their formula was used to calculate a disease index: (1*tillers with score 1 + 2*tillers with score 2 + 3*tillers with score 3) / total tillers scored) * (100 / 3).

Plots were scored for lodging on 23 October and 16 November 2015, with the % of the plot showing lodging being recorded.

What happened?

The trials established well, but levels of eyespot (76% incidence on Mace stems) were intermediate due to few rainy days during tillering and early stem extension. Weeds, other diseases and insect pests were adequately controlled.

Variety screening. Wheat varieties with highest incidence of eyespot included Scout, Mace, Wallup and Wyalkatchem (Fig. 1). The least affected wheat varieties included Trojan, Spitfire and Emu Rock, which all carry a gene that confers MS resistance to crown rot. Emu Rock, Trojan, Gazelle and Scope had the lowest lodging levels and Suntop and Scout had the highest lodging levels (Fig. 2). Lodging in Spitfire, Suntop and Scout (Fig. 2) was consistent with the incidence of eyespot in their stems. All other wheat varieties generally had lower lodging levels (Fig. 2) than indicated by the incidence of eyespot in their stems (Fig. 1).

Barley varieties generally had lower rates of eyespot incidence than did the wheat varieties (Fig. 1) and the levels of lodging (Fig. 2) for all barley varieties was consistent with the incidence of eyespot in their stems.

Fungicide efficacy. All the products applied provided some protection against eyespot with the incidence of eyespot in stems ranging from 14% (most effective) to 41% (least effective), compared with an eyespot incidence of 76% for the untreated control. Most fungicide products provided a significant lowering of lodging levels when compared with the control, particularly where a PGR was added (Figure 5). Yield improvements over the untreated control were also achieved, with yield increases ranging from 7% to 22% (0.35-1.11 t/ha) across the products applied.

What does this mean?

Yield loss. In Mace (susceptible) in our trials, yield losses from eyespot were at least 27% (1.36 t/ha) in 2014 (entirely due to eyespot lesions) and at least 22% (1.11 t/ha) in 2015 (some influence of lodging on yield). Given the differences in eyespot inoculum levels and seasonal conditions at the 2014 and 2015 trial sites, these results suggest that significant yield losses can be expected from eyespot on lower Eyre Peninsula if eyespot inoculum is present at high levels. Where harvest is badly compromised by lodging due to eyespot, yield losses could be considerably higher than this.

Variety screening. Results from 2015 showing Trojan and Emu Rock were least affected by eyespot and Mace, Scout and Wyalkatchem were worst affected is consistent with 2014 results. Results from 2014 indicate that Shield, Axe, Cobra and Corack should also be avoided where eyespot is an issue.

The incidence of eyespot in barley varieties was somewhat lower than that seen in bread wheat, but this difference is less clear than for 2014. Barley varieties appear to be less consistent in their response to eyespot than the bread wheat varieties which makes it difficult to recommend one variety over another or over bread wheat. Lodging incurred as a result of eyespot lesions weakening stems was relatively higher than that in bread wheat varieties which suggests that barley affected by eyespot might be more at risk of yield losses due to harvest difficulties.

Data from the variety screening trials (which included breeders' lines for which data are not presented here) will be provided to breeders to feed into their breeding programs.

Fungicide efficacy. Most of the fungicide products assessed reduced eyespot incidence and expression in bread wheat. Although no product achieved complete control of the disease, the level of control was sufficient to result in significant yield improvements in treated plots when compared with the untreated plot. Significant differences were difficult to detect between the products which means that once products are registered for use in managing eyespot, it is likely that the choice of product will mainly be decided by the price of that product.

Plant growth regulants alone or in combination with fungicide products were effective in reducing lodging due to eyespot, but the economics of this would need to be considered carefully.

Data from fungicide trials have been distributed to participating companies and it is anticipated that at least two fungicides will be registered/have label extensions for eyespot control in cereals in Australia in 2016.

Future research opportunities include:

- Further screening of cereal varieties (including new varieties pre- and post-release).
- Quantifying the effect of varietal resistance on the magnitude of yield improvements due to fungicide application.
- Improving contact of fungicides with the base of plants. Including nozzle types, boom heights and timing of applications to ensure the canopy is open. Earlier timing of applications may also allow application in the same pass as herbicides, but only if this does not compromise eyespot control.
- Epidemiological studies to determine timing of air-borne spore dispersal and therefore optimum time for sowing.

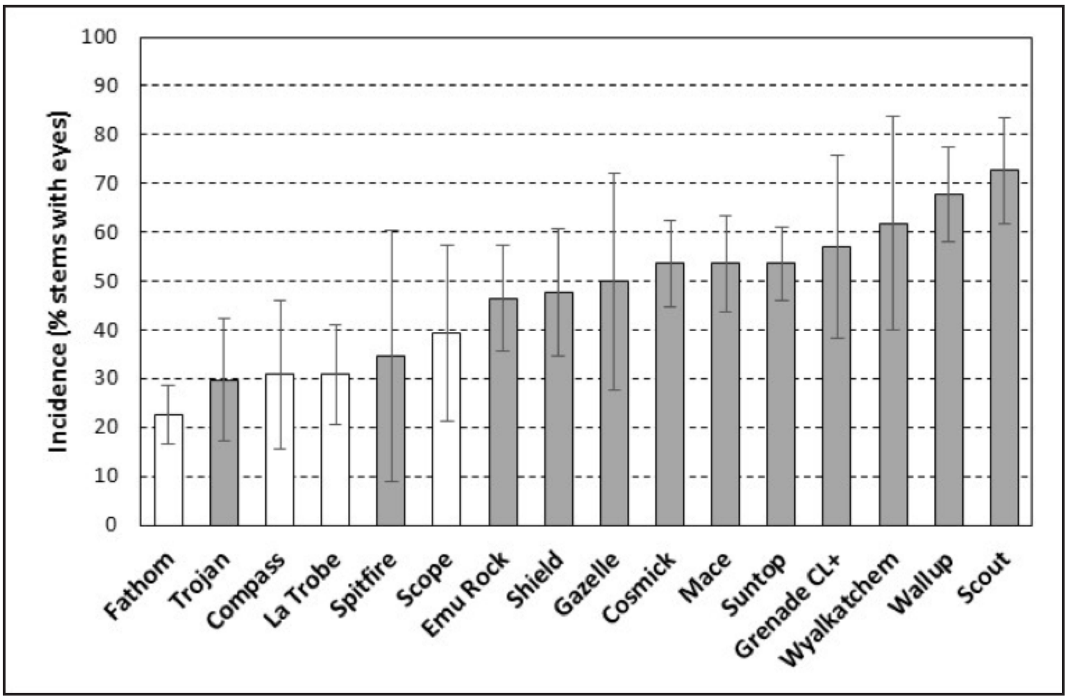


Figure 1 Effects of cereal type and variety on incidence of eyespot – Edillilie, 2015. Bread wheat varieties are presented as grey and barley varieties as white columns.

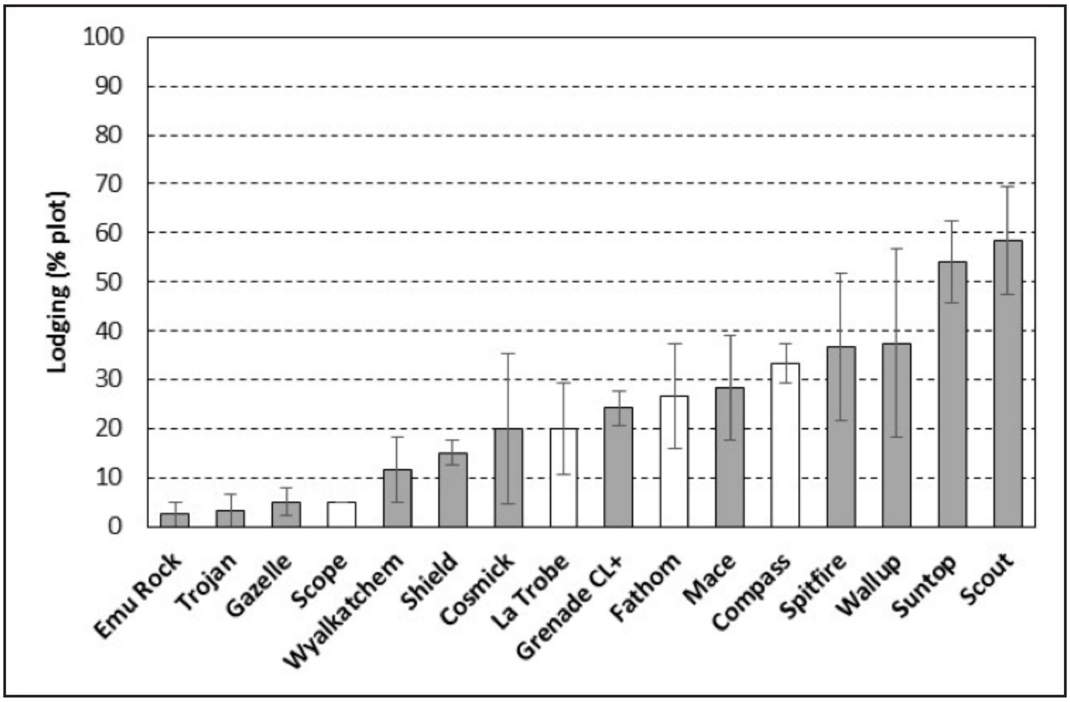


Figure 2 Effects of cereal type and variety on lodging due to eyespot – Edillilie, 2015. Bread wheat varieties are presented as grey and barley varieties as white columns.

Disease

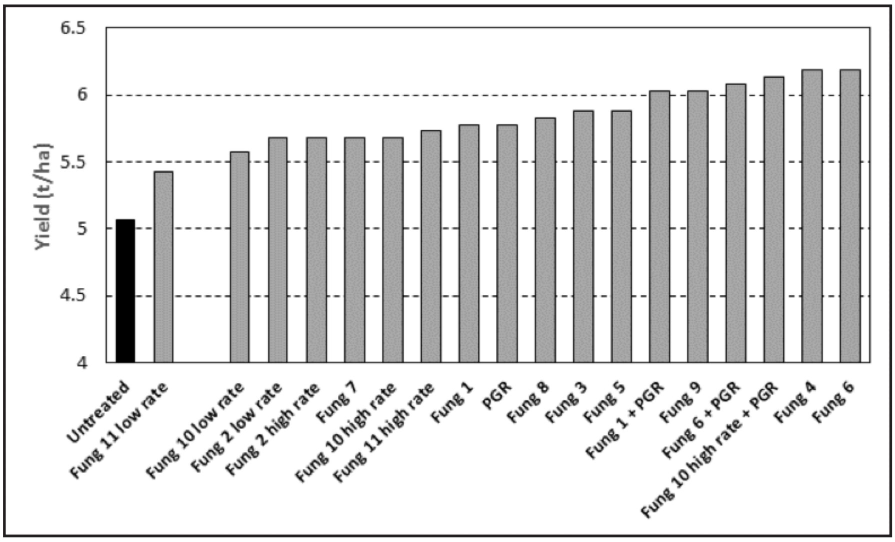


Figure 3 Effects of fungicide (Fung) and plant growth regulant (PGR) treatments on yield of Mace bread wheat in the presence of eyespot – Edillilie 2015. Treatments in the same block as the untreated control have yields which are not significantly different from the untreated.

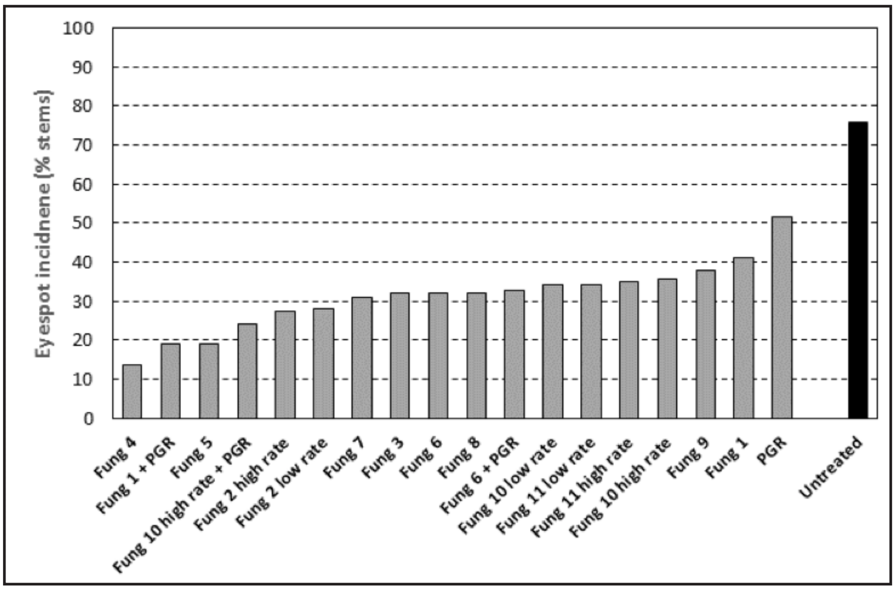


Figure 4 Effects of fungicide (Fung) and plant growth regulants (PGR) treatments on incidence of eyespot in Mace bread wheat – Edillilie 2015. All treatments had significantly lower incidence of eyespot on stems than the untreated.

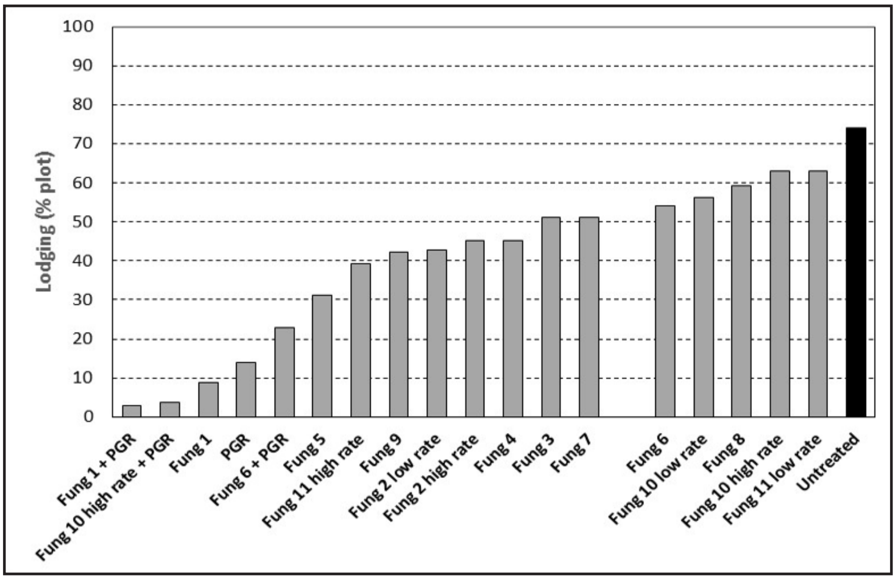


Figure 5. Effects of fungicide (Fung) and plant growth regulants (PGR) treatments on lodging due to eyespot in Mace bread wheat – Edillilie 2015. Treatments in the same block as the untreated have lodging percentages which are not significantly different from the untreated.

Acknowledgements

This project was funded by GRDC through DAS0139 "Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in South Australia". Thanks to Joe and Tracy Dahlitz for providing a trial site on their property at Edillilie and to Pat Head (Landmark – Cummins Agricultural Services) for managing the site and applying treatments and organising assessment of treatments. Thanks also to those who assisted in planning for these trials – BASF Australia Ltd, Bayer CropScience Australia, Syngenta Australia Pty Ltd, Adama Agricultural Solutions Ltd and Landmark – Cummins Agricultural Services.

Spot form net blotch on the Eyre Peninsula – what are the losses?

Hugh Wallwork[1] and Blake Gontar[2]
[1]SARDI, Waite Campus, [2]SARDI, Port Lincoln

RESEARCH

Disease

Key messages

- **Multiple fungicide treatments provided very good control of SFNB in trials with severe disease at Wharminda in 2014 and 2015.**
- **Predicted yield losses to SFNB in an environment and location conducive to the disease have been generated for varieties covering a range of resistance levels. Losses of 14 and 20% have been observed in varieties rated SVS and around 9% for varieties rated MS.**
- **Some varieties show increased susceptibility to SFNB as the season progresses. This needs to be factored into disease resistance ratings.**
- **In a trial situation, resistant varieties will show yield losses despite excellent disease control, due to the metabolic cost of resisting large amounts of inoculum from neighbouring untreated susceptible plots.**
- **The economics of controlling SFNB with fungicides could be marginal in many environments and so growers should use this data along with grain values and observations of disease severity and yield potential in their paddocks to decide whether to apply fungicides.**

Why do the trial?

GRDC have established a national network of trials looking to evaluate the yield losses to a wide range of fungal and nematode diseases in wheat and barley and to relate those losses to variety resistance ratings. These particular trials are targeting spot form of net blotch (SFNB) in Mallee environments where the disease appears to be most prominent. Wharminda was specifically chosen as the disease occurs in the NVT trial located there every year and mostly in the absence of other diseases such as net form net blotch (NFNB), leaf rust and scald that could confound analysis and interpretation of the trial data.

Yield losses to NFNB, leaf rust and scald are better understood than for SFNB as each of these diseases have been shown to readily cause losses of 50% or more in susceptible varieties under favourable conditions in SA. Also where one of these diseases has been present the benefit of fungicide sprays has been clearly evident. Similar high losses have not been demonstrated for SFNB and it has been questionable whether the use of fungicide sprays has been warranted, especially as products available prior to the arrival of Systiva have not been very effective against this pathogen.

How were the trials run?

The two trials were run alongside the barley NVT trials at Wharminda in 2014 and 2015. The same sized plots were used as the NVT yield trials and all management treatments other than fungicides applied were the same as for the NVT yield trial. Twelve varieties were selected each year to represent the range of resistance levels to SFNB and including varieties that were relevant to the Eyre Peninsula environment but avoiding varieties such as Maritime that are very susceptible to NFNB that could be present in the trial. Trials designs included 3 replicates in 2014 and 4 replicates in 2015 and followed a split block design where sprayed treatments were blocked in the columns to reduce errors from stopping and starting spraying within the trial.

In 2014 there was a very low level of NFNB in the trial, in Fathom, but the level was considered too low to have any significant impact. There were no other leaf or root diseases obviously present. In 2015 no other foliar pathogens were detected but there was some patching of Rhizoctonia throughout the trial and it is possible that the fungicide treated plots were advantaged to some degree by the effect on Rhizoctonia.

In 2014 the trial was sown on 14 May with 100 kg/ha 18:20:0:0 and with Impact In Furrow applied to all plots. The seed was not treated and fungicides were applied as following: 11 June 500 ml Bumper (propiconazole); 10 July 800 ml Amistar Xtra (azoxystrobin) plus Adigor @ 2% surfactant; 16 September 500 ml Bumper. This regime of spraying was designed to and did prevent any appreciable infection of the treated plots with SFNB.

In 2015 the trial was sown on 11 May with 80 kg/ha 18:20:0:0 and with no in-furrow treatments. The seed of the treated plots had Systiva (fluxapyroxad) applied at 150 ml/100 kg seed. Fungicide sprays, all Prosaro at 300 ml/ha, were applied on 15 June (GS 22), 8 July (GS 25-31), 7 August (GS 33) and 4 September (GS 45).

Assessments of disease were made on three occasions in 2014 (19 August, 4 September, 22 September) using a standard 1-9 rating scale where 1= R, 3 = MR, 5=MS, 7=S and 9=VS. Also on 25 September an assessment of leaf area infected of the flag leaf -1 was made on each of ten leaves of each of the untreated plots and on one rep of the treated plots.

In 2015 assessments of disease were made on four occasions (13 August, 1 September, 22 September, 6 October) using the same 1-9 scale. Also on 22 September an estimate of the total % plot area infected with SFNB was made.

The trials were harvested on 5 November in 2014 and 12 November 2015 and seed saved for grain quality analysis although this has not been included in this article as it has not yet been completed.

What happened in 2015?

Spot form net blotch was very severe in the most susceptible varieties Hindmarsh, SloopSA, SY Rattler and Dash. The most resistant varieties were Fathom and Skipper which showed only low levels of infection. A good range of resistance levels were observed which were closely in line with the ratings posted in the Sowing and Cereal Variety Disease Guides. The ratings were mostly consistent from one date to the next although several varieties, notably Compass, Flagship, Schooner and Scope were rated more susceptible relative to others as the season progressed (Figure 1). We have known previously that Schooner has a seedling resistance gene, Rpt4, that loses its effectiveness at later growth stages and these assessments are consistent with that knowledge.

On 22 September 2015 an assessment of the total leaf area of the plot infected was made as well as a standard disease severity rating and, as would be expected, there was a very close correlation between the two scores (Figure 2). The leaf area assessment was made to compare this method with the 1-9 rating scale to help plan future evaluation methods.

Each variety was shown to have a yield reduction where the plots were not treated with fungicides (Figure 3).The main point to note is that despite severe symptoms the losses did not exceed 15% in Hindmarsh, the most susceptible of varieties currently grown in the region. Secondly it is of interest to note that even the most resistant varieties, with little disease evident, showed a yield loss of around 7%. Two possible explanations for this are: Where a resistant plant receives a high level of inoculum due to being in close proximity to a susceptible plot, it will have to expend a considerable level of metabolic energy activating its resistance mechanisms to counter the pathogen attack. Where such a plant is surrounded by similarly resistant plants in a normal paddock situation the level of inoculum attacking the plant will be very low in comparison. The second explanation is that the fungicide is reducing losses to another pathogen in the plots. In this case there were effectively no other foliar pathogens in the plots but Rhizoctonia patching was present to a significant degree and could account for the yield loss as Systiva does have some efficacy against Rhizoctonia.

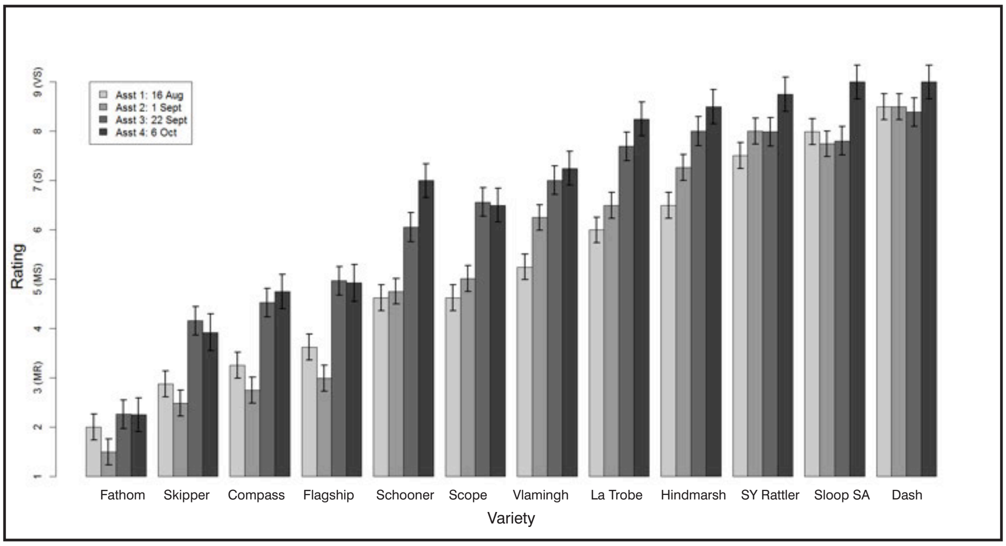


Figure 1 Disease ratings for 12 varieties at four assessment dates in 2015.

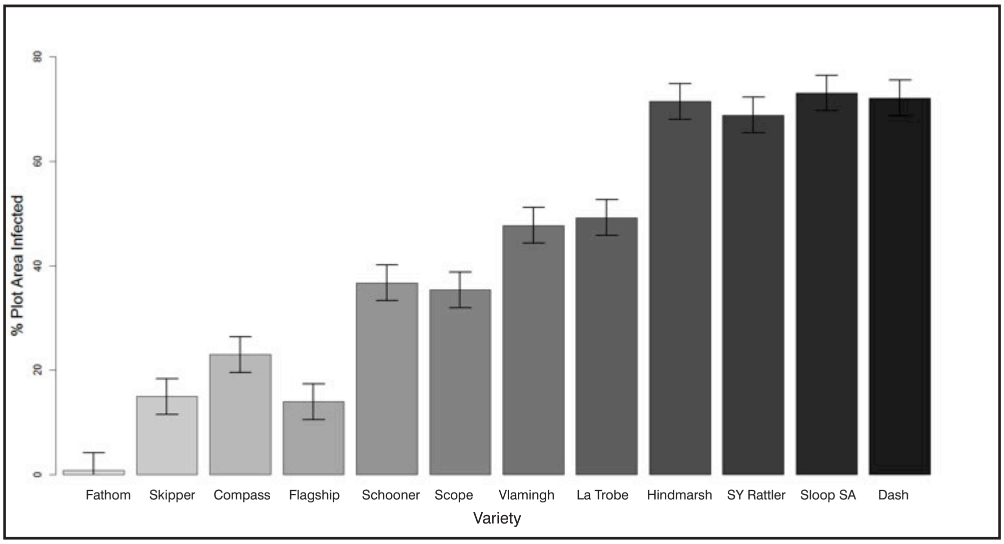


Figure 2 Assessment of plot area infected on 22 September 2015 for 12 varieties.

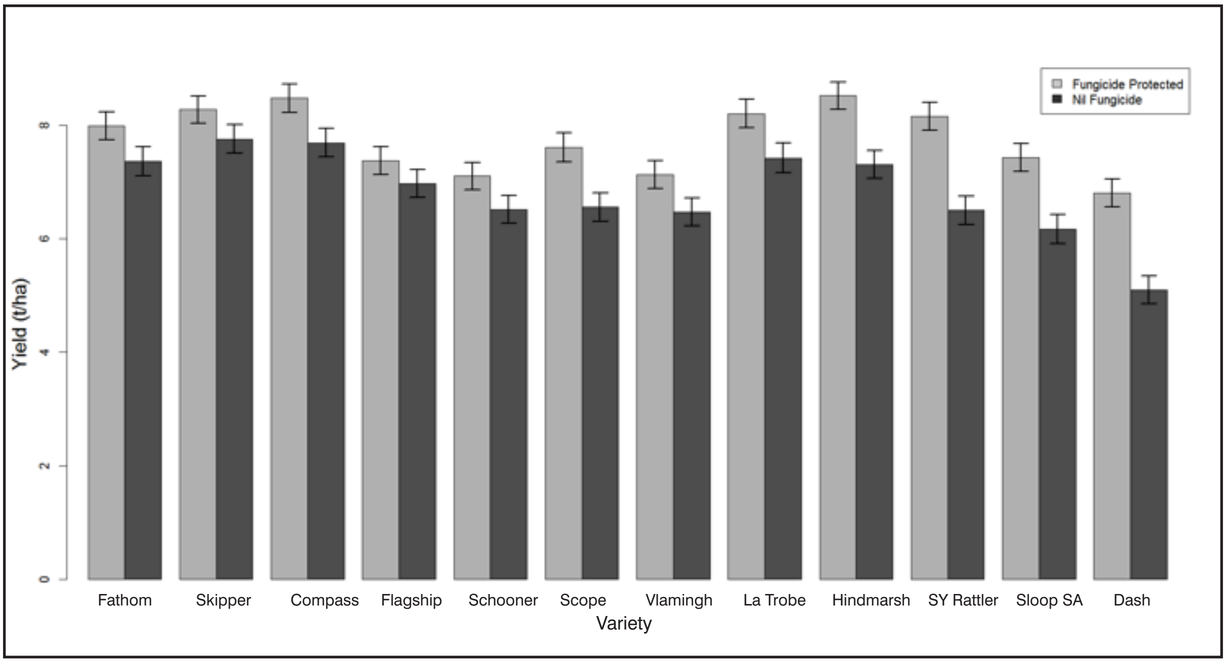


Figure 3 Yields of 12 varieties with and without complete disease control in 2015.

When the yield loss ratio (infected plant yield / treated plant yield) is plotted against the disease rating of the 12 varieties on the different dates the points describe a curve. Figures 4 and 5 show the results on two of the dates. This confirms that the ratings used in describing the resistance of varieties are not part of a linear scale and that the differences in terms of inoculum generation and yield loss are very much greater at the susceptible end of the scale.

When a similar graph was made using the % leaf area infected on 22 September a similar curve was formed with the R2 value increased just slightly (Figure 6).

Using the regression curves from 2015 it is possible to generate a predicted yield loss value under 2015 conditions for each disease rating category, independent of any specific varieties in this trial. Using data from 13 August the predicted value for a variety rated MS (rating of 5) gives a yield loss ratio of 0.89 (10% loss). A rating of S (7) gives a yield loss ratio of 0.84 (16% loss) and an SVS (8) gives a yield loss ratio of 0.8 (20% loss). Similar yield loss figures are obtained when the disease ratings obtained on subsequent dates are used (Table 1). It is seen that just as the disease ratings tend to increase as the epidemic develops, so does the apparent yield loss for that variety rating diminish. For this and other reasons it is important that the disease ratings provided in sowing and cereal variety disease guides take into account the time when resistance data are collected.

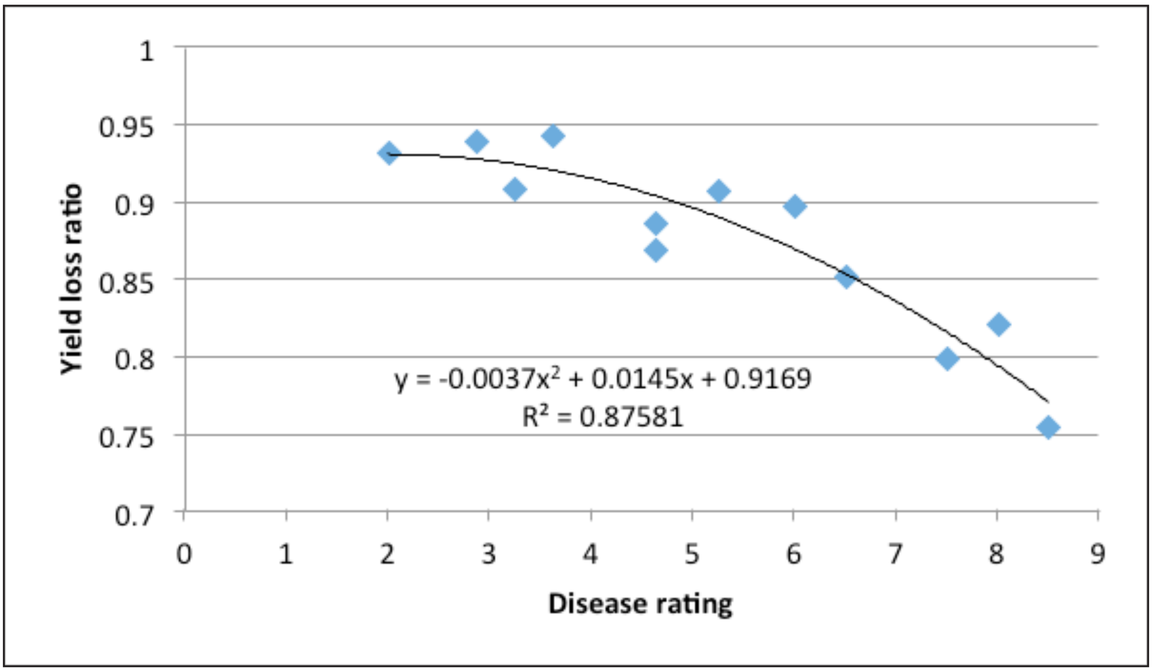


Figure 4 Plot of yield loss ratio using disease rating taken on 13 August 2015.

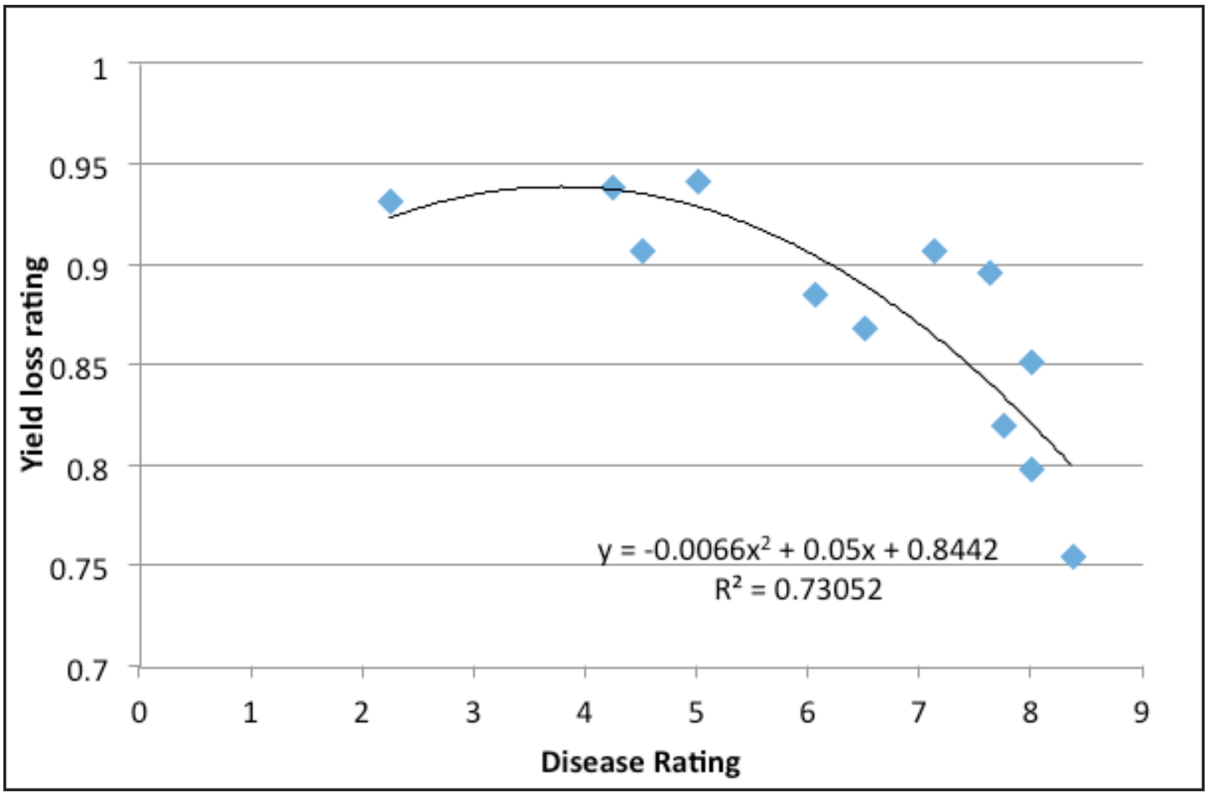


Figure 5 Plot of yield loss ratio using disease rating taken on 22 September 2015.

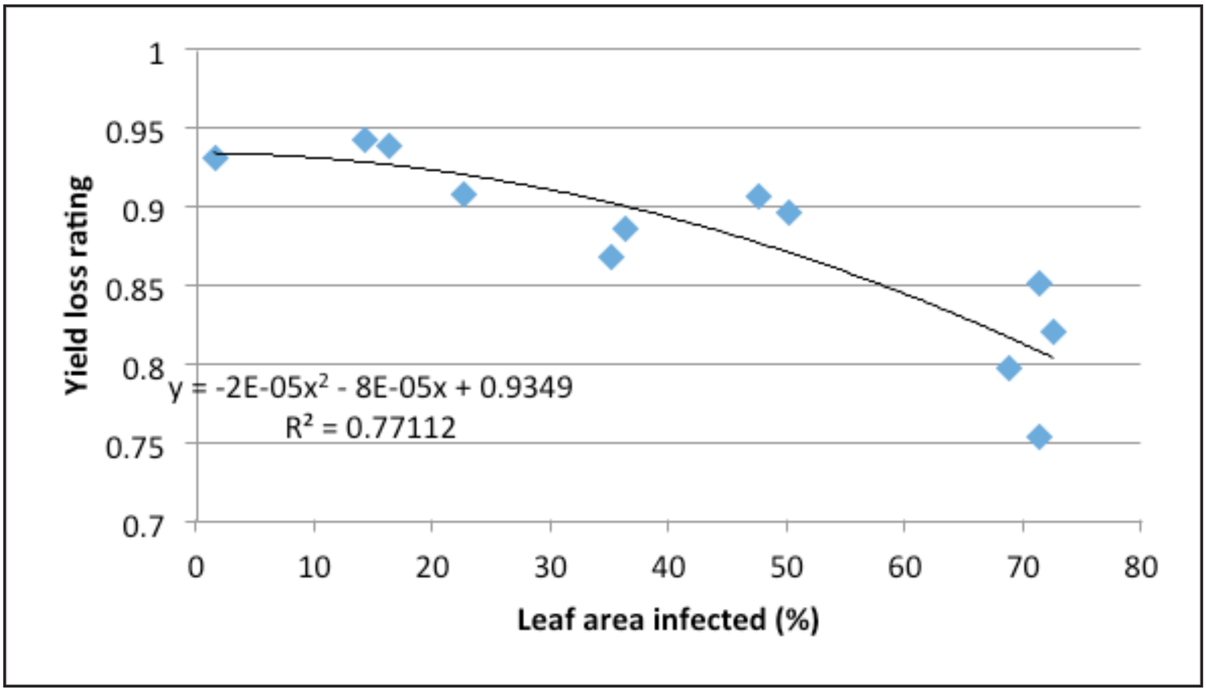


Figure 6 Plot of yield loss ratio using % leaf area infected on 22 September 2015.

If the observation of around 7% yield loss for the most resistant varieties is due to the metabolic cost of resisting infection as described above then this needs to be factored in for the more resistant varieties only. If however the 7% figure reflects the control of Rhizoctonia in this trial then the yield loss figures need to be lowered by 7% all round.

When a plot is made of the yield loss ratio using % leaf area infected on 22 September 2015 one can make a prediction of the yield loss to be expected based on leaf area (Figure 6). For Wharminda in 2015 a paddock that displayed 30% leaf area lost at the end of September would be expected to lose about 8.5% of its yield. A paddock that displayed 50% and 70% leaf area infected would be expected to lose 12% and 17% yield respectively. Similar to the disease ratings graphs, these figures need adjusting to discount the observed 7% yield loss recorded for the most resistant varieties.

Table 1 Predicted yield loss (%) for varieties based on disease ratings under environmental conditions at Wharminda in 2015.

Disease rating	13 Aug	1 Sept	22 Sept	4 Oct
RMR	7	7	8	8
MS	10	9	7	7
S	16	15	13	11
SVS	20	20	18	15

What happened in 2014?

The trial at Wharminda in 2014 was very similar to that in 2015 with the exception that GrangeR and Macquarie were grown instead of SY Rattler and Vlamingh. Buloke was also grown in place of Scope but these varieties are almost identical for SFNB resistance and plant type so should be interchangeable. As in 2015 Compass, Schooner and Buloke (Scope) appeared considerably more susceptible on the third scoring date than they had at the earlier scoring dates. Similar differences at later assessment dates have been noted for Scope when NVT trials have been assessed at other sites over the years.

Looking at the yield differences with and without fungicide treatments (Figure 8) it is apparent that similar yield losses were observed in the same varieties in both years. One exception is Buloke that showed no appreciable yield loss in 2014 compared to Scope in 2015.

GrangeR was an unfortunate choice for this trial as instead of losing yield to SFNB it actually gained yield from infection. This is not entirely surprising in that varieties that are later maturing and/or put on too much biomass may suffer under moisture or heat stressed environments and therefore some early green leaf reduction may provide a yield benefit by reducing transpiration and excessive vegetative growth. This variety was excluded from data analysis plotting yield loss against disease ratings at different dates. These plots are not shown but the R^2 values (0.76, 0.69 and 0.64) for the 3 assessment dates are slightly lower than for 2015 likely due to the reduced numbers of replicates used in 2014. These analyses led to a summary (Table 2) of predicted yield loss in 2014 similar to Table 1 for 2015.

Predicted yield losses were very similar to those in 2015 at the MS level but considerably lower in the more susceptible varieties. As with 2015 the earlier assessment dates showed higher predicted yield losses mainly because of the increased susceptibility of some varieties at the later dates. This confirms that in future we need to be aware of the effect of scoring dates when evaluating varieties for disease resistance.

The 2014 data was also similar to the 2015 data in that the most resistant varieties, and predicted yield for a variety rated RMR, again showed significant yield losses where the plots were not treated. For the 2014 trial where there was little or no obvious Rhizoctonia patching affecting the trial or other fungal diseases present, it is most likely therefore that the yield loss was due to the metabolic cost to the plants of generating the resistance mechanisms against the SFNB pathogen. That being the case it is possible to speculate that the Systiva used in 2015 provided around 2-3% yield advantage through the control of Rhizoctonia. Further trials are required to support these hypotheses.

Data still to come

Collection and analysis of data from these trials is still in progress. This includes grain quality analyses and alternative statistical approaches to comparing the yield loss ratio estimates to disease ratings. Another similar trial in 2016 using the same 12 barley varieties would provide excellent confirmation of the assumptions and models generated in 2014 and 2015. This will depend on renewed funding from the GRDC projects supporting these trials.

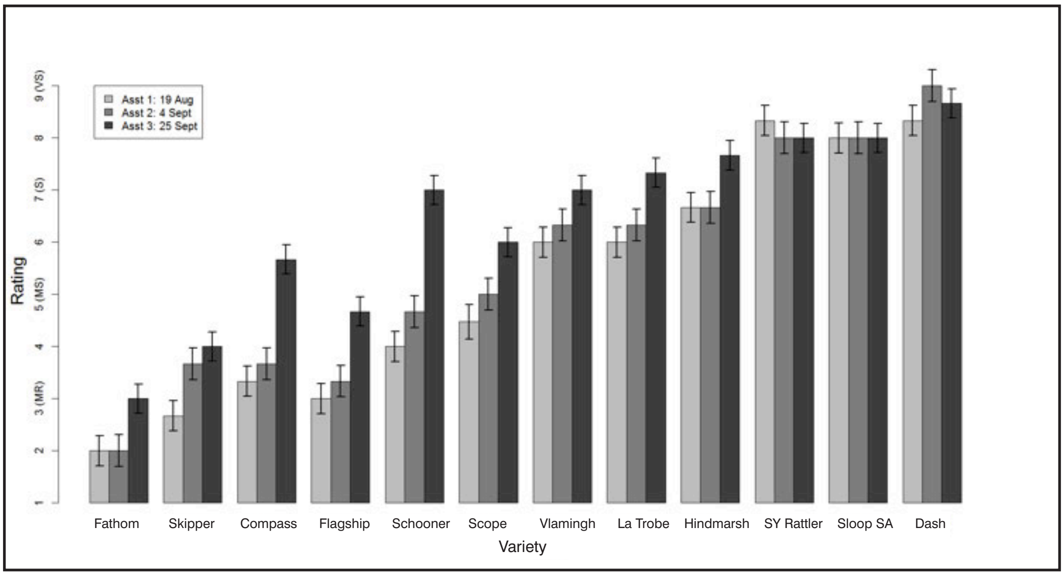


Figure 7 Disease ratings for 12 varieties at three assessment dates in 2014.

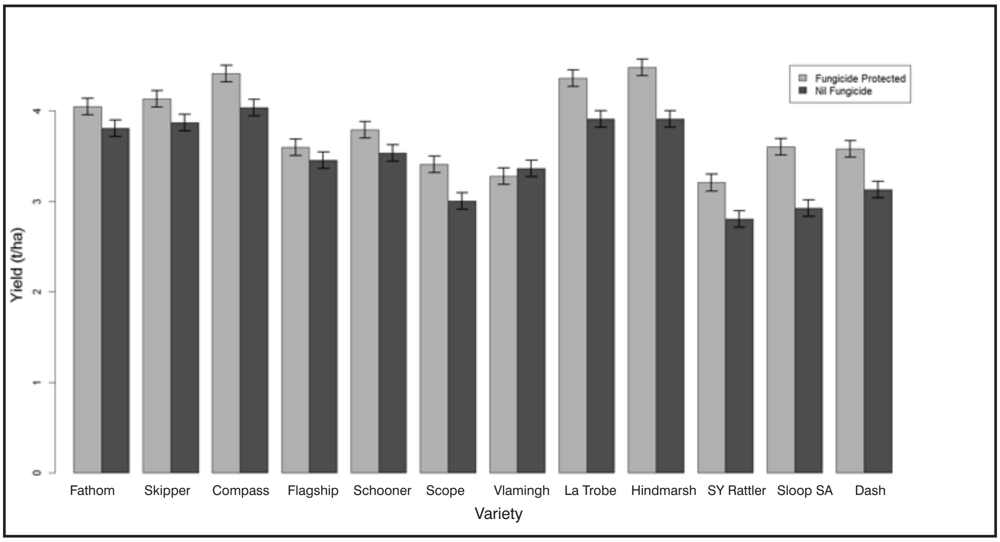


Figure 8 Yield of 12 varieties with and without complete disease control in 2014.

Table 2 Predicted yield loss (%) for varieties based on disease ratings under environmental conditions at Wharminda in 2014.

Disease rating	19 Aug	4 Sept	25 Sept	4 Oct
RMR	5	4	5	8
MS	10	9	7	7
S	13	12	10	11
SVS	14	14	12	15

Conclusions

The yield loss figures reported on here indicate that SFNB is not a very damaging pathogen compared to NFNB, leaf rust and scald, but that in prone areas growers are best avoiding varieties that are rated S or worse to this disease as they can lead to yield losses of up to 20%.

Data from the trials can be used to estimate potential yield losses based on a variety's resistance rating and/or the level of disease observed in a crop during the growing season.

The yield loss figures reported on here are likely to be close to the maximum likely to occur in Mallee environments in SA and Victoria as Wharminda is very prone to the disease due to the large area sown to barley and the environmental conditions favouring the pathogen at this site. The epidemics observed in 2014 and particularly 2015 were consistent with earlier epidemics observed at this site so this data should be able to provide a reliable guide for future years for this environment.

The data suggest that for varieties rated MS or worse, the benefits of using a fungicide for control of SFNB could be significant at Wharminda even though a single application of fungicide will not retrieve all of the losses. At locations less prone to the disease, losses will be lower than at Wharminda, making the use of fungicides more questionable. Systiva seed treatment is much more effective than a fungicide spray in protecting the crop but the higher application cost will need to be factored into the economic cost/benefits analysis for disease control.

Yield losses could rise to higher levels should growers opt to sow more susceptible varieties in future as this would lead to higher levels of inoculum in stubbles. Similarly, greater use of more resistant varieties such as Compass, or even La Trobe compared to Hindmarsh, should reduce inoculum levels and therefore potential losses in the region. Also, if Systiva and other effective fungicides are adopted widely, it is to be expected that inoculum levels, and therefore damage, will be reduced in future, provided the efficacy of these treatments can be maintained in the face of an evolving pathogen.

Acknowledgements

Sowing and management of trials by the New Variety Agronomy Group based in Port Lincoln. Assistance with disease assessments: Marg Evans, Mark Butt and Alan Mayfield. Clayton Forknall, Queensland Department of Agriculture and Fisheries, provided assistance with the trial design and analyses.

The GRDC provided the funding for the trials in 2014 and 2015. In 2014 this came through Greg Platz in the Department of Agriculture and Fisheries in Queensland via DAW00245 (Yield loss response curves for host resistance to leaf, crown and root diseases in wheat and barley). In 2015 funding came through Mark McLean and Agriculture Victoria via DAV000129 (Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in Victoria).

How current cereal cultivars affect multiplication of root lesion and cereal cyst nematodes in the field

RESEARCH

Katherine Linsell[1], Joshua Fanning[2], Sjaan Davey[1], Sabela Munoz Santa[3], Bev Gogel[3], Grant Hollaway[2] and Alan McKay[1]

[1]SARDI, Nematology and Diagnostics, Plant Research Centre, Waite Campus, [2]Agriculture Victoria
[3]Statistics for the Australian Grains Industry, University of Adelaide, Waite Campus

Disease

Key messages

- **Choose the best adapted high yielding varieties, but try to minimise use of cereal cyst (CCN) and root lesion nematode (RLN) susceptible varieties, as these can support production of very high populations that may cause problems for subsequent crops.**
- **The effect of varieties on nematode numbers varies depending on the starting population and between seasons. In general two consecutive resistant varieties/crops are needed to reduce high numbers.**
- **The most resistant CCN varieties of interest to the Eyre Peninsula include Scout, Commander, Hindmarsh (R), Estoc and Kord CL Plus (MR).**
- **Bread wheat varieties are generally more susceptible to RLN, *P. thornei* and *P. neglectus,* than barley and triticale varieties. Durum wheat varieties are more resistant to *P. thornei* than bread wheat.**
- **Compass (MR) was the most resistant barley variety to both *Pratylenchus* species.**
- **While some bread wheat varieties have useful levels of resistance to RLN including Wyalkatchem (MRMS) for *P. neglectus,* Dart (MRMS) for *P. thornei* and Wallup (MRMS) for both *Pratylenchus* species. The popular varieties such as Mace, Trojan and Axe are MS for both species.**
- **See the Cereal Variety Disease Guide for resistance ratings.**

Why do the trial?

The aims of the field trials conducted by GRDC DAS00116 were to assess the impact of named varieties on RLN (*Pratylenchus neglectus* and *Pratylenchus thornei*) and CCN (*Heterodera avenae*) populations in the field, and tolerance, in the Southern Australian cropping regions to assist:

- o growers to select the best varieties to grow when these nematodes are present in their paddocks to help manage nematode densities and prevent yield losses.
- o breeders to develop new resistant and tolerant varieties.

The RLN *P. thornei* and *P. neglectus* can cause up to 12% yield losses in cereals. *P. neglectus* is the most common RLN on the EP but *P. thornei* is slowly spreading across upper EP and is becoming established in calcareous sands. Resistant varieties reduce nematode populations in the soil. There is growing interest in development and use of cereal varieties resistant to *P. neglectus* and *P. thornei* as both have wide distribution and broad host range. Development and use of CCN resistant varieties has been very effective in reducing CCN populations to low levels; but CCN levels will increase if susceptible varieties are overused.

How was it done?

A total of four *H. avenae,* six *P. thornei* and seven *P. neglectus* cereal trials were established across Eyre Peninsula, Yorke Peninsula, SA and Vic Mallee, Adelaide Plains and Wimmera between 2010 and 2014. Sites were selected with medium populations of the target nematode and low incidence of other pathogens, though avoiding Rhizoctonia proved difficult in some regions.

In year 1, susceptible and resistant varieties were grown to create paired plots of high and low nematode numbers. In the following year, named cereal varieties including bread wheat, durum wheat, triticale and barley were grown in the paired plots using a randomized block design with 5 replicates. Nematode numbers in each plot were measured before sowing and after harvest using SARDI's PreDicta B DNA based soil testing service. The variety effect on nematode multiplication (resistance) was assessed by calculating the change in nematode numbers between pre-sowing and post-harvest. The difference in yield between the paired low and high nematode plots was used to determine how well each variety could tolerate the respective nematodes.

The latest data analysis techniques were used to minimize effects of spatial variability.

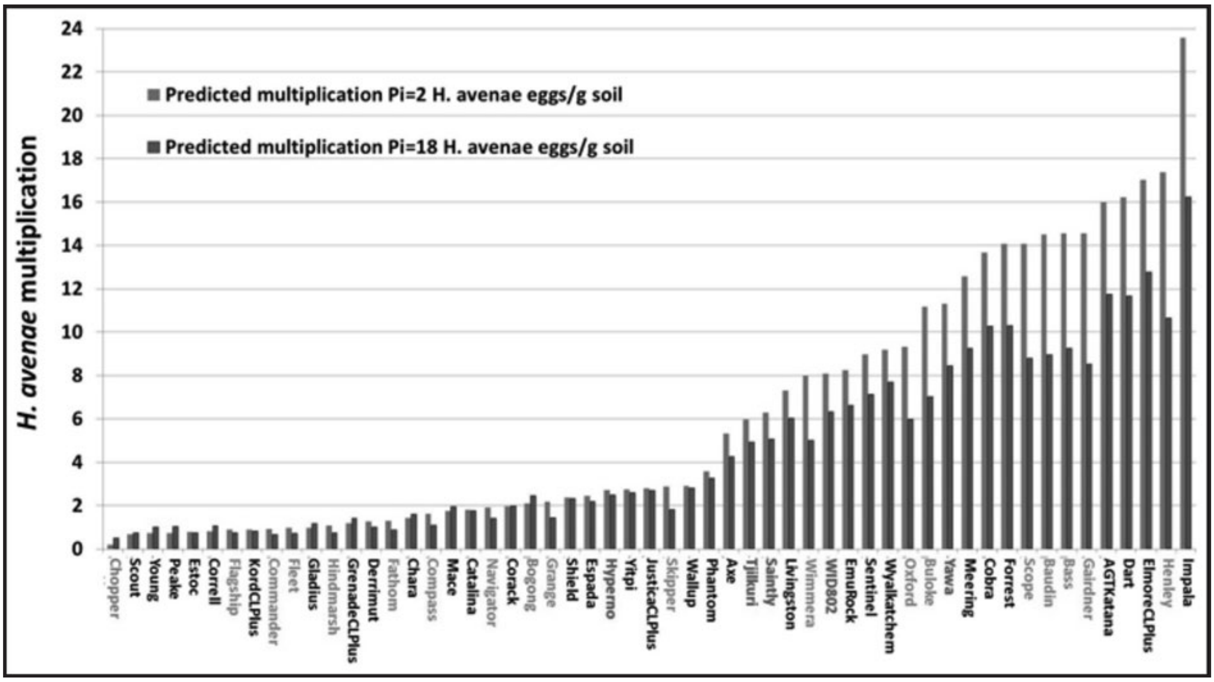


Figure 1 CCN (**Heterodera avenae*****) average predicted multiplication on cereal varieties in four Southern Australia field trials 2011-2013 at low (2*** **H. avenae/*****g soil) and high (18*** **H. avenae//*****g soil) densities.***

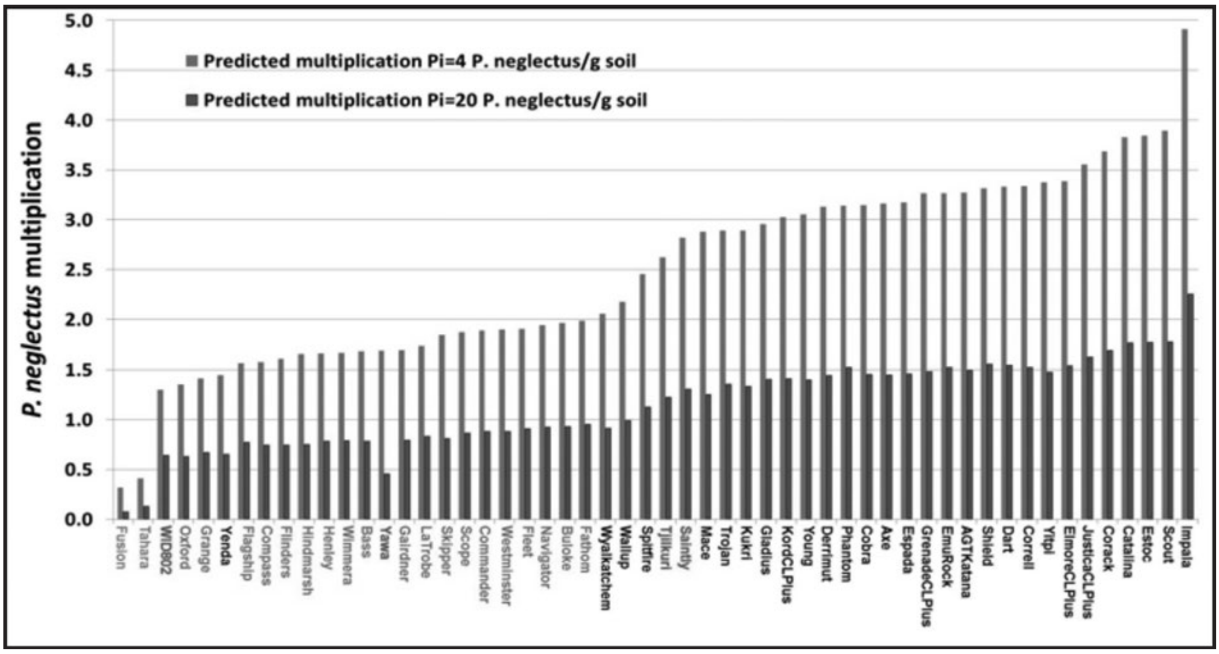


Figure 2 **Pratylenchus neglectus** ***average predicted multiplication on cereal varieties in seven Southern Australia field trials 2012-2014 at low (4*** **P. neglectus/*****g soil) and high (20*** **P. neglectus/*****g soil) densities.***

What happened?

The rankings of varieties for resistance to CCN and RLN were highly correlated between the low and high nematode density treatments both within and between sites, and seasons. So a multi environment trial (MET) analysis was used to generate average predicted multiplication rates for each variety for low and high initial nematode levels averaged across all sites

What does this mean?

The rankings of varieties by their impact on multiplication of *H. avenae, P. thornei* and *P. neglectus* was remarkably consistent across low and high nematode density treatments within and between sites. While multiplication rates vary with different initial levels and in different seasons, the overall rankings of the varieties is consistent across most trials.

Predicted multiplication rates in low and high initial nematode densities allows growers to see how specific varieties are likely to impact on high RLN and CCN levels in their paddocks. For example, moderately resistant varieties may increase low populations but cause large populations to decline. The most resistant wheat varieties of interest to CCN include Scout (R), Estoc and Kord CL Plus (MR) and the most susceptible, Wyalkatchem, Emu Rock and Cobra (Figure 1). The most resistant barley varieties of interest to CCN include Commander and Hindmarsh (R) and the most susceptible, Scope (Figure 1).

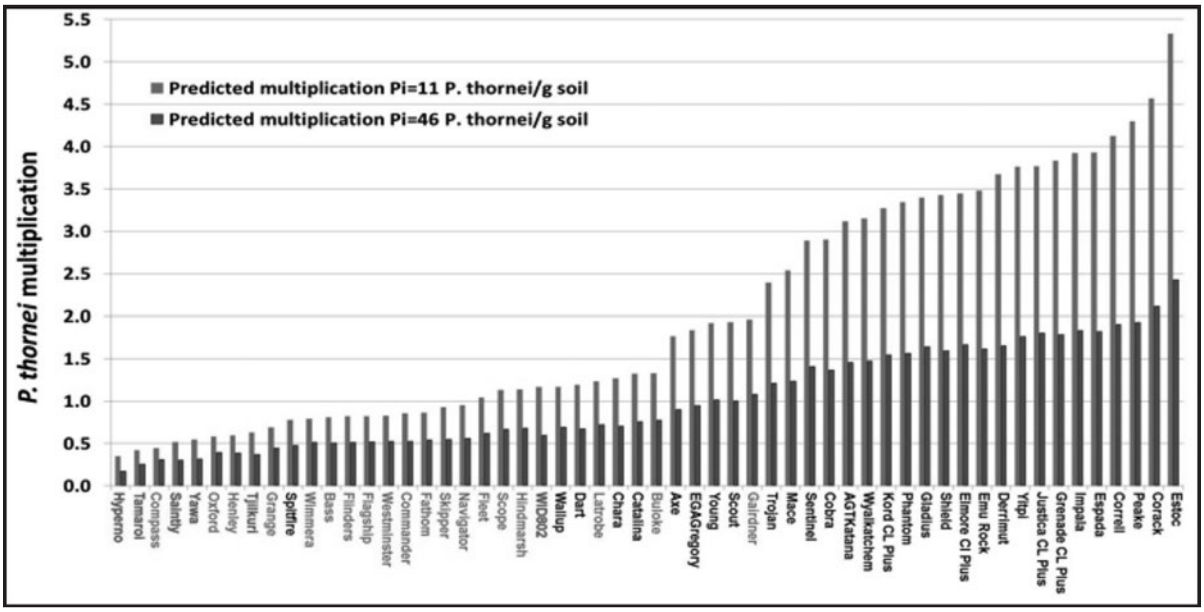


Figure 3 **Pratylenchus thornei** ***average predicted multiplication on cereal varieties in Southern Australia field trials 2012-2014 at low (11*** **P. thornei/*****g soil) and high (46*** **P. thornei/*****g soil) densities.***

It is important to be aware that MRMS varieties like Mace can still increase CCN populations but not as quickly or to as large numbers as varieties rated more susceptible (Figure 1).

A proportion of the initial CCN population will carryover and the amount is likely to vary between seasons. This carryover will tend to cause multiplication rates to be underestimated especially for the low nematode density treatments.

For both RLN species bread wheats are generally more susceptible than barley and triticale. Durum is generally more resistant to *P. thornei* (Figures 2 and 3). Some bread wheat varieties have useful levels of resistance to RLN; Wyalkatchem (MRMS) for P. neglectus (Figure 2), Dart (MRMS) for *P. thornei* (Figure 3) and Wallup is MRMS to both Pratylenchus species. Higher yielding varieties which are moderately susceptible include Mace and Trojan for *P. neglectus*, and Axe and Scout for *P. thornei* (Figures 2 and 3).

The most susceptible wheat varieties to both Pratylenchus species were Corack and Estoc. Scout is susceptible to *P. neglectus* and Justica CL Plus for *P. thornei* (Figures 2 and 3). These varieties can increase low to moderate RLN numbers to high levels and will maintain high populations.

Compass barley (MR) is useful for supressing both Pratylenchus species (Figure 2 and 3). Note some barley varieties can still leave relatively high nematode populations so it may take several seasons to reduce RLN populations to numbers below damage thresholds.

While all three nematodes caused significant losses, the relative losses were not consistent across sites and seasons (indicating a strong genotype by environment (GxE) interaction). So for the moment we cannot assign reliable tolerance ratings. Further work is required to develop methods to understand the GxE interactions affecting tolerance and devise an appropriate rating system.

Acknowledgements

This project was funded by the Grains Research and Development Corporation (DAS00116) a part of the National nematology project. Thank you to the SARDI teams for setting up and maintaining these sites and to the growers for use of their land.

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC Grains Research & Development Corporation
Your GRDC working with you

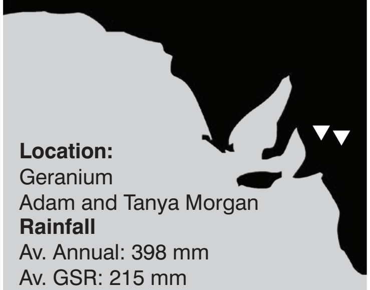
Impact of soil openers on *Rhizoctonia* fungicide wheat yield responses

Alan McKay[1], Simon Jacobs[1], Katherine Linsell[1], Paul Bogacki[1] and Ray Correll[2]

[1]SARDI, Plant Research Centre, Waite Campus, [2]RHO Environmetrics Pty Ltd

DEMO

Best practice



Location:
Geranium
Adam and Tanya Morgan
Rainfall
Av. Annual: 398 mm
Av. GSR: 215 mm
2015 Total: 321 mm
2015 GSR: 145 mm
Paddock History
2013: Wheat
2012: Wheat
Soil Type
Calcareous and over clay
Diseases
Rhizoctonia solani (AG8)
Plot Size
20 m x 1.5 m x 6 reps

Location:
Moorlands
Andrew Thomas
Rainfall
Av. Annual: 375 mm
Av. GSR: 201 mm
2015 Total: 293 mm
2015 GSR: 126 mm
Paddock History
2013: Wheat
2012: Wheat
Soil Type
Non-wetting sand
Diseases
Rhizoctonia solani (AG8)
Plot size
20 m x 1.5 m x 6 reps

Key messages

- **Increased root growth associated with application of Uniform® fungicide in all treatments did not always translate into a significant yield increase in field trials conducted in the SA Murray Mallee in 2015. Low spring rainfall is likely to be a key factor.**
- **Knife point, triple disc and bentleg soil openers that disturb soil to at least 10 cm with seed sown about 3 cm deep produced the greatest yield minus fungicide in Rhizoctonia trials at Geranium 2015.**
- **Knife point, narrow point (Atomjet) and triple discs produced the greatest yield when Uniform was dual banded at 200 ml/ha behind the press wheel and 200 ml/ha on the base of the furrow increasing wheat yield by 0.22 t/ha.**
- **With all openers crop roots were protected only within the fungicide treated zone and not between the rows.**
- **To increase the reliability of a positive return on investments to control rhizoctonia root rot, further work is needed to better understand responses in different seasons, interactions with other diseases and farm practices including post emergent N application.**

Why do the trial?

Rhizoctonia root rot caused by *Rhizoctonia solani AG8* is a serious disease in cereals in the low to medium rainfall cropping districts in the southern, western and lower northern regions especially on sandy soils and some high rainfall zones. Recent fungicide registrations provide growers with a greater range of options to reduce yield losses caused by Rhizoctonia. However, the cost of fungicides, variation in yield responses between seasons and lack of information on which soil openers provide the best yield responses, are identified barriers to adoption especially in the low rainfall regions. This article reports on the current analysis of results of a project that has been investigating wheat yield responses using Uniform dual banded on the surface of the furrow (200 ml/ha) and on the base of the furrow (200 ml/ha) under different soil openers (GRDC DAS00125 / SAGIT S314).

How was it done?

In 2015, trials were established at Geranium and Moorlands, SA Murray Mallee, to evaluate yield losses caused by rhizoctonia root rot with different soil openers (Table 1). A randomised split plot design with 6 replicates was used. Uniform was split banded at 200 ml/ha on the surface of the furrow and 200 ml/ha at the base of the furrow for all treatments except one where the full rate was banded at the base of the furrow. Sites were selected with a history of rhizoctonia root rot, previous crops were cereals and with medium to high pre-sowing Rhizoctonia levels as reported by PreDicta B.

Plots were fertilised with a 1:1 mix Granulock Z and Gran-Am at 85 kg/ha (12N+9P+12S) applied with seeds for single shoot systems or deep banded with double shoot systems (Table 1). At both sites, all plots were planted with Grenade CL Plus wheat. The Geranium site was sown on 12 May with a targeted seeding depth of 3 cm and seeding rate of 78 kg/ha. Post emergent N was applied at 40 kg urea/ha in first week of July. The Moorlands site was sown on 21 May at a depth of 4 cm, a seeding rate of 85 kg/ha and post emergent N plus micronutrients were applied on 10 August.

PreDicta B was used to assess treatment effects on levels of Rhizoctonia, and wheat root DNA levels in soil. Soil samples were collected from each plot during August and October. The sites were harvested in late November and yields of each plot measured. Data was analysed by Dr Ray Correll of RHO Environmetrics.

Table 1 Soil opener and fungicide treatments.

Treatment	Sakura herbicide	Depth of till (mm)	Fertiliser	Fungicide Application	Speed (km/h)
Knife point	Yes	100	Deep banded	Split In Furrow/Surface	6
AtomJet	Yes	50	Combined	Split In Furrow/Surface	6
Bentleg	Yes	130	Combined	Split In Furrow/Surface	6
Single disc	Yes	60	Combined	Split In Furrow/Surface	11
Single disc	Yes	60	Combined	In Furrow only	11
Single disc	No	60	Combined	Split In Furrow/Surface	11
Triple disc	Yes	100	Deep banded	Split In Furrow/Surface	11
Triple disc	Yes	100	Deep banded	Split In Furrow/Surface	6
Triple disc	No	100	Deep banded	Split In Furrow/Surface	6
Triple disc + Scoop	Yes	100	Deep banded	Split In Furrow/Surface	4.2
Knife point	Yes	100	Deep banded	NONE (seeder control)	6

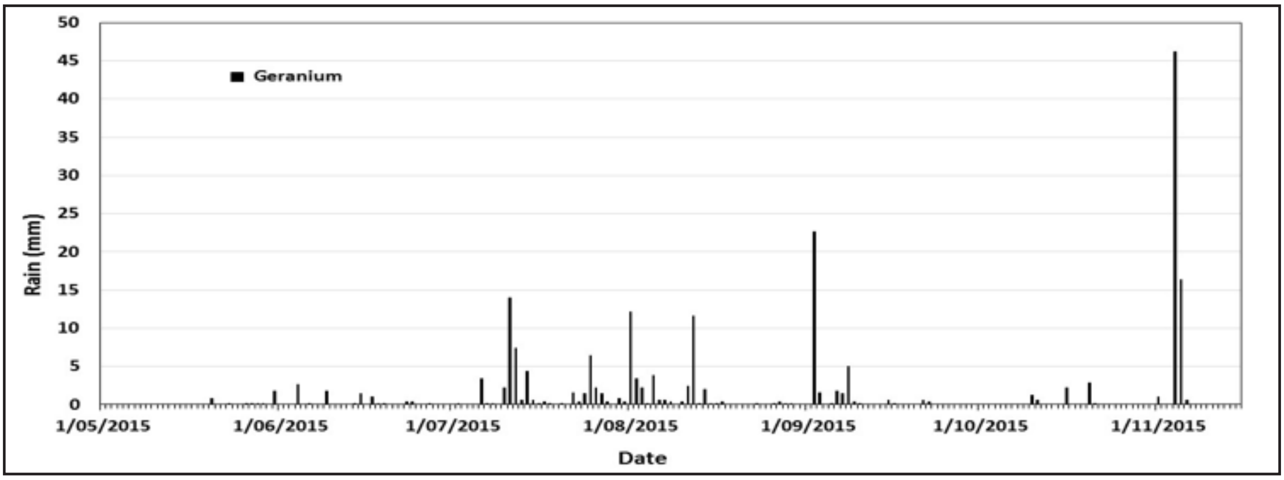


Figure 1 Growing season rainfall at Geranium in 2015.
Note: the crop had matured before the large rain events in early November.

The trials were sown by UniSA using a research plot seeder set up to deliver the fungicide treatments to one half of the plots (e.g. 3 out of 6 rows). All treatment runs thus comprised a no-fungicide reference within, to enable accurate fungicide assessment suited to the patchiness of rhizoctonia root rot. A zero-fungicide control plot was also used to assess any plot seeder bias.

What happened?

Growing season rainfall at Geranium totalled 145 mm (Figure 1), with a September to October rainfall total of 42 mm. The large rain events in early November were too late to benefit yield and not included as part of the growing season total. Soil temperatures at a depth of 5 cm were also collected (data not presented).

Averaged across all treatments, the fungicide;

- Reduced Rhizoctonia levels by 52% and 57% on-row in August and October respectively ($p<0.001$) (Figure 2);
- Increased root growth by 67% and 65% in August and October respectively ($p<0.001$) (Figure 3); and,
- Increased wheat yield by 0.22 t/ha ($p<0.001$) (Figure 4).

Had there been more spring rainfall, yield responses would probably have been greater. The fungicide responses were consistent across the soil openers except for the experimental bentleg opener, which showed no significant fungicide effect on Rhizoctonia levels, wheat root growth in August, on grain yield (Figure 2, 3 and 4).

Removing the top 3 to 4 cm of soil (which contains about 75% of Rhizoctonia inoculum) away from the seeding furrow using a scoop in front of the triple disc did not produce any disease or yield benefits, however it did significantly improve crop establishment in a duplicate trial at Moorlands which had non-wetting sand (yield at this site was severely affected by frost).

The highest yielding treatments at Geranium, all with fungicide, included knife point, narrow point (Atomjet) and triple disc. The best openers without fungicide were bent leg, knife point and triple disc. The effect of the bent leg warrants further investigation.

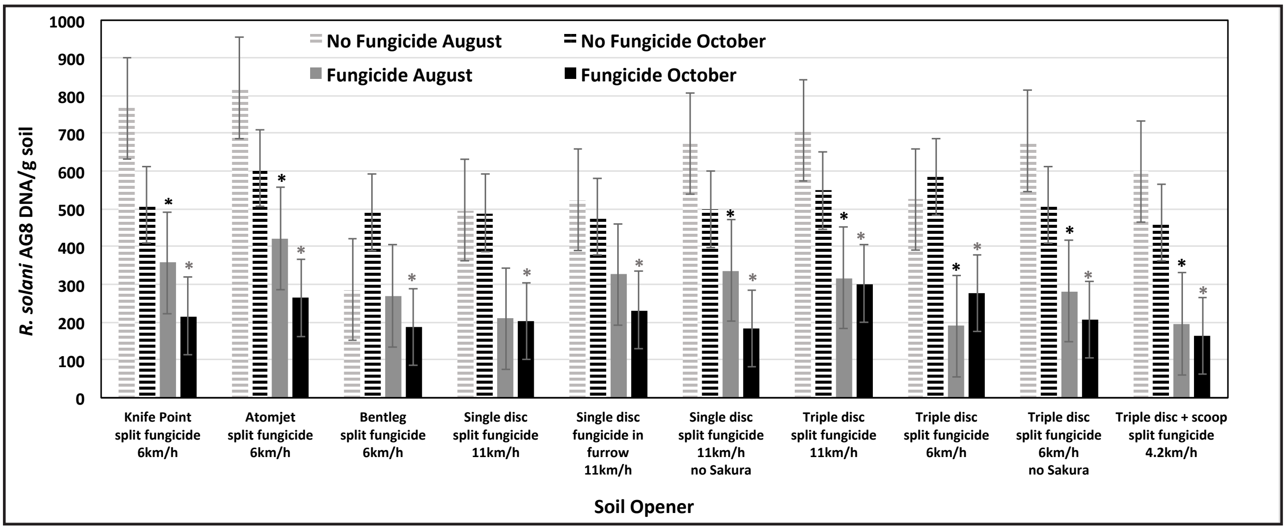


Figure 2 Effect of soil opener on **Rhizoctonia solani AG8** ***density on row +/- fungicide at Geranium in August & October 2015.***

** fungicide response significant at p<0.05 (bars are standard errors SE).*

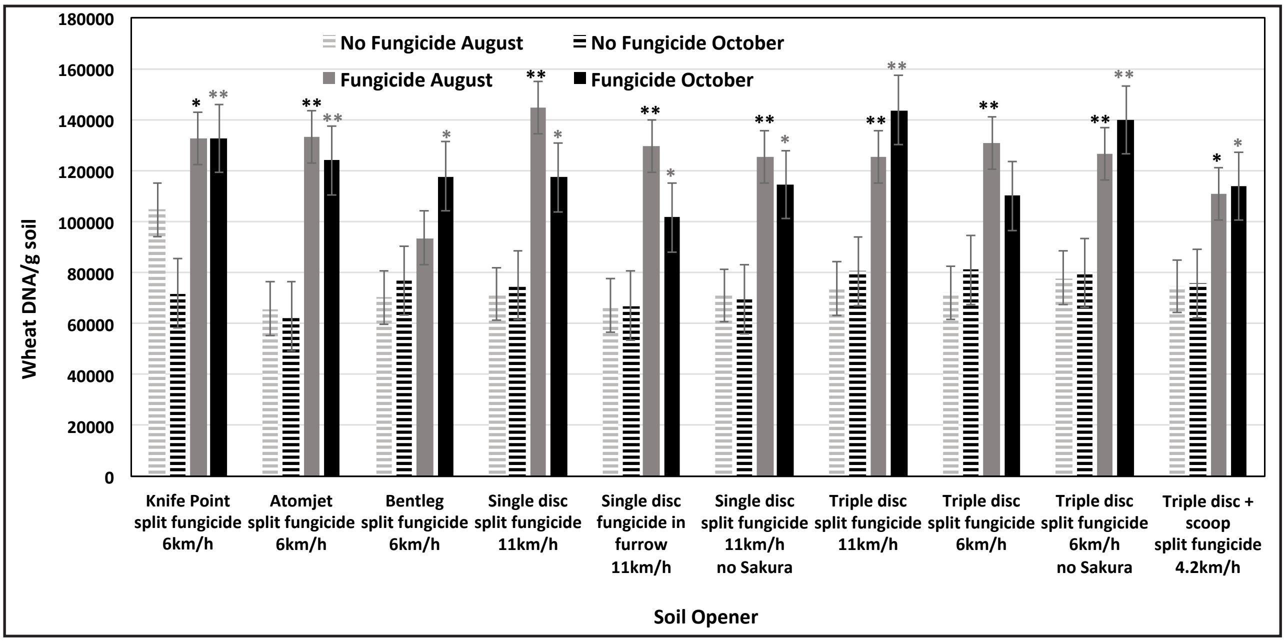


Figure 3 Effect of soil openers +/- fungicide on wheat root growth on row at Geranium in August & October 2015.

** fungicide response significant at p<0.05 and ** p<0.001, (bars are standard errors SE)*

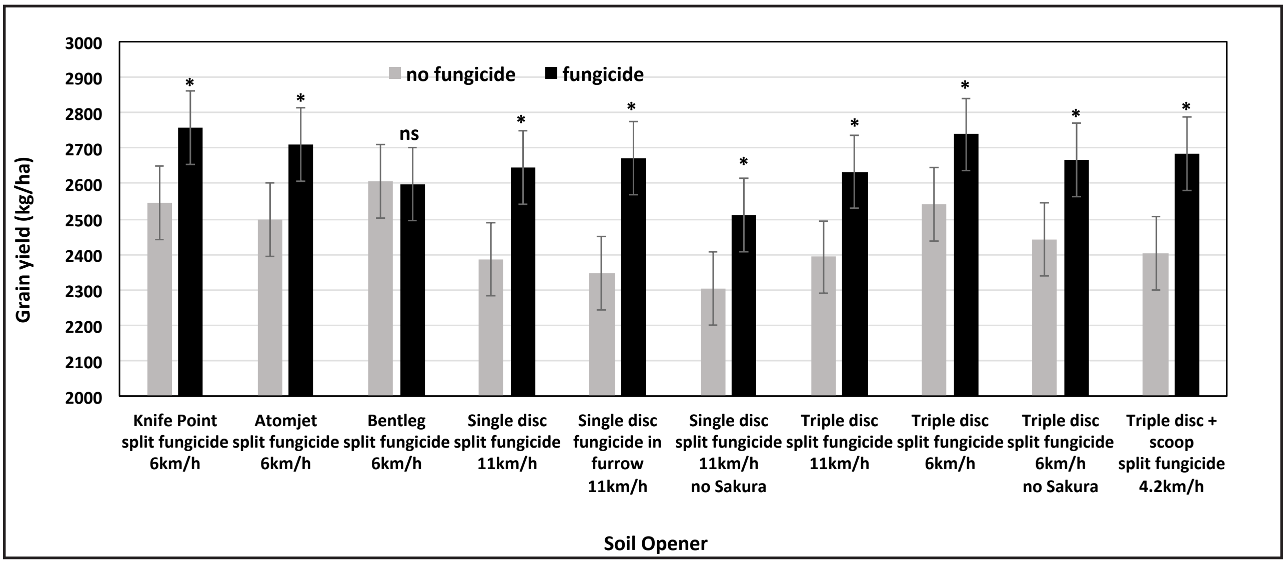


Figure 4 Soil openers yield responses +/- fungicide at Geranium 2015.

** fungicide response significant at p<0.05 and ** p<0.001, (bars are standard errors)*

What does this mean?

Analysis and interpretation of this data is continuing, there were many significant effects, interactions and correlations, results presented in this article summarise the main findings so far.

- Application of fungicide to control Rhizoctonia in wheat is likely to produce the greatest yield responses when there is significant spring rainfall.
- Application of Uniform at seeding as a dual band on furrow surface (200 ml/ha) and at the base of furrow (200 ml/ha), increased root growth by over 50% in wheat in the top 10 cm within the row and the magnitude of the response was maintained or increased as the season progressed. Roots were protected only within the fungicide treated zone and not between the rows.
- Average yield responses in the plus fungicide treatments at Geranium did not reflect the improved root growth which was often >50%. The low yield responses were probably due to low spring rainfall which totalled 42 mm.
- Knife point, triple disc and bentleg soil openers that disturb soil to at least 10 cm with seed sown about 3 cm deep produced the greatest yield minus fungicide in Rhizoctonia trials at Geranium 2015. Knife point, narrow point (Atomjet) and triple discs produced the greatest yield when Uniform was dual banded at 200 ml/ha behind the press wheel and 200 ml/ha on the base of the furrow increasing wheat yield by 0.22 t/ha. A duplicate trial at Moorlands in 2015 was lost to frost. Similar yield responses were observed in previous trials conducted in 2014.
- Uniform dual banded increased yield by a similar amount with all soil openers except the bentleg opener (the bentleg had the lowest Rhizoctonia levels in August, but levels were similar to other openers in October).
- Further work is needed to better understand treatment responses in different seasons, interactions with other diseases and farm practices including post emergent N application. This information will assist growers to identify the situations where they will get a positive return on investments to control Rhizoctonia.

Acknowledgments

GRDC and SAGIT for funding the research. SARDI New Crop Agronomy group for managing weed control and harvesting the trials. All the growers that kindly allowed SARDI to conduct the trials on their land.

Registered products: see chemical trademark list.

Fluid delivery systems and fungicides in wheat

RESEARCH

Amanda Cook, Ian Richter and Wade Shepperd
SARDI, Minnipa Agricultural Centre

Searching for answers

Location:
Warramboo
Darren Sampson and family
Rainfall
Av. Annual: 313 mm
Av. GSR: 227 mm
2015 Total: 326 mm
2015 GSR: 237 mm
Yield:
Potential: 3.2 t/ha
Actual: 3.0 t/ha
Paddock History
2015: Mace wheat
2014: Mace wheat
2013: Medic pasture
Soil Type
Red sandy loam
Plot size
20 m x 2 m x 3 reps

Location:
Streaky Bay
Luke Kelsh and family
Rainfall
Av. Annual: 379 mm
Av. GSR: 304 mm
2015 Total: 249 mm
2015 GSR: 212 mm
Yield:
Potential: 2.0 t/ha (W)
Actual: 1.2 t/ha
Paddock History
2015: Mace wheat
2014: Medic pasture
2013: Mace wheat
Soil Type
Grey calcareous sandy loam
Plot size
20 m x 2 m x 3 reps

Key messages

- **Phosphoric acid showed a yield response at Streaky Bay in 2014 of 13% and 2015 of 8%.**
- **Fungicides did not reduce Rhizoctonia infection or significantly increase yield in 2015 at either site despite high levels of inoculum.**
- **Including fungicides will increase input cost and risk over a cropping program.**
- **The addition of trace element or manganese treatments did not improve yield at Streaky Bay or Warramboo in 2015.**

Why do the trial?

A SAGIT Fluid delivery project was funded to update the benefits of fluid delivery systems from previous research and assess the potential of fluid nutrients and disease control strategies in current farming systems. The fluid systems (fertilisers or nutrients) have the potential to increase production through delivery of micro and macro nutrients, reduce cost of trace element delivery and increase control of cereal root and leaf disease.

Historically, fungicidal control of Rhizoctonia, which infects the major crops grown in southern Australia, has generally been poor, but fluid delivery systems with fungicides are a new option of delivery which may increase production and improve disease control. This trial was undertaken to assess the benefits of delivery of nutrients and these products, and various application strategies, on wheat in two upper Eyre Peninsula environments.

How was it done?

Three replicated trials were established, one at Warramboo on a red sandy soil and two at Streaky Bay on a grey calcareous sand in 2015. At Streaky Bay the nutrition and fungicide treatments were split into two smaller trials located behind each other due to the site variations with hills and shallow soil. Both trials had nutrition delivery treatments and fungicide application strategies. The fluid fertiliser delivery system placed fluid fertiliser approximately 3 cm below the seed at an output rate of 100 L/ha. The fungicide fluid system could also be split to deliver fluids both below the seed at approximately 3 cm, and above in the seeder furrow behind the press wheel in a 1 cm band.

The control treatment was 60 kg/ha of Mace wheat with 50 kg/ha of 18:20:0:0 (DAP). All phosphorus treatments were applied to the same rate of 9 units of phosphorus (P) and balanced with urea or UAN to 10 units of nitrogen (N). Manganese (Mn) was selected as the main focus trace element, with zinc (Zn) and copper (Cu) also included in the trace element mix. A DAP fertiliser dry blend with Mn @ 1.5 kg/ha was sourced. Phosphoric acid and granular urea, and ammonium poly phosphate (APP) and urea ammonium nitrate (UAN) were used as fluid fertiliser products to compare with granular fertilisers. Manganese sulphate was dissolved with standard rate being 1.5 kg/ha and 3 kg/ha as a high rate. 1 kg/ha Zn, as zinc sulphate and 0.2 Cu of copper sulphate were dissolved in the standard rates of trace elements, which were also delivered as foliar applications at 4-5 leaf stage.

The fungicides Uniform, EverGol, Vibrance (seed dressing) were assessed for Rhizoctonia disease suppression at different rates and in split applications. Triadimenol was also applied on fertiliser as a treatment.

The Warramboo trial was sown on 19 May with pre-sowing weed control of 1.5 L/ha Roundup Attack, 1.5 L Boxer Gold and 80 ml/ha Nail. In crop weed control was on 31 July with 1.2 L/ha of Broadside, later than ideal due to the sampling required on the trial. Urea was spread over the whole trial on 31 July at 20 kg/ha.

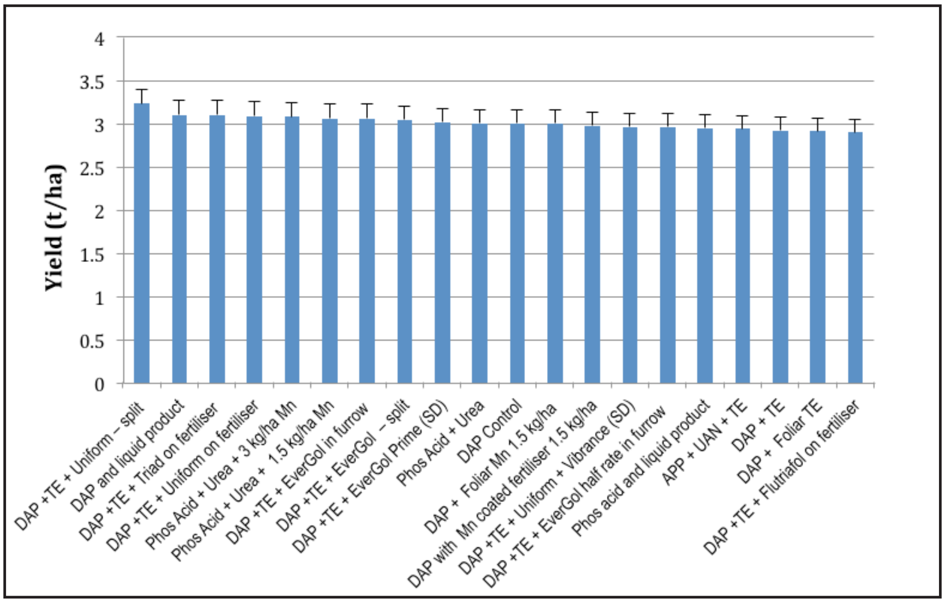


Figure 1 Yield for Mace wheat with fertiliser and fungicide treatments at Warramboo trial, 2015 (non-significant).

Disease

The Streaky Bay trial was sown in dry conditions on 28 May with pre-sowing weed control using 1.5 L/ha Roundup Attack, 1.5 L Boxer Gold and 100 ml/ha Nail. It was sprayed on 11 July with 240 ml/ha of Dominex Duo for insect control. The trace element foliar treatments were applied at Zadocks growth stage 22 on 14 August. In crop weed control was on 3 September with 1.5 L/ha of Amicide 700 to control Lincoln weed (*Diplotaxis tenuifolia*) and sheep weed (*Lithospernum avensis*).

PreDictaB disease inoculum levels (RDTS), plant establishment, Rhizoctonia seminal root score, Rhizoctonia crown root score, green leaf area index, grain yield and quality were measured during the season.

Rhizoctonia infection on seminal roots and crown roots was assessed using the root scoring method described by McDonald and Rovira (1983) approximately seven weeks from seeding, on 13 July at Warramboo and 20 August at Streaky Bay. Crown roots per plant were also counted on these samples with the number of roots infected with Rhizoctonia used to calculate % crown root infection.

Trials were harvested on 16 November at Warramboo and 17 November at Streaky Bay. Data were analysed using Analysis of Variance in GENSTAT version 16.

What happened?

At both sites, the initial Predicta B inoculum level predicted a high risk of Rhizoctonia disease (Warramboo 150 pg DNA/g soil, Streaky Bay 208 pg DNA/g soil), Take-all and *Pratylenchus neglectus* were low risk. Warramboo also had low levels of Cereal Cyst Nematode.

Both sites have alkaline pH, reasonable soil phosphorus levels and adequate nutrient levels (data not presented). Initial soil moisture levels were much lower at Streaky Bay than Warramboo. The main difference with these soil types from previous soil analyses are the calcium carbonate content of around 55-80% to 60 cm at Streaky Bay and Piednippie compared to 0-25% calcium carbonate content on the red sandy loams of Central Eyre Peninsula.

Plant establishment in ideal seeding conditions at Warramboo averaged 124 plants/m^2 but some fungicide treatments lowered plant establishment. In Streaky Bay the general plant establishment was poor due to the dry seeding conditions and not affected by treatments.

Rhizoctonia patches were present the Streaky Bay trial early in the season. The low soil moisture resulted in stressed plants and limited early plant growth. The trial at Warramboo had similar Rhizoctonia disease inoculum levels as Streaky Bay with some patches present in the trial area. The barley crop grown in the paddock showed significant Rhizoctonia disease symptoms.

There were no differences at Warramboo in dry matter or grain yield in fungicide and nutrition treatments, with treatments averaging 3.0 t/ha (Figure 1). Grain quality showed no differences with the trial averages being; test weight of 81.5 (kg/hL), protein 9.1%, screenings 1.3% (data not presented).

The fungicide treatments at Warramboo had Rhizoctonia infection on both seminal and crown roots however there were no significant differences between the fungicide treatments imposed on Rhizoctonia root assessment taken at eight weeks (data not presented). The application of fungicides in furrow did not perform better than fertiliser application or seed dressing at this site.

There were no significant differences in 2015 at Warramboo between the fungicide treatments (Figure 1), but there were small differences in fungicide treatments in 2014. The input costs (Table 1) of the treatments in the 2015 seasons at the Warramboo site shows the increased input cost over the control with higher risk over a whole cropping program. This soil type also showed no yield response to phosphorus or alternative phosphorus sources, highlighting the need for a responsive soil type before changing to a fluid fertiliser strategy for phosphorus.

Table 1 The input cost ($/ha) of the nutrition and fungicide treatments imposed at Warramboo in 2015.

Treatment	Variable costs* ($/ha)	P fertilser ($/ha)	Nitrogen +Trace Elements ($/ha)	Fungicide ($/ha)	Total Cost ($/ha)
DAP and Liquid Trace elements Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha	99	38	15		152
Phosphoric acid and 3 kg/ha MnSO4 liquid and Gran Urea	99	43	26		168
Phosphoric acid and Gran urea (equivalent 50 kg/ha DAP)	99	43	23		165
Phosphoric acid and 1.5 kg/ha MnSO4 liquid and Gran Urea	99	43	24		166
DAP and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha	99	38	13		150
DAP and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha	99	38	15		152
APP and UAN (equivalent 50 kg/ha DAP) and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha	99	53	15		167
DAP with Mn coated fertiliser 1.5 kg/ha	99	38	13		150
Control DAP	99	38	11		148
DAP+TE Uniform @ 300 ml/ha Split IF	99	38	15	19	171
DAP+TE EverGol 80 ml/ha Split IF	99	38	11	9	157
DAP+TE Uniform on fertiliser @ 300 ml/ha	99	38	15	19	171
DAP+TE Uniform@300 ml/ha + Vibrance (SD)	99	38	15	25	177
DAP and TE EverGol 80 ml/ha IF	99	38	15	9	161
DAP and TE EverGol 40 ml/ha IF	99	38	15	4	156
DAP and TE EverGol (SD) 80 ml/100 kg seed	99	38	15	9	161

Variable costs are seed, chemical, repairs and maintenance, fuel and crop insurance

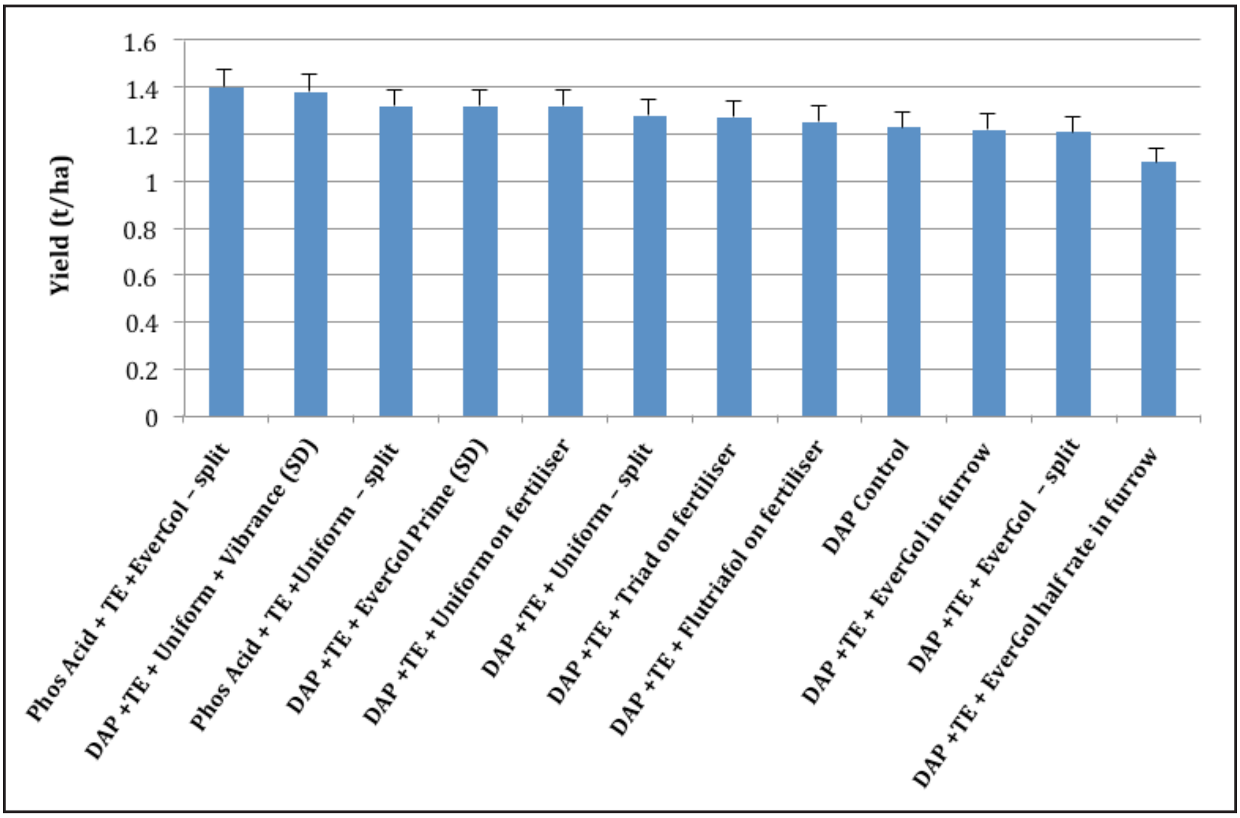


Figure 2 Yield for Mace wheat with fertiliser and fungicide treatments at Streaky Bay trial, 2015 (non-significant).

Table 2 Fluid delivery of nutrition trial growth measurements, yield and grain quality for Mace wheat at Streaky Bay, 2015.

Treatment	Plant establishment (plants/m^2)	Early dry matter (g/plant)	Late dry matter (t/ha)	Yield (t/ha)
Phosphoric acid and 1.5 kg/ha MnSO4 liquid and Gran Urea	79	0.34	3.4	1.30
Phosphoric acid and 3 kg/ha MnSO4 liquid and Gran Urea	81	0.30	3.3	1.28
Phosphoric acid and Gran urea (equivalent 50 kg/ha DAP)	75	0.39	3.3	1.24
Phosphoric acid and liquid product	92	0.32	3.2	1.24
APP and UAN (equivalent 50 kg/ha DAP) and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha	84	0.28	3.0	1.16
DAP and Liquid Trace elements Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha	89	0.25	2.9	1.08
DAP and liquid product	88	0.25	2.9	1.08
DAP with Mn coated fertiliser 1.5 kg/ha	109	0.23	2.6	1.07
DAP and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha	82	0.21	2.5	1.00
Control	96	0.23	2.3	0.95
DAP and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha	108	0.21	2.4	0.91
LSD (P=0.05)	*19*	*0.10*	*0.7*	*0.16*

The trial at Streaky Bay was very uneven and had patchy growth due to moisture stress early as well Rhizoctonia disease expression. The Streaky Bay nutrition trial had visual differences in early growth with the phosphoric acid treatments looking better than other treatments. The phosphoric acid treatments were the highest yielding (Figure 2). The grain quality at Streaky Bay was not affected by treatments and averaged test weights of 82.4 (kg/hL), protein of 10.8% and screenings of 5.3% for both trials.

The fungicide trial was generally more even in growth earlier in the season than the nutrition trial, but Rhizoctonia patches were still present. There were no treatments which were visually better in the fungicide trial during the season. There were no differences in early and late dry matter (data not presented) or yield in the fungicide treatments in 2015 (Table 2), despite reasonable levels of Rhizoctonia seminal and crown root infection.

In 2015 there was a 0.11 t/ha (8%) yield increase from 1.25 t/ha using granular DAP to 1.36 t/ha using phosphoric acid in this soil type in a dry season. A similar trial conducted at Streaky Bay, in 2014, showed a 0.13 t/ha yield increase (13%) over DAP using phosphoric acid as the phosphorus source.

The trace element treatments or manganese treatments did not improve yield at either site in 2015.

What does this mean?

Consistent improvements in grain yield have been observed through using a fluid form of phosphorous (phosphoric acid) over a granular product on the highly calcareous sandy loams soils of Streaky Bay in both 2014 and 2015. However yield improvements to the same products were not observed on the red sandy soil at Warramboo in either year. This highlights the specific soil type benefit in using fluid phosphorous fertilisers and their advantage on calcareous soil types.

In 2015 trails at both Streaky Bay and Warramboo were unable to demonstrate any yield advantage to using a range of fungicides aimed at controlling rhizoctonia. The current research on fungicides for rhizoctonia control shows yield variation between seasons which may depend on spring rainfall (McKay, A., *et. al*). Using break crop rotations and lowering rhizoctonia inoculum levels before a cereal crop may be the best option. All current information should be taken into account when formulating a management plan to control rhizoctonia in high risk situations.

These trials will be sown again in 2016 to have a better understanding of the best fertiliser mixes and fungicide applications and to increase confidence in fluid delivery systems.

Acknowledgements

A big thank you to Sue Budarick for doing the Rhizoctonia root disease assessments. Thank you to Nigel Wilhelm for input into this trial also Darren Sampson and Luke Kelsh and families for supporting research by having trials on their properties. Trial funded by SAGIT Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems, S614.

Registered products: see chemical trademark list.

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

SAGIT

Disease

Fluid delivery systems in canola

Amanda Cook, Ian Richter and Wade Shepperd
SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

Location:
Coulta
Morgan family
Rainfall
Av. Annual: 525 mm
Av. GSR: 465 mm
2015 Total: 397 mm
2015 GSR: 350 mm
Yield
Potential: 3.6 t/ha (C)
Actual: 2.0 t/ha
Paddock History
2015: CL Canola
2014: Barley
2013: Wheat
Soil Type
Grey loamy sand
Plot Size
20 m x 2 m x 3 reps

Key messages

- **There were no differences in canola Blackleg infection or yield using fungicides as seed treatments or in-furrow in 2015.**
- **In 2014 combined protection of a fungicide on seed and in the furrow as a banded fluid reduced Blackleg infection and increased yield.**
- **The selection of Blackleg resistant varieties in the rotation is important.**

Why do the trial?

A SAGIT Fluid delivery project was funded to update the benefits of fluid delivery systems from previous research and assess the potential of fluid nutrient delivery systems and disease control strategies compared to current systems. The fluid systems have the potential to increase production through delivery of micro and macro nutrients, lower cost of trace element delivery and better control of cereal and canola root and leaf diseases.

Blackleg continues to be a major issue facing canola growers especially on lower Eyre Peninsula and fluid delivery systems for product delivery may increase production and improve disease control. With the development of fungicides and the ability to deliver liquid products around the seed row during the seeding pass, there is now a range of application strategies available to growers to make use of these new products. Two trials separately investigated the relative benefits of a range of fungicide strategies for Blackleg control and a range of manganese (Mn) delivery options on canola yield. The performance of fluid phosphorus was also tested.

How was it done?

In autumn 2014, a national trial was set up to examine sampling position and stubble addition effect on crown rot detection. Four separate soil samples were collected from each of 129 NVT sites. At each site, two samples were collected on the row and two between the rows of the previous cereal crop. For each sampling position, one sample was supplemented with 15 pieces of cereal or grass weed stubble about 5 cm long (one piece by 15 locations) and the other was not. Samples were analysed using the PreDicta B DNA test.

What happened?

In the 2015 the trials were split, with the Blackleg trial located at Coulta and the nutrition trial focusing on manganese located at Farm Beach. Both replicated trials were sown with Clearfield 45Y86CL (CL canola) at 3 kg/ha. PreDictaB disease inoculum levels (RDTS), plant establishment, Blackleg infection and grain yield were measured during the season.

For the Blackleg trial the fertiliser treatment was 100 kg/ha of 18:20:0:0 with in furrow fungicides or trace elements delivered as a fluid. The trace element treatment had Mn at 1.5 kg/ha of manganese sulphate, 1 kg/ha Zn as zinc sulphate and 0.2 kg/ha Cu as copper delivered at a water rate of 80 L/ha. The fungicides Jockey and Intake were evaluated for Blackleg disease control. The paddock was spread with 500 kg/ha of gypsum in mid-April. The paddock was sprayed with 2.5 L/ha Roundup Attack with 2% LI700, 1.5 L/ha TriflurX, 100 ml/ha Goal, 40 g/ha Sentry and 290 ml/ha Lorsban with an 80 L/ha water rate. The trial was sown on 14 May.

Weed control was applied broad acre on 20 June with Targa @ 500 ml and Select @ 500 ml with 5% uptake at 100 L/ha water rate. 90 kg/ha of urea was applied broad acre on 25 June and also on 13 July. The fungicide trial was desiccated on 2 November with Sprayseed 250 @ 4 L/ha and harvested on 16 November 2015.

The Mn trial was not harvested because of very poor establishment, a dry finish and extensive bird damage near maturity which made fair comparisons between treatments impossible. Only results from the Coulta Blackleg trial are reported.

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

Fungicide treatment	Canola establishment (plants/m^2)	Blackleg score (% infection)	Yield (t/ha)
Intake (in furrow) and Jockey (on seed)	32.7	10.2	2.18
Intake (in furrow)	35.0	11.1	2.01
Intake (on fertiliser)	38.6	15.1	2.08
Jockey (seed)	39.9	22.4	1.87
Control	29.7	12.6	2.09
Control plus Trace elements	30.1	19.8	2.11
LSD (P=0.05)	*ns*	*ns*	*ns*

Table 1 Disease scores, growth measurements and yield for CL canola with fungicide treatments in Coulta trial, 2015.

What happened?

The fungicide trial was located at Coulta within an intensive canola cropping region with a potentially high Blackleg disease pressure. A PredictaB test showed high disease risk for Rhizoctonia but low risk levels for *Pratylenchus neglectus.*

The initial soil data showed adequate soil nutrition, phosphorus and trace elements at the trial site with 71 mm of soil moisture in the plant root zone.

Establishment was unaffected by fungicide treatments, averaging 34 plants/m^2 (Table 1). The Blackleg infection was lower in 2015 (av. 15%) compared to 2014 (av. 29%). There were no significant differences in Blackleg infection due to the fungicide treatments imposed as seed dressings or in furrow recorded at this site in 2015. There were no differences in yield recorded in 2015 (Table 1).

What does this mean?

In the 2014 season in the same trial the combined fungicide treatments did significantly increase yield over the nil fungicide control treatment at a similar site, however the difference in Blackleg disease levels scored was not significant (EPFS Summary 2014, Fluid delivery systems in canola, p104).

In 2015 there were no significant differences in Blackleg infection or yield at this site. The selection of resistant varieties with high Blackleg ratings within paddock rotations is important.

Acknowledgements

Thank you to the Morgan family for having the trial on their property, and Terry Blacker and Ashley Flint for help with these trials. Trial funded by SAGIT Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems, S614.

Registered products: see chemical trademark list.

Section 4

Section Editor:
Nigel Wilhelm
SARDI, Minnipa Agriculture Centre

Farming Systems

Farming systems projects on Eyre Peninsula in 2015

Naomi Scholz
SARDI, Minnipa Agricultural Centre

INFO

Title	Maintaining profitable farming systems with retained stubble	Application of CTF in low rainfall zone	Eyre Peninsula Grain & Grain 3	Overdeoendence on Agrochemicals
Project Code	EPF00001	ACT00004	SFS00028	CWF00020
Funder	GRDC	GRDC	GRDC	GRDC
Partners	Lead: EPARF SARDI (delivery)	Lead: Australian Controlled Traffic Farming Association (ACTFA) SARDI (delivery)	Lead: SARDI (delivery) Rural Solutions SA (extension) EPARF, LEADA	Lead: Central West Farming Systems
Duration	5 years, end 30/06/2018	5 years, end 30/06/2019	3 years, end 31/12/2016	3 years, end 30/06/2017
Area covered	Upper EP There is a LEADA project covering lower EP. Part of the GRDC Stubble Initiative, covering the southern grain growing region of Australia. 10 major grower group partners plus CSIRO.	Upper EP Other groups involved are Upper North Farming Systems, Central West Farming Systems, Mallee Sustainable Farming, BCG, SPAA, DEPI VIC.	EP Other groups involved are Southern Farming Systems, East SA managed by Ag Excellence Alliance, BCG, and Mallee Sustainable Farming.	Upper EP, Upper North SA Other groups involved are BCG, Mallee Sustainable Farming.
Aim	Increased knowledge and skills allowing farmers and advisers to improve farm profitability while retaining stubble in farming systems on upper Eyre Peninsula.	Adoption of Controlled Traffic Farming (CTF) in the LRZ is very low (eg SA/Vic Mallee, 4%) compared to other zones in the Region (eg Vic HR, 26%). This is believed to reflect scepticism about its benefits in many LRZ environments when weighed up against the cost of adopting the practice. The project will evaluate whether or not this scepticism is justified.	Growers and advisors using processes, tools or packages to design and manage flexible mixed farming systems equipping them with the ability to adopt and respond to changing environment and market conditions to manage risk and generate profits.	By 30 June 2017, 1500 growers and 20 advisors of the low rainfall zone of the southern GRDC region have the knowledge (technical & economic) and tools to reduce their dependence on agrochemicals.

Topics to be addressed	The build-up of snails, mice and fungal disease carryover on cereal stubble and increasing in-crop weed infestation. Difficulty of establishing crops into medic pasture residue. Establishment of crops on non-wetting soils.	Effects of compaction on light soils. Increased yield or cost savings (e.g. less fuel) by alleviating compaction damage. Management of wheel tracks and CTF implementation when using very wide equipment.	Grazing and better managed crops and pastures in the crop rotation and improving farm business decision making skills.	Reducing dependence on chemicals by using other methods to reduce weed numbers, such as increasing crop competition through increasing sowing rate, narrowing row spacings, row direction (shading effect).
Trial/demo sites in 2015	Lock – Hentschke, comparing crop establishment based on time of sowing, seeding rate, position and depth on non-wetting sand. MAC – South 7, sowing into stubbles, height and in-row vs inter row. MAC – S3S, spray topping pastures. Mt Cooper – Gunn, establishment into pasture residues mown/worked/ harrowed/nil. Link site: MAC Airport - crop sequencing	Research site MAC S3S – range of compaction treatments applied in wet and dry conditions, to see if there are impacts on yield. Seeking grower demonstration site on upper EP.	MAC – S7, high vs low input and grazed vs ungrazed mixed farming systems trial. Collection of snail data for Stubble project. MAC – S6E barley grazing demo. MAC – S7, medic pasture trial with inoculation, sowing and grazing treatments. MAC– S7, impact of grazing and N application on two wheat cultivars. Minnipa – demo, value of stubble in the system including wheat, barley and canola stubble.	MAC – S4, row spacing and seeding rate and the influence on weed numbers by crop competition. MAC – N7/8, row spacing and row direction (North-South and East-West) and the influence on surrogate weed numbers (oats) by crop competition.
Outputs to be delivered	Produce guidelines to control pests, weeds and diseases while retaining stubble to maintain or improve soil health, and reduce exposure to wind erosion.	Research and development sites, extension of information through existing events and publications.	A series of workshops, case studies, demonstrations and research articles to help growers manage risk and generate profits in mixed farming systems.	Research and development sites, extension of information through existing events and publications.

The value of break crops in low rainfall farming systems

Michael Moodie[1] and Nigel Wilhelm[2]
[1]Mallee Sustainable Farming, Mildura; [2]SARDI, Minnipa Agricultural Centre

RESEARCH

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 two to three 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.**

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.

Note that progressive reports for the Minnipa site have appeared in the last three editions of the EP Farming Systems Summary (for example, EPFS Summary 2014, p134-139).

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.

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

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.

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.

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/t above oaten hay
Livestock (grazing)	$66/ha	Cereal zone prime lamb: $33/DSE/ha x 2 DSE ha

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.

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.

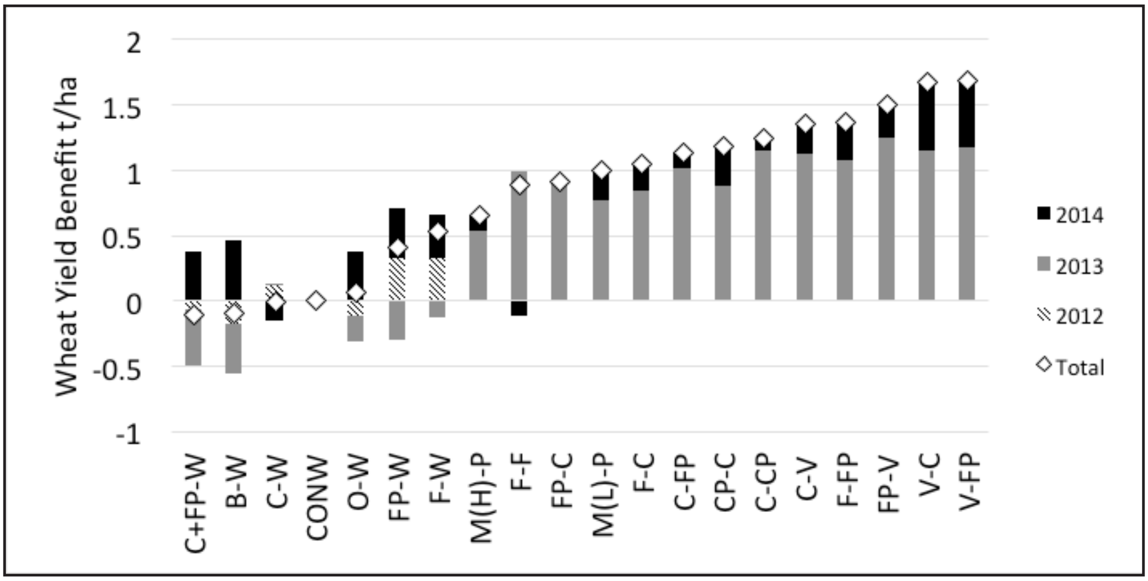


Figure 1 Wheat yield benefit (treatment wheat yield – continuous wheat yield) achieved at the Mildura site following one and two year break phase. Yields of the continuous wheat treatment (CONW) were 0.93, 1.42 and 1.31 t/ha in 2012, 2013 and 2014 respectively.

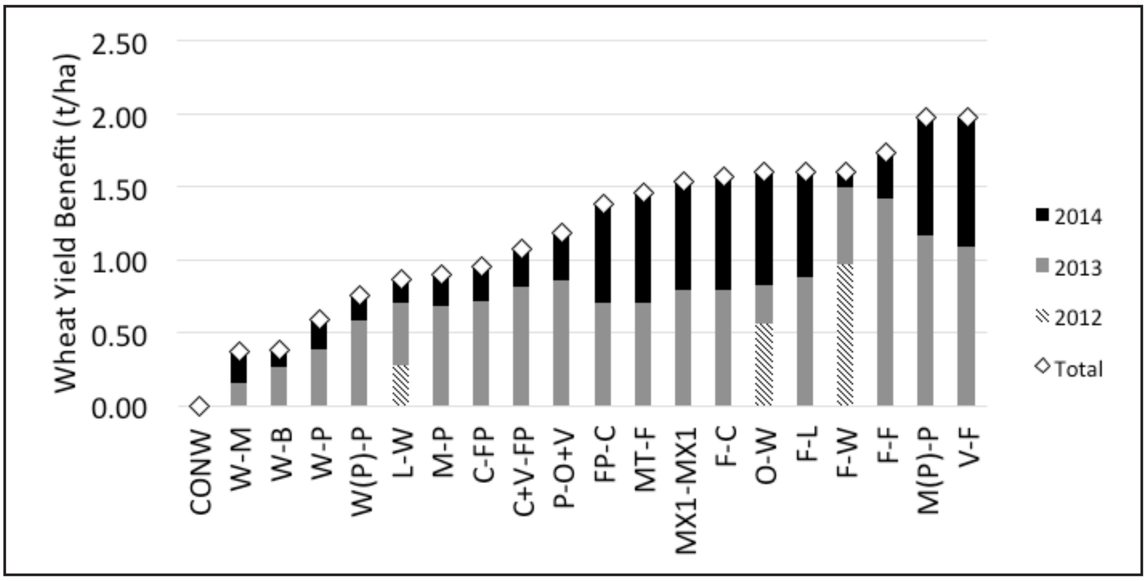


Figure 2 Wheat yield benefit (treatment wheat yield – continuous wheat yield) achieved at the Appila site following one and two year break phase. Yields of the continuous wheat treatment (CONW) were 1.65, 2.79 and 1.41 t/ha in 2012, 2013 and 2014 respectively.

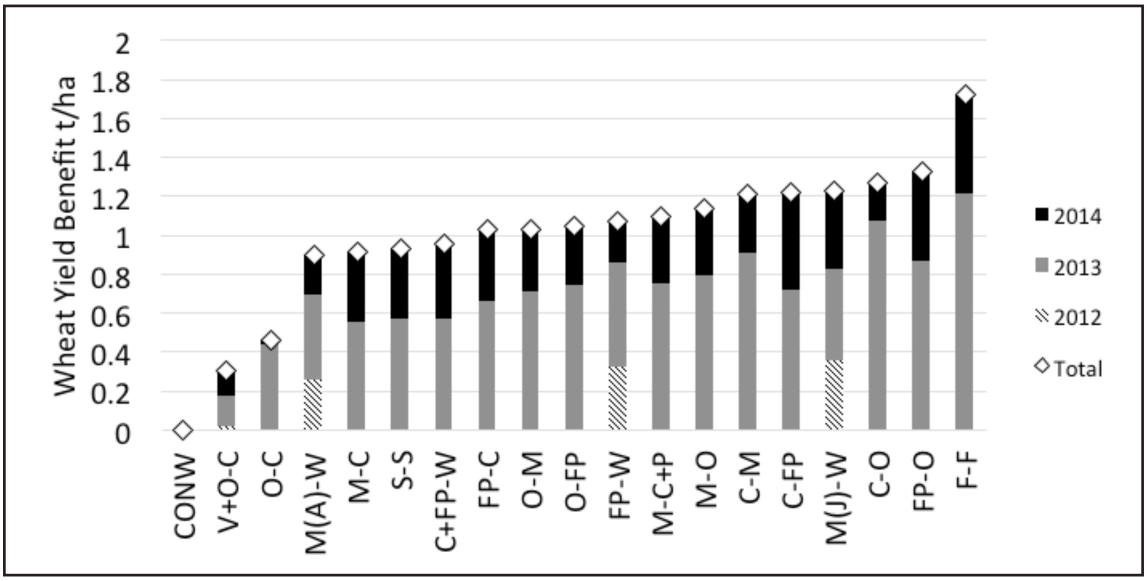


Figure 3 Wheat yield benefit (treatment wheat yield – continuous wheat yield) achieved at the Minnipa site following one and two year break phase. Yields of the continuous wheat treatment (CONW) were 1.70, 1.66 and 3.28 t/ha in 2012, 2013 and 2014 respectively.

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.

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		

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.

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.

Maintaining Profitable Farming Systems with Retained Stubble

Naomi Scholz
SARDI, Minnipa Agricultural Centre

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. They are 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 a 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.

Impact of retaining stubble in low rainfall farming systems

Amanda Cook, Wade Shepperd and Ian Richter
SARDI, Minnipa Agricultural Centre

Try this yourself now

Location:
Minnipa Agricultural Centre
paddock S7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 1.2 t/ha
Paddock History
2015: Grenade wheat
2014: Grenade wheat
2013: Mace wheat
Soil Type
Red loam
Plot Size
18 m x 2 m x 3 reps

Key messages

- **There were no differences in wheat yield at Minnipa in response to stubble architecture, seeding position and nitrogen treatments in 2015.**
- **In 2015 plant establishment was reduced with cultivation and the addition of nitrogen at seeding compared to standing stubble cut low at harvest. The extra nitrogen applied at seeding also reduced the early dry matter.**
- **Removing and cutting stubble low decreased the Yellow Leaf Spot disease incidence and snail numbers compared to high cut stubble.**
- **Stubble management and seeding position had little effect on grass weed numbers.**
- **Overall at Minnipa, stubble management and seeding position have not impacted highly on crop production, weeds, disease and pests over two years with relatively high stubble loads in low rainfall farming systems.**

Why do the trial?

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

The Minnipa Agricultural Centre (MAC) S7 stubble retention trial was established to maintain or improve crop production through applying alternative weed, disease and pest control options in pasture wheat rotations in the presence of crop residues. The trial was established in 2013 with wheat and different stubble treatments imposed at harvest annually. It was sown either inter row or on row with wheat in 2014 and 2015 to determine the impacts of stubble management on crop production, weeds, disease and pests in low rainfall farming systems.

How was it done?

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

In 2014 and 2015 the trial was sown either (i) Inter row (between last season's stubble) or (ii) On row (in same position every season over the top of the previous crop rows) with Grenade CL Plus wheat @ 60 kg/ha and base fertiliser of DAP @ 60 kg/ha. Measurements taken during the season were stubble load, soil moisture, emergence count, grass weed counts (at establishment and at harvest), Yellow Leaf Spot score, snail numbers at harvest, grain yield and grain quality.

In 2015 the trial was sown in dry conditions on 12 May and all plots were split with urea being added to one half at 40 kg/ha applied at seeding. This rate was estimated to match estimated annual nitrogen tie up with the retained stubble loads. Since 5.8 kg N is required per tonne of stubble to break it down (Kirby *et al*. 2004), for 3.5 t/ha of wheat stubble approximately 20 kg N is required, or may have been tied up due to the stubble being present in the retained stubble treatments. An extra 20 kg/ha of urea was spread on all plots on 9 June 2015. The decision to add extra nitrogen as a split treatment was made after reviewing the 2014 season results (see below).

The trial was sprayed with 1.2 L/ha Roundup Attack and 2.5 L/ha Boxer Gold on 12 May. The trial was scored for Yellow Leaf Spot damage on 16 July. The trial was also sprayed with 750 ml/ha Tigrex and 100 ml/ha Lontrel on 23 July, and harvested on 11 November 2015.

What happened?

Site characteristics

In 2014 soil characteristics in 0-20 cm zone were, soil pH (CaCl2) 7.9, Cowell P 28 mg/kg, phosphorus buffering index (PBI) 142 and salinity ECe 1.76 dS/m. The soil nitrogen measured in the stubble high treatment in April 2014 was 105 kg mineral N/ha in the 0-60 cm zone and in April 2015 was 134 kg/ha (0-60 cm). Salinity increases down the profile but is still within the low range. The initial stubble load in 2014 of between 3.4 and 3.8 t/ha was not different to the retained stubble treatments (Table 3). Predicta B soil analysis prior to the 2015 crop predicted a high risk of Rhizoctonia disease (339 pg DNA/g soil), Yellow Leaf Spot inoculum was present and Pratylenchus thornii levels were medium risk (25 nematodes/g soil).

Yield and biomass production

Wheat plant establishment was the same in all treatments in 2014 but in 2015, plant numbers were lower with extra N applied at seeding and with cultivated stubble. The drier seeding conditions in 2015 generally reduced plant establishment.

There was a 0.17 t/ha wheat yield advantage in the 2014 season due to removing or cultivating the previous season's stubble (Table 1). The dry 2013/14 summer and low mineralisation may have resulted in extra nitrogen being available to the crop in the treatments with stubble removed (less tie up of residual nitrogen) during the growing season. The addition of nitrogen was included as a treatment in 2015.

There was a 0.08 t/ha yield advantage in 2014 by inter row cropping rather than placing the seed on row. There were no differences in wheat yield or grain quality in 2015 (Table 2).

There were no differences in April 2015 for soil moisture or soil N (data not presented).

Table 1 2014 establishment and grain yield and quality of wheat as affected by stubble management in 2013 and seeding alignment, and initial stubble loads. Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.

2013-15 Stubble treatments	2014 Stubble load (t/ha)	2014 Plant establishment (plants/m²)	2014 Yield (t/ha)	2014 Screenings (%)	2014 Protein (%)	2015 Stubble load (t/ha)
Stubble standing high	3.4	91	2.40	3.0	10.1	5.8
Stubble standing low	3.8	102	2.45	2.5	10.1	6.9
Stubble cultivated	3.4	94	2.58	3.6	10.1	4.3
Stubble removed	-	94	2.62	3.8	10.0	-
LSD (P=0.05)	*ns*	*ns*	*0.08*	*0.6*	*ns*	*ns*
Inter row		98	2.55	3.2	10.1	
On row		92	2.47	3.2	10.1	
LSD (P=0.05)		*ns*	*0.06*	*ns*	*ns*	

Table 2 2015 establishment and grain yield and quality of wheat as affected by stubble management in 2013-15 and seeding alignment. Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.

2013-15 Stubble treatments	Plant establishment (plants/m²)	Early dry matter (kg/m²)	Yellow Leaf Spot (0-10)	Late dry matter (kg/m²)	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Stubble standing high	65	0.01	6.0	0.43	1.19	11.1	79.6	5.7
Stubble standing low	71	0.01	5.4	0.41	1.28	11.0	79.8	4.3
Stubble cultivated	45	0.01	5.4	0.42	1.26	10.1	80.2	5.2
Stubble removed	73	0.01	4.3	0.43	1.20	11.0	80.5	5.0
LSD (P=0.05)	*14*	*ns*	*0.8*	*ns*	*ns*	*ns*	*ns*	*ns*
Inter row	65	0.01	5.1	0.41	1.24	10.9	80.2	4.9
On row	62	0.01	5.4	0.43	1.22	11.1	79.9	5.3
LSD (P=0.05)	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
*No extra N	75	0.02	5.3	0.40	1.22	10.6	80.2	5.9
*60 kg/ha N	52	0.01	5.3	0.44	1.25	11.4	80.0	4.3
LSD (P=0.05)	*9*	*0.002*	*ns*	*ns*	*ns*	*0.14*	*ns*	*0.8*

**N applied as 2015 treatment only*

Table 3 Grass weed numbers (plants/m²) in response to stubble and seeding alignment treatments in 2014 and 2015.

Stubble treatment	2014				2015			
	Initial		In Crop		Initial		In Crop	
	Rye grass	Barley grass	Rye grass	Barley grass	Rye grass	Barley grass	Rye grass	Barley grass
Stubble standing high - inter row	9.7	6.1	4.3	8.5	0.7	0	1.5	2.3
Stubble standing high - on row	9.5	3.5	5.1	10	0.6	0	2.7	0.5
Stubble standing low - inter row	10.0	4.4	4.5	6.6	1.8	0	1.8	1.0
Stubble standing low - on row	12.2	5.7	6.1	9.4	1.0	0	1.8	0.2
Stubble cultivated - inter row	11.8	5.1	5.3	8.5	1.9	0	1.5	1.5
Stubble cultivated - on row	8.0	4.0	4.8	8.8	1.9	0	2.2	2.0
Stubble removed - inter row	5.3	1.8	3.4	7.3	1.3	0	3.2	1.0
Stubble removed - on row	10.3	5.0	8.3	7.5	2.8	0	0.5	1.0
*LSD (P=0.05) stubble*seeding alignment*N*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

Disease: Yellow Leaf Spot disease incidence in 2015 decreased with removal of wheat stubble (Table 2).

In the dry conditions the extra nitrogen applied reduced early dry matter, due to lower plant establishment from fertiliser toxicity in the low moisture conditions. The extra nitrogen applied did not increase grain yield but did result in an increase in grain protein from 10.6% to 11.4% with no extra nitrogen fertiliser.

Agronomic factors

Weeds: In 2014 weed numbers for ryegrass or barley grass were the same for all stubble management and seeding alignment treatments (Table 3). There were greater numbers of ryegrass at the start of the season; however barley grass numbers were higher in the crop with 46% germinating in crop, possibly due to the later germinating genotype at MAC.

In 2015 in dry seeding conditions only 44% of ryegrass germinated early, with 66% emerging in crop, and 100% of the barley grass came up after seeding. Grassy weed numbers were lower than expected in 2015, and were too low to cause severe competition with wheat. Wild oats were more prevalent in 2015 (data not shown). There was a significant effect between late ryegrass and stubble management with the removed stubble treatment and the crop sown inter row. However the weed numbers were very low with only with 3.2 plants/m² and the effect was due to weeds germinating in the last season's row.

Pests: In 2014, there were no differences in snail numbers at harvest (average 1.7 snails/m²). In 2015 snail numbers progressively decreased from 2.0 snails/m² in high standing stubble through low and cultivated stubble to only 0.5 snails/m² in removed stubble (data not presented).

What does this mean?

The dry conditions at seeding in 2015 resulted in the cultivated treatment having lower plant numbers. The extra nitrogen applied at seeding also reduced early dry matter compared to the nil treatment, possibly due to lower plant establishment and fertiliser toxicity in low moisture conditions in 2015. In other seasons there have been minimal fertiliser toxicity effects with this rate at seeding.

In 2014 there was a 0.17 t/ha yield advantage due to removing or cultivating the previous season's stubble and a 0.08 t/ha yield advantage by inter row cropping rather than placing the seed on row. There were no differences in wheat yield between stubble management, seeding alignment and extra nitrogen at seeding in 2015.

Removing the stubble and cutting it low had the advantages of decreasing Yellow Leaf Spot in the second year Grenade CL Plus wheat crop and lowering snail numbers compared to high cut stubble.

In 2014 grassy weed numbers were similar in all treatments. In 2015 seasonal conditions resulted in fewer early germinating grass weeds with only 44% of ryegrass and no barley grass germinating before seeding. Stubble management and seeding position had little effect on grass weeds.

Overall the results from this research at Minnipa indicates stubble management and seeding position have not impacted highly on crop production, weeds, disease and pests over two years with relatively high stubble loads in low rainfall farming systems.

References

Kirkby, C., Kirkegaard, J., Richardson, A., Wade, L., Blanchard, C. and Batten, G. (2011). *Stable soil organic matter: A comparison of C:N:P:S ratios in Australian and other world soils.* Geoderma, 163, 197-208.

Acknowledgements

Thank you to Sue Budarick for processing samples. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

Registered products: see chemical trademark list.

Herbicide efficacy in retained stubble systems

Amanda Cook[1], Andy Bates[2], Wade Shepperd[1] and Ian Richter[1]
[1]SARDI, Minnipa Agricultural Centre, [2]Bates Agricultural Consulting

RESEARCH

Searching for answers

Location:
Minnipa Agricultural Centre paddock S7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 1.6 t/ha
Paddock History
2015: Mace wheat
2014: Wheat
2013: Wheat
Soil Type
Red loam
Plot Size
20 m x 2 m x 3 reps

Key messages

- **In 2015 the drier start to the season and low soil moisture resulted in lower herbicide efficacy and less chemical damage than expected.**
- **In different stubble management systems the activity and resulting weed control of specific herbicides will be influenced by the solubility index (movement through the soil profile with rainfall events) of that herbicide. Soil texture and soil chemical properties can affect chemical movement and availability in the soil profile.**
- **Herbicide performance will vary seasonally due to soil moisture levels, rainfall pattern post application, timing of weed germination, position and number of weed seeds in the profile, etc. Understanding how the various herbicides work can reduce the likelihood of failures.**
- **Herbicides are only one tool for weed control – always adopt an integrated weed control package that includes non-chemical control, and where possible, consecutive seasons of total weed control.**
- **Consider the whole farming system when making chemical decisions as the impact may last for several seasons (eg. effects on medic germination and medic seed bank).**

Why do the trial?

The GRDC project 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' aims to improve farm profitability while retaining stubble in farming systems on upper Eyre Peninsula (EP). Weed control in stubble retained systems can be compromised when stubbles and organic residues intercept the herbicide and prevent it from reaching the desired target, or the herbicide is tightly bound to organic matter. Reduced herbicide efficacy in the presence of higher stubble loads is a particular issue for pre-emergence herbicides. Current farming practices have also changed weed behavior with a shift in dormancy in barley grass genotypes now confirmed in many paddocks on Minnipa Agricultural Centre (MAC) (B Fleet, EPFS Summary 2011, p 177). As a part of the stubble project this trial was undertaken to assess herbicide efficacy in different stubble management systems.

Background?

To understand how herbicides preform it is important to know the properties of the herbicide, the soil type and how the herbicide is broken down in the environment. The availability of a herbicide is an interaction between the solubility of a herbicide, how tightly it is bound to soil particles and organic matter, soil structure, cation exchange capacity and pH, herbicide volatility, soil water content and the rate of herbicide applied (Congreve and Cameron, 2014).

Herbicides intercepted by organic material will be subject to a certain level of binding, depending on the herbicide's characteristics. Some will be tightly bound and lost to the system in terms of weed control, others will be loosely bound and relatively soluble and will be returned to the soil by subsequent rainfall events. However, loosely bound herbicides may also be prone to losses by volatilisation and photodegradation (Congreve and Cameron, 2014). The solubility and soil water movement potential of key herbicides is listed in Table 1.

When a herbicide is incorporated into the soil a percentage will bind to soil organic carbon and soil particles. The strength of binding is called the soil/water adsorption coefficient (Kd). The binding is highly influenced by the level of organic matter so is calculated by taking into account the level of organic matter Koc = Kd/soil organic carbon. The higher the Koc value the more tightly the herbicide is bound. A low Koc value means the herbicide is less tightly bound and able to move with the soil water, which happens in sandy soils or soils with low organic matter (Congreve and Cameron, 2014). The Koc values for key herbicides are listed in Table 1.

Table 1 Solubility and soil water movement potential of key herbicides

Chemical	Group	Soil Binding (Koc)	Solubility (mg/L @ 20°C)	Soil water movement
Trifluralin	D	17,500 Tightly bound and non-mobile	0.22 mg/L Low solubility Likely to require moist conditions for incorporation and uptake	Tightly bound and non-mobile so consider stubble load, as well as herbicide and water rate
Lexone (Metribuzin)	C	60 Mobile – likely to move with soil water	Lexone 1165 mg/L High solubility	Quite mobile and highly soluble – moves with soil water down the profile
Logran	B	60 Mobile – likely to move with soil water	815 mg/L High solubility	Quite mobile and highly soluble – moves with soil water down the profile
Diuron	C	813 Slightly mobile	36 mg/kg Low solubility Likely to require moist conditions for incorporation and uptake	Slightly mobile but low solubility therefore tends to stay in topsoil
Avadex (Tri-allate)	J	3030 Slightly mobile	4 mg/L Low solubility Likely to require moist conditions for incorporation and uptake	Slightly mobile but low solubility therefore tends to stay in topsoil
Sakura	K	95 Moderately mobile, will wash off stubble	3.5 mg/L Low solubility Likely to require moist conditions for incorporation and uptake	Moderately mobile but low solubility and limited movement with soil water
Boxer Gold Prosulfocarb and s-metolachlor	K	Prosulfocarb part of Boxer Gold 1500 Slightly mobile s-metolachlor part of Boxer Gold 200 Moderately mobile	Prosulfocarb part of Boxer Gold – 13 mg/L Low solubility Likely to require moist conditions for incorporation and uptake s-metolachlor part of Boxer Gold – 480 mg/L Moderate solubility	Slightly mobile but low solubility therefore tends to stay in topsoil Moderately mobile and moderately soluble – can move with soil water down the profile
Simazine	C	130 Moderately mobile	5 mg/L Low solubility Likely to require moist conditions for incorporation and uptake	Slightly mobile but low solubility therefore tends to stay in topsoil

Data collated from GRDC Pre-emergent herbicide Manual, M Congreve and J Cameron, 2014, and pers comm from A Bates and B Fleet, 2015.

Soil moisture is also critical to the performance of herbicides in soils. If soil water is low, plant uptake will be lower and a greater percentage of the herbicide will be bound onto the soil and become unavailable.

Stubble, existing weed cover and crop cover (for post sowing applications) in a zero or minimal till system will intercept some of the herbicide before it reaches the soil. The amount of herbicide intercepted will be proportionate to the percentage of ground cover. Interception can have two negative effects; herbicide can be tied up on the stubble or in the canopy and will not be available for weed control; and it can lead to uneven coverage on the soil surface lowering herbicide effectiveness and increasing potential weed escapes (Congreve and Cameron, 2014).

How was it done?

The Minnipa Agricultural Centre paddock S7 was sown to Mace wheat on 10 May 2014 and yielded 3.2 t/ha with 9.1% protein. Two different wheat stubble management strategies were implemented at harvest; traditional spread stubble and harvest windrows. The third stubble management strategy was implemented on 15 April 2015 with total stubble removal by burning and the harvest windrows within the trial area were also burnt on the same day.

Table 2 Effect of stubble management on crop establishment, dry matter and yield as well as weed and medic populations in 2015.

	Establishment (plants/m^2)	Early crop dry matter (t/ha)	Early in-crop Barley grass 24 July (plants/m^2)	Medic growth (0-3 rating)*	Late in-crop Barley grass 26 Oct (plants/m^2)	Yield (t/ha)
Burnt stubble	105	0.22	3.1	1.01	6.8	1.63
Spread stubble	93	0.19	1.8	0.78	4.8	1.55
Burnt windrows	97	0.22	6.7	0.94	10.3	1.69
LSD (P=0.05)	*4*	*0.02*	*1.7*	*0.12*	*2.7*	*0.04*

** Visual medic rating system where 0=no medic, 1=small suppressed medic, 2=small and large medic, 3=mostly large medic plants*

The trial was sown with Mace wheat @ 60 kg/ha and DAP @ 60 kg/ha on 11-12 May in dry seeding conditions. The trial area received a knockdown of 1.2 L/ha of Roundup Attack on 11 May. The chemical treatments listed in Table 3 were individually mixed in small pressure containers and applied on the 11 and 12 May using a shrouded boomspray at 100 L/ha of water.

Minnipa received 35 mm rainfall for April and 6 mm in the five days before sowing with 3 mm after sowing. Conditions were drier the week after sowing before another 6 mm fell, with a total of 16 mm for May. The trial was sown at 3-4 cm depth with an Atom-Jet spread row seeding system with press wheels. The trial was also sprayed on 27 July with 5g/ha of Ally and BS1000 at 100ml/100 L for control of soursob (*Oxalis pes-caprae*).

Measurements taken were stubble load pre-seeding, soil moistures, plant emergence counts, early and late grass weed counts, medic growth score, grain yield and grain quality. Data were analysed using Analysis of Variance in GENSTAT version 16. The least significant differences are based on F prob=0.05.

What happened?

Stubble treatments (averaged over all chemical treatments)

Early dry matter and grain yield were lower in the spread stubble system than burnt and windrow and this may have been due to less moisture reaching the seed bed and also tie up of nitrogen resulting in early nitrogen deficiency (Table 2). There may also have been some yellow leaf spot interactions.

Chemical treatments

There were no impacts of stubble management on the performance of individual chemical treatments so results presented in this section are averaged over all three stubble management treatments.

Wheat establishment was not affected by any chemical treatment and varied between 95 and 103 plants/m^2. Grain yield was lowest in the untreated control and most chemical treatments increased yields but only by up to 8% which suggests grassy weed pressure was low. This is consistent with the low populations of barley grass which developed in 2015. As a consequence, few chemical treatments were more profitable than doing nothing for grassy weed control.

On average 45% of the barley grass population emerged later in the season, approximately six weeks after sowing, excluding those treatments with Sakura. Effects of chemical treatments on early barley grass numbers were inconsistent, but by late in the season, any treatments containing Sakura, or Monza alone, had lower barley grass numbers than the untreated control.

Medic germination was affected by some chemicals and the residual effect may impact on future seed bank and germination.

Barley grass numbers at the first sampling were low (less than 10 plants/m^2) across the whole trial, regardless of chemical treatments (Table 3). Sakura and mixes containing Sakura decreased early dry matter of the crop (Table 3).

Trifluralin and Diuron mixes caused some crop damage but the crop recovered better than expected and dry matter production of the crop was as good as in the untreated control by sampling, probably due to less soil water movement of the chemicals. In a dry start Boxer Gold did not appear as effective on barley grass as ryegrass, but post application gave some suppression activity on all grasses.

Medic germination was very low with Monza and Lexone (Metribuzin), so carefully consider the use of these chemicals as some will have more than a one year effect on medic regeneration. Ward's weed (*Carrichtera annua*) was not controlled in this trial by Monza.

Table 3 Effect of chemical treatments on crop establishment, dry matter and yield as well as weed and medic populations in 2015.

Chemical treatment	Group	Dry matter (t/ha)	Establishment (plants/ m^2)	Early in-crop Barley grass 24 July (plants/ m^2)	Average Medic growth (0-3 rating) ^	Late Barley grass 26 Oct (plants/ m^2)	Yield (t/ha)	Chemical cost ($/ha)	Income# less chemical cost ($/ha)
Control Untreated		0.23	102	7.3	1.5	11.1	1.55	-	391
Trifluralin (1.5 L/ha)	D	0.20	98	4.6	1.4	8.8	1.63	9	402
Trifluralin (2 L/ha)	D	0.21	99	2.0	1.1	8.0	1.58	12	386
Trifluralin (1.5 L/ha) + Lexone (Metribuzin) 180 g (post)	D+C	0.20	98	5.3	0.3	11.7	1.64	15	399
Trifluralin (1.5 L/ha) + Diuron 900 (400 g/ha) (pre-emergent)	D+C	0.21	98	3.4	1.0	7.8	1.64	14	399
Trifluralin (1.5 L/ha) + Diuron 900 (high rate) (pre-emergent)	D+C	0.24	102	3.5	1.0	5.7	1.67	19	402
Trifluralin (1.5 L/ha) + Avadex (Tri-allate) (1.6 L/ha) (pre-emergent)	D+J	0.23	95	2.0	1.2	8.3	1.64	25	388
Trifluralin (1.5 L/ha) (pre) + Monza (sulfosulfuron) (25 g/ha) (post)	D+B	0.21	101	3.3	0.2	7.1	1.66	35	384
Monza (sulfosulfuron) 25 g (pre-emergent)	B	0.20	98	5.3	0	2.8	1.65	26	390
Sakura (118 g) (pre-emergent)	K	0.17	96	2.5	0.8	1.8	1.64	40	373
Monza (sulfosulfuron) (25 g) + Sakura (118 g) (pre-emergent)	B+K	0.19	101	2.6	0	1.0	1.61	66	340
Sakura (118 g)+ Avadex (Tri-allate) 3 L (pre-emergent)	K+J	0.22	96	1.0	0.8	0.5	1.64	70	343
Boxer Gold (2.5 L/ha) (pre-emergent)	K+J	0.21	97	4.1	0.9	9.7	1.59	37	364
Boxer Gold (2.5 L/ha) (post)	K+J	0.26	103	5.6	1.3	11.6	1.60	37	366
Sakura (118 g)+ Avadex (Tri-allate) 3 L (pre-emergent) + Boxer Gold 2.5 L (post)	K+J	0.18	97	1.5	0.6	1.0	1.63	107	304
LSD (P=0.05)		*0.04*	*ns*	*ns*	*0.3*	*6.7*	*0.09*		

^ (0-3 rating where 0=no medic, 1=small suppressed medic, 3=larger medic plants)
 # Wheat price of $252/t used for AUH2 on 1 December 2015 at Port Lincoln, less chemical cost.
**some treatments in the trial are for research purposes only.*

What does this mean?

Despite high cereal stubble loads, completely removing stubble by burning did not improve the efficacy of any of the chemical packages tried in this trial. These results suggest that under the production regimes of upper EP, stubble management is unlikely to impact negatively on performance of pre-emergent herbicides targeting grassy weed control, with adequate water rates. However, this trial did not place the chemical packages "under pressure" because grassy weeds populations were low.

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

When choosing the most appropriate pre-emergent herbicide for use in stubble retained systems, it is important to consider;

- the likely rainfall pattern and soil moisture conditions post application,
- the susceptibility of the crop to the herbicide,
- the position of the weed and crop seeds in the soil profile,
- the mobility of the herbicide in soil water,
- and the persistence of the herbicide activity relative to the germination pattern of the target weeds.

References

GRDC Pre-emergent herbicide Manual, M Congreve and J Cameron, 2014.

Acknowledgements

Thanks to Sue Budarick for her help and processing samples from this trial. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

Registered products: see chemical trademark list.

Farming Systems

SARDI

GRDC Grains Research & Development Corporation Your GRDC working with you

EPARF Eyre Peninsula Agricultural Research Foundation

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Grass weed management in pasture

Amanda Cook, Wade Shepperd and Ian Richter
SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

Location:
Minnipa Agricultural Centre
paddock S3S
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 2.0 t/ha
Paddock History
2015: Mace wheat
2014: Regenerated medic pasture
2013: Medic pasture
Soil Type
Red loam
Plot Size
18 m x 2 m x 3 reps

Key messages

- **Following two years of grass free medic pasture soil mineral nitrogen levels averaged 158 kg N/ha and all disease inoculum levels were low.**
- **Cutting the medic pasture for hay lowered dry matter production and medic pod set in the following season.**
- **An early light tickle resulted in higher weed germination and lower powdery mildew damage in spring.**
- **Full cut tillage following two years of grass free medic resulted in the highest wheat yields while a discing prior to seeding resulted in the lowest yield.**
- **Working medic residues in the year prior reduced the following wheat yield but grain protein was higher.**
- **Cutting a medic pasture for hay in 2013 reduced medic productivity in 2014 and lowered wheat grain protein in 2015.**

Why do the trial?

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

The Minnipa Agricultural Centre S3S pasture trial was established in 2013 to assess barley grass weed management with a two year medic pasture break. The trial had different grass weed management and tillage treatments imposed in 2013 and in 2014. The trial was then sown with wheat in 2015.

How was it done?

The replicated trial was established in 2013 by Roy Latta in MAC S3S paddock. The pasture treatments imposed in 2013 were:

i. selective grass control,
ii. selective grass control and mowing/haycut and
iii. selective grass control and pasture topping.

Broadstrike @ 25 g/ha and 100 ml/100L of Chemwet was applied to the paddock on 23 May 2013 for broadleaved weed control. Selective grass control was also applied to the whole paddock on 5 June with 250 ml/ha of Targa Bolt and Hasten @ 1 L/100L. The pasture topping treatment was imposed by boomspray on 20 August with 200 ml/ha of Roundup Attack. The mowing treatment was imposed on 22 September when the rest of paddock was cut for medic hay.

In 2014 the 3 blocks were each split into worked (a light tillage with an off-set disc) or unworked areas on 1 March. The trial area was sprayed on 9 June with 425 ml/ha Select, 25 g/ha Broadstrike and 1 L/100L Hasten for grasses and broadleaved weeds. Early dry matter and weed counts were taken on 18 June before the paddock was grazed. Powdery mildew and aphid damage was scored on 25 August.

In 2015 pre-sowing treatments imposed were:

I. harrowing to remove medic stubble,
II. disc/light tillage,
III. full cut tillage and
IV. direct drill were imposed across the worked and unworked split plots.

The plots were worked with an off-set disc on 15 April, the harrowing treatment on 28 April and the full cut working was on 8 May.

What happened?

The trial was sown with Mace wheat @ 60 kg/ha and base fertiliser of 18:20:0:0 @ 60 kg/ha in drying conditions on 20 May. The trial was sprayed on 20 May with a knockdown of 1.5 L/ha of Treflan, 1 L/ha of Roundup Powermax and 80 ml/ha of Nail. The trial was also sprayed with 750 ml/ha Tigrex and 100 ml/ha Lontrel on 23 July and harvested on 12 November.

Measurements taken during the season were dry matter medic pasture residues and seed production, soil moisture, emergence count, grass weed counts (at establishment, in crop and at harvest), grain yield and grain quality.

Table 1 Soil analysis of direct drilled treatments after two years of medic pasture (average of 9 samples) in 2015.

Depth (cm)	pH (CaCl)	Cowwell P (mg/kg)	PBI	EC (1:5)	ECe (dS/m)	Total soil N (kg/ha)		Volumetric soil moisture April 2015 (mm)	
						unworked	worked	unworked	worked
0-10	8	35	122	0.144	1.44	39	29	9	9
10-30	8	5	159	0.143	1.43	47	44	18	15
30-60						18	21	21	18
60-100						57	61	25	23
Total reserves (0-100)						162	154	73	65

Table 2 Medic growth and weed numbers in 2013 and 2014.

2013 Treatment*	2013 Sept	2013 Dec	2014 treatment	2014 June	2014 Aug	2014 Sept				2015 Feb
	Early dry matter (t/ha)	Medic pod yield (t/ha)		Early dry matter (t/ha)	Powdery mildrew patches (%)	Barley grass (plants/m²)	Rye grass (plants/m²)	Wild oats (plants/m²)	Broad leaf weeds# (plants/m²)	Medic pod yield (t/ha)
Selective grass only	4.59	0.34	worked	4.16	10	20	20	140	160	1.20
			unworked	3.27	40	0	40	0	210	1.69
Mowing haycut	1.16	0.16	worked	3.15	15	0	30	0	720	0.57
			unworked	2.79	35	0	0	0	250	0.47
Pasture topped	5.10	0.33	worked	3.08	20	110	20	10	250	1.10
			unworked	3.53	50	0	0	20	180	1.60

 # Milk thistle, Lincoln weed, marshmallow, wild turnip, buck bush, capeweed

What happened?

The 2015 soil data (Table 1) shows the trial site is alkaline in pH, with adequate phosphorus and high mineral nitrogen reserves, a moderate phosphorus buffering index (PBI) and salinity within the low range. There were no differences between initial soil moistures in 2013 or 2014 (data not presented). Predicta B inoculum levels predicted all diseases were at low risk after two years of medic pasture.

In 2013 the mown/haycut treatment had much lower late dry matter and medic pod set than the chemical treatments. In March 2014 tillage treatments were imposed across the grass control treatments. The worked areas had a higher early medic dry matter with the best being 4.16 t/ha with selective grass control compared to the unworked with 3.27 t/ha (Table 2). In 2014 powdery mildew was an issue in this trial, as it was on many pastures in that spring. Damage was lower on the worked treatments possibly due to reduced inoculum levels from partly burying infected medic residues from the previous season.

The worked treatments generally had more grass and broadleaf weeds during the 2014 season (Table 2). The mowing/hay cutting treatment had impacts on 2014 seed production with fewer medic pods harvested from these treatments compared to the chemical treatments. Both unworked chemical treatments had higher medic pod yield than the worked treatments.

Wheat establishment in dry seeding conditions were similar in the direct drilled and harrowed treatments and these were both higher than in the full cut and disced treatments (Table 3).

The 2015 grain yield was higher in the mowing/haycut and pasture topped treatment than the grass free treatment imposed in 2013. In all tillage treatments the worked plots yielded lower than unworked (Table 3). The 2015 grain yield was lowest in the disced treatment and highest with the full cut imposed before seeding (Table 3).

Table 3 Establishment, grain yield and grain quality of wheat in 2015 as affected by previous medic pasture management.

2013 treatment*	2014 treatment	2015 treatment	Establishment (plants/m²)	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	1000 Grain weight (g)
Pasture topped	unworked	Disc	114	2.00	14.9	74.3	24.4
	worked	Disc	101	1.84	15.5	73.0	23.1
Mowing/haycut	unworked	Disc	118	2.25	14.3	75.4	25.3
	worked	Disc	126	2.07	14.9	73.7	24.2
Selective grass only	unworked	Disc	106	1.77	15.6	76.1	24.6
	worked	Disc	116	1.55	16.2	74.3	23.2
		Average	**113**	**1.91**	**15.2**	**74.4**	**24.1**
Pasture topped	unworked	Full cut	125	2.30	14.5	74.6	24.7
	worked	Full cut	120	2.17	14.9	73.2	23.5
Mowing/haycut	unworked	Full cut	112	2.33	13.8	76.2	25.9
	worked	Full cut	112	2.15	14.7	73.8	23.9
Selective grass only	unworked	Full cut	120	1.98	14.1	77.2	26.4
	worked	Full cut	117	1.77	15.5	74.0	23.5
		Average	**118**	**2.12**	**14.6**	**74.8**	**24.6**
Pasture topped	unworked	Harrowed	126	2.21	15.0	73.5	24.2
	worked	Harrowed	136	2.14	15.2	72.7	23.2
Mowing/haycut	unworked	Harrowed	119	2.27	14.0	75.8	26.0
	worked	Harrowed	124	2.20	14.8	73.8	24.1
Selective grass only	unworked	Harrowed	141	1.93	15.1	75.7	24.6
	worked	Harrowed	132	1.77	15.7	74.4	24.6
		Average	**129**	**2.09**	**15.0**	**74.3**	**24.2**
Pasture topped	unworked	Direct drilled	129	2.15	14.6	74.2	24.8
	worked	Direct drilled	140	1.95	15.3	73.2	23.2
Mowing/haycut	unworked	Direct drilled	116	2.31	13.9	76.0	26.2
	worked	Direct drilled	132	2.28	14.6	73.7	24.5
Selective grass only	unworked	Direct drilled	134	1.78	15.4	75.3	24.4
	worked	Direct drilled	130	1.60	16.2	73.1	22.9
		Average	**130**	**2.01**	**15.0**	**74.2**	**24.3**
LSD (P=0.05) Individual treatments			*17*	*0.12*	*0.54*	*1.11*	*1.1*
2015 tillage averages			*7*	*0.05*	*0.22*	*0.5*	*0.4*

**In 2013 all treatments had selective grass control on 5 June*

Table 4 Main effect of tillage treatments on grain yield and quality in 2015.

2015 tillage treatment	Protein (%) 2014 tillage treatment		Screenings (%) 2014 tillage treatment	
	unworked	worked	unworked	worked
Disc	14.9	15.5	22.2	27.2
Full cut	14.1	15.0	18.8	24.2
Harrowed	14.7	15.3	20.9	25.2
Direct drilled	14.6	15.4	21.1	25.7
LSD (P=0.05)	*0.3*		*2.7*	

Overall the grain samples had very good protein levels after the two years of pasture break due to high 2015 initial soil nitrogen. The unworked treatments had lower grain protein across all tillage treatments compared to the worked treatment (Table 4). The 2013 treatment of hay cut medic pasture resulted in lower protein than the other two grass control treatments.

Screenings in the trial were very high, with the worked treatments being higher than the unworked (Table 4). The mowing/haycut treatment in 2013 had lower screenings levels possibly due to lower nitrogen mineralisation, but the levels were still above the maximum delivery standard of 10%.

Pre-seeding grass weed counts taken on 20 May 2015 were very low and averaged zero barley grass/m^2, 0.06 rye grass/m^2 and 0.21 wild oats/m^2 (data not presented). Barley grass germination was generally lower than expected at the start of the 2015 season due to the dry conditions which suppressed early weed germination. The 2013 and 2014 pasture management and 2015 tillage systems had no effect on the final grass weed numbers taken in October 2015, and levels were very low with less than 1 plant/m^2 for barley grass, ryegrass and wild oats in all treatments (data not presented).

What does this mean?

Two years of medic pasture with different grass weed management regimes resulted in high soil nitrogen levels and lowered disease inoculum to minimum levels, including Rhizoctonia solani. The mown/hay cut medic pasture treatment had impacts in 2014 and early 2015 with lower medic production and lower pod set in both years which also followed through to lower grain protein in wheat grown in 2015.

The 2014 light tillage with an off-set disc in the medic pasture resulted in higher germination of both grass and broadleaved weeds. The worked treatment had less damage and browning off due to powdery mildew in spring on the medic pastures.

The tillage treatments in 2015 impacted on wheat yield with the full cut tillage yielding highest and discing the lowest. In all tillage treatments the worked plots in 2014 yielded lower than unworked and had higher protein levels, which may have been due to the greater number of weeds in 2014.

The impact of two years of medic pasture with selective grass control in both years reduced grassy weed populations to very low levels, even without spray topping or hay cutting, with the light tillage resulting in greater weed germination during the 2014 season.

This research will be ongoing and resown to cereal this season to determine the impact of tillage in a second year of cereal on grass weed numbers and crop production.

Farming Systems

Acknowledgements

Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

Registered products: see chemical trademark list.

Crop establishment on non-wetting soil

Amanda Cook, Wade Shepperd and Ian Richter
SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

Location:
Murlong
Stuart Hentschke
Rainfall
Av. Annual: 336 mm
Av. GSR: 250 mm
2015 Total: 294 mm
2015 GSR: 229 mm
Yield
Potential: 2.4 t/ha
Actual: 0.6 t/ha
Paddock History
2015: Mace wheat
2014: Scope CL Barley
2013: Kord CL wheat
Soil Type
Non-wetting sandy loam
Plot Size
12 m x 2 m x 3 reps

Key messages

- **Crop establishment increased with on row sowing. Stubble from the previous season helps soil moisture infiltrate into non-wetting sands and into a position closer to the seed.**
- **Initial germination of brome grass weeds was higher with inter row sowing.**
- **Late brome grass weed numbers was also greatest with inter row sowing. Sowing on row may also increase crop and weed competition as will a higher seeding rate.**

Why do the trial?

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

One issue EP farmers identified as a problem with stubble retained systems was sowing into non-wetting sands and the resulting uneven and reduced germination. A trial at Murlong (near Lock) was established in 2013 to compare how crop establishment is affected by time of sowing, sowing rate, and seed position and depth on a non-wetting sand and crop performance. The trial has been re-seeded in the 2014 and 2015 growing seasons.

How was it done?

Wheat plots were established at Murlong in 2013 with Kord CL wheat @ 60 kg/ha and base fertiliser of 18:20:0:0 (DAP) @ 60 kg/ha. Average yield of wheat in that year was 1.78 t/ha (see EPFS Summary 2014, Crop establishment on non-wetting soil, p147 for management details). In 2014 the trial was sown with Scope CL barley at 65 kg/ha and 18:20:0:0 @ 65 kg/ha with three different times of sowing; 15 April (TOS 1), 13 May (TOS 2) and 10 June (TOS 3). At each time of sowing (main plots) there were two sowing rates of 40 kg/ha and 60 kg/ha, two different seed placements; on row and inter row, and two sowing depths of 0-1 cm and 3-4 cm. These factorial treatments were replicated 3 times. TOS 1 and TOS 2 were harvested on 10 November and TOS 3 on 24 November.

In 2015 the trial was sown on 18 May in dry conditions with Mace wheat @ 40 and 60 kg/ha seeding rates, either on row (in same position every season) or inter row (between last season's stubble) and either 0-1 cm or 3-4 cm depths on the same previous season's treatments. The fertiliser was 60 kg/ha of DAP and 50 kg/ha of ammonium sulphate. A trace element mix of manganese sulphate at 1.5 kg Mn/ha, zinc sulphate at 1 kg Zn/ha and copper sulphate at 0.2 kg Cu/ha were also delivered as a fluid at seeding. Extra urea was broadcast on all plots on 10 August @ 40 kg/ha. The trial was sprayed with a knockdown of 1L/ha of Roundup Powermax, 1.5 L/ha Avadex and 1.5 L/ha Treflan on 18 May. The trial was also sprayed with 750 ml/ha Tigrex and 100 ml/ha Lontrel on 10 August.

Measurements taken during the season were stubble load pre-seeding, soil moisture, soil nutrition, emergence counts, grass weed counts (in crop early, 29 June and pre harvest, 28 October), grain yield and grain quality. The trial was harvested on 19 November.

Table 1 Plant growth, grain yield and quality as affected by seed placement, depth and seeding rate (averaged across the other treatments) at Murlong in 2015.

		Establishment (plants/m²)	2015 Harvest Index	Late dry matter (kg/m²)	Yield (t/ha)	Protein (%)	Screenings (%)	Test weight (kg/hL)
Placement	On-row	**95.4**	0.38	0.43	0.58	11.7	**10.4**	75.8
	Inter-row	**56.3**	0.39	0.41	0.55	11.8	**8.4**	76.6
Depth	0-1 cm	78.2	0.38	**0.40**	0.57	11.7	10.0	76.1
	3-4 cm	73.5	0.39	**0.44**	0.56	11.7	8.8	76.3
Sowing rate	40 kg/ha	**62.7**	0.38	0.42	0.56	11.7	9.4	76.4
	60 kg/ha	**88.9**	0.39	0.42	0.57	11.7	9.4	76.0
LSD (P=0.05)		*20.2*	*0.02*	*0.03*		*ns*	*1.8*	*ns*

(Significant effects (P=0.05) in **BOLD***)*

Table 2 2014 TOS effect on 2015 plant establishment.

	Establishment (plants/m²) 2015 placement	
2014 TOS	On-row	Inter-row
TOS 1	111 a	46 b
TOS 2	113 a	44 b
TOS 3	62 a	79 a
Average	95a	56b
LSD (P=0.05)	*30 (within TOS)*	

Table 3 Average brome grass weed establishment in 2015.

Placement	Seeding Rate	Early Brome grass between crop rows (plants/m²)	Early Brome grass in crop row (plants/m²)	Late Brome grass (plants/m²)
On row	40 kg/ha	8.5	3.1	5.3
On row	60 kg/ha	3.4	2.4	4.7
Inter row	40 kg/ha	12.4	1.3	6.0
Inter row	60 kg/ha	13.2	1.1	6.7
LSD (P=0.05)		*6.9*	*1.5*	*ns*

What happened?

Barley in 2014 had visually better plant growth after 4 weeks with deeper sowing (3-4 cm) in both TOS 1 which occurred on 15 April and TOS 2 on 13 May. The third time of sowing established slowly and looked poor compared to TOS 1 and TOS 2 all season.

Harvest biomass in 2014 was similar with TOS 1 and TOS 2 at about 1.5 t/ha. There was a decline in final dry matter production with TOS 3 to less than 1 t/ha, sown on the 10 June (data not presented). There were no differences in stubble dry matter production between inter row or on row seeding, or the different seeding rates.

In 2015 in drier than ideal seeding conditions, plant establishment was generally poor and patchy due to severe water repellency (Table 1 and 2). Sowing on row in 2015 more than doubled plant establishment except in TOS 3 which had less stubble. Increasing seeding rate resulted in greater plant numbers at seeding (Table 1) but seeding depth had little effect. Grain yield achieved at this site (little more than 0.5 t/ha) was extremely low compared to the potential yield of 2.4 t/ha despite increased nitrogen fertiliser applications and the addition of trace elements as a fluid at seeding. The yield difference may be partly due to brome grass weed competition. Treatment effects on yield were small and inconsistent.

Early brome grass numbers before in crop spraying were lower with on row sowing (Table 3) and most of the brome grass came up in between the rows of the crop. Late brome grass numbers were slightly higher with inter row sowing (6 to 6.7 brome/m^2) compared to on row (4.7 to 5.3 brome/m^2).

What does this mean?

In 2015 crop establishment was very variable and patchy but improved with on row seeding. Previous research in other regions have shown in drier seasons the previous season stubble helps soil moisture infiltrate into non wetting sands and preserve it in a position closer to the seed. The improvements in crop establishment from treatments last year did not improve yields in 2015.

Initial germination of brome grass was higher with inter row sowing and the total brome grass weed numbers before harvest was also greatest with inter row sowing. This result may be due to the seed falling into the last year's furrow at harvest. Sowing on row may also increase crop and weed competition as will higher seeding rate.

Acknowledgements

Thank you to the Hentschke family for having this trial on their property. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

Registered products: see chemical trademark list.

Establishing pasture into stubble at Mount Cooper

RESEARCH

Amanda Cook, Wade Shepperd and Ian Richter
SARDI, Minnipa Agricultural Centre

Searching for answers

Location:
Mt Cooper
Ian, Robyn and Angus Gunn
Rainfall
Av. Annual: 435 mm
Av. GSR: 325 mm
2015 Total: 268 mm
2015 GSR: 234 mm
Yield
Potential: 7.3 t/ha (pasture)
Actual: 3.2 t/ha
Paddock history
2015: Medic pasture
2014: Wheat
2013: Medic pasture
Soil Type
Red loam
Plot Size
20 m x 4 m x 3 reps

Key message

There were no differences in medic regeneration in wheat stubbles either harvested at two heights, left standing or rolled.

Why do the trial?

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

One issue upper EP farmers identified as a problem was sowing into retained pasture residue with pasture vines causing issues with blockages at sowing and uneven germination. Also establishing legume pastures into heavy stubble residues has also an issue in this region. The trial at Mount Cooper was designed to compare plant establishment and production, and weed and pest control effectiveness in the presence and absence of previous crop or legume pasture residues.

How was it done?

On 7 April 2014, four residue treatments were imposed on a pasture from 2013 at Mount Cooper (1.6 t/ha of vine and leaf material). The treatments were: (i) Harrowed, (ii) Mowed to the ground (residue removal), (iii) Cultivated with offset disc and (iv) Untreated control.

In 2014 the trial was sown on 21 May with Mace wheat @ 65 kg/ha and base fertiliser of DAP @ 75 kg/ha into the residue treatments. There were no differences in wheat establishment, yield or grain quality due to different pasture residue treatments imposed before seeding (Table 2). At the end of the 2014 season the stubbles were harvested at two heights of 15 cm (low) and 30 cm (high).

In 2015 the wheat stubble cut at different heights were either left standing or rolled with a rubber pea roller on 7 April to determine the impact of wheat stubble management on medic regeneration and establishment in the following season.

The measurements taken in 2015 were soil moisture, plant emergence counts, early and late dry matter. Data were analysed using Analysis of Variance in GENSTAT version 16.

What happened?

The initial soil data taken at the site (April 2014) showed at soil pH ($CaCl_2$) of 7.9, a Colwell P of 10, phosphorus buffering index of 128, and soil N level of 84 kg N/ha in the 0-60 cm depth.

The initial wheat stubble levels in April 2015 were variable but showed no consistent differences from the 2014 tillage and harvest treatments imposed (Table 1).

The 2015 season was initially very dry in most regions including Mount Cooper. The medics germinated in mid-April with the first rains, however struggled early in the season due to very little follow up rainfall events. Spring rainfall allowed the medic pasture to grow some bulk.

There were no differences in the medic plant establishment, early or late dry matter of the regenerating medic pasture between the different stubble management treatments imposed at harvest the year before (Table 2).

Table 1 Wheat stubble residues after 2014 tillage and harvest treatments.

2014 pasture residue treatment 7 April 2014	2014 harvest wheat stubble treatment 21 Nov 2014	Wheat stubble residue April 2015 (t/ha)	Wheat yield 2014 (t/ha)
Residue harrowed	Cut high	5.2	3.6
	Cut low	5.0	
Residue mown	Cut high	4.1	3.6
	Cut low	4.7	
Residue cultivated	Cut high	5.8	3.6
	Cut low	6.8	
Untreated control	Cut high	4.4	3.5
	Cut low	5.5	
LSD (P=0.05)		*ns*	*ns*

Table 2 Pasture measurements following wheat stubble treatments at Mount Cooper in 2015.

Wheat stubble treatment 7 April 2015	Medic establishment (plants/m^2)	Early dry matter 25 May (t/ha)	Late dry matter 19 August (t/ha)
Cut high rolled	119	0.95	3.34
Cut high standing	124	1.05	3.35
Cut low rolled	104	1.06	3.26
Cut low standing	121	0.90	2.98
LSD (P=0.05)	*ns*	*ns*	*ns*

What does this mean?

In the 2015 with a dry start to the season at Mount Cooper there were no differences in medic pasture regeneration and production given different harvest stubble heights and management with rolling the stubble.

In 2014 the 1.6 t/ha medic pasture residue did not cause problems at sowing in drier sowing conditions and there were no differences in wheat establishment, yield or grain quality due to different pasture residue treatments imposed before seeding.

The results from this research over three seasons have showed no differences in crop or pasture establishment or production however a different sowing system or different sowing conditions may have changed plant establishment and yield outcomes. There were no major weed or pest issues at this site in either season.

Acknowledgements

Thank you to the Gunn family for having the trial on their property. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

The impact of livestock on paddock health

RESEARCH

Jessica Crettenden

SARDI, Minnipa Agricultural Centre

Try this yourself now

Location:
Minnipa Agricultural Centre
paddock S7

Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm

Yield
Potential: 7.4 t DM/ha (pasture)
Actual: 4.1 t/ DMha

Paddock History
2014: Wheat
2013: Wheat
2012: Medic pasture

Soil Type
Red sandy loam

Soil Test
Organic C%: 1.16
Phosphorus: 20 - 26 mg/kg

Plot Size
3.5 ha

Yield Limiting Factors
Nil

Livestock
Enterprise type: Self-replacing merinos
Stocking rate: Rotational grazing and district practice

Key messages

- **Grazing sheep have not damaged soil health over eight years of several crop/pasture rotations.**
- **In 2015 total annual biomass was greater in higher input and grazed rotations. High input grazed systems carried twice the stocking rate of a low input system.**

Why do the trial?

Since 2008, a paddock on the Minnipa Agricultural Centre has been studied to determine the impact of a higher input system compared to a more traditional lower input system on overall paddock health.

How was it done?

The paddock history and background to the trial, including results from the last eight years, are described in EPFS Summaries 2008 to 2014.

The eight year rotation studied was wheat, wheat, pasture (volunteer and sown annual medic), wheat, pasture (self-regenerating annual medic), wheat, wheat and finally pasture (self-regenerating annual medic). This rotation was split into four sections, with high and low input systems with grazed and ungrazed treatments to study the influence of sheep in the mixed farming system.

In 2015 the trial was retained as a self-regenerating annual medic, with a fertiliser treatment of 18:20:00 DAP broadcast @ 100 kg/ha to the high input areas on 23 April. Soil water and fertility were measured at four selected permanent points in each section on 4 May and snail numbers and mice holes were counted on the same day. Medic establishment, weed counts and groundcover were also measured on 4 May.

The high input scenario was rotationally grazed with higher stocking rates at 43 DSE/ha on the improved pasture from 19 August for 31 days (1333 DSE grazing days). Warm and dry conditions in late September meant the heavily grazed medic was not able to recover sufficiently for sheep to return to the paddock for a second graze. The low input scenarios with traditional grazing were set-stocked with lower winter stocking rates of 13 DSE/ha for 49 days (637 DSE grazing days) from 19 August to 6 October. Biomass and groundcover were measured pre and post grazing, with pasture cages placed in the grazed treatments to determine intake. Sheep were removed from grazing treatments at anthesis, when groundcover was still considered sufficient to protect the paddock. Grass weeds were sprayed-out of the ungrazed sections on 7 October. No spraying was required on grazed treatments. Soil water for all treatments was measured on 18 December.

What happened?

Table 1 presents the 2013, 2014 and 2015 phosphorous, total nitrogen and soil organic carbon results. There was a decline in mineral N at the beginning of 2015 following two years of wheat, with higher N in the ungrazed treatments, opposing the trend of more N measured in the grazing treatment in the previous two years. Colwell P and soil organic carbon levels have been steady, and generally there have been no notable changes after eight years of the trial.

There was no difference in medic establishment, however grass weed counts were higher in the grazed treatments at this time (averaging 44 versus 26 plants/m^2 in the grazed and ungrazed treatments respectively), resulting in more groundcover in these sections. Snails and mice at this stage appeared to be higher in the ungrazed treatments.

Medic production increased in response to the higher input and grazed treatments. Biomass at anthesis was higher in ungrazed treatments, however this is just reflective of livestock consumption. Water use efficiency of medic (kg biomass/mm/ha, French Schultz) in 2015 averaged 62 percent of potential pasture growth from 258 mm of growing season rainfall (Table 2).

Table 1 Colwell P (0-10 cm), total mineral nitrogen (0-60 cm) and soil organic carbon (0-10 cm) pre-seeding in 2013, 2014 and 2015 following annual medic (2012), wheat (2013) and wheat (2014) respectively.

System	Colwell P (mg/kg)			Total mineral nitrogen (kg/ha)			Soil organic carbon (%)		
	2013	2014	2015	2013	2014	2015	2013	2014*	2015
Low input - grazed	34	36	26	111	78	24	1.3	1.0	1.2
Low input - ungrazed	27	24	24	84	39	30	1.2	1.0	1.1
High input - grazed	18	16	20	118	85	23	1.2	1.0	1.2
High input - ungrazed	22	18	21	74	54	32	1.1	1.0	1.1

**Please note that soil organic carbon results in the EPFS Summary 2014 were incorrect. Table 1 shows the corrected data.*

Table 2 Medic biomass production and water use efficiency 2015.

System	Biomass at anthesis (t DM/ha)	Total biomass (t DM/ha)	Water use efficiency (% of potential)
Low input - grazed	2.8	5.2	66
Low input - ungrazed	3.7	3.7	65
High input - grazed	3.2	5.7	65
High input - ungrazed	4.1	4.1	54

Sheep intake averaged 2.4 t DM/ha (averaging 3.8 kg DM/DSE/day) in the low input treatment, and the high input treatment averaged 2.6 t DM/ha (averaging 1.9 kg DM/DSE/day) for the period of grazing. This figure does not take into account trampling of pasture, which is usually considered to be 10%. Sheep condition score was measured pre and post grazing, averaging 3.5, with no difference in condition from the start to the end of grazing or between treatments. Sheep were removed at anthesis and when medic residue needed to be retained for groundcover with 3.2 and 2.8 kg DM/ha of biomass remaining in the high and low grazed treatments respectively. Sheep feed intake levels and trampling had no impact on end of season groundcover, with all treatments having over 90% groundcover at anthesis.

What does this mean?

Similar to results in 2012, which was the last phase of medic in the trial rotation; the higher input, improved self-regenerating medic pasture increased biomass production and carried a higher stocking rate. The grazed treatments had greater water use efficiency and produced sufficient feed to sustain sheep condition over the grazing period. The high input grazed treatment supported twice the DSE grazing days of the low input treatment. This greater carrying capacity on the high input treatment was due to higher medic production, which is conceivably the result of the fertiliser input in 2015 and medic sown in 2010. Grazing stimulated the medic to grow, and it was able to respond to timely rainfall events throughout the growing season, which resulted in grazed treatments producing an average of 1.5 t DM/ha more total biomass than ungrazed treatments, and no negative impact on soil health.

The differences in profit margin and other mixed farming systems benefits and detriments between the four systems will be analysed after the 2016 season to summarise this long-term trial through funding provided by the Grain and Graze project.

Acknowledgements

I gratefully acknowledge the help of Mark Klante and Brett McEvoy for site management and John Kelsh for data collection. The Eyre Peninsula Grain and Graze 3 project is funded by GRDC (SFS00028).

Profitable crop sequences on upper Eyre Peninsula – the final year

RESEARCH

Nigel Wilhelm[1] and Michael Moodie[2]

[1]SARDI, Minnipa Ag Centre; [2]Mallee Sustainable Farming, Mildura

Try this yourself now

Location:
Minnipa Agricultural Centre
Airport paddock
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 2.9 t/ha
Paddock History
Prior to 2011 > 10 years cereal
Soil Type
Red sandy clay loam
Plot Size
20 m x 2 m x 3 reps
Yield limiting factors
Nitrogen, Phosporus, Grass weed competition

Key messages

- **For the first year following breaks in 2011-12, wheat production was unaffected by break history compared to continuous wheat, but only because expensive herbicides kept high grassy weed seed banks at bay.**
- **Soil mineral N and water leading into 2015 were the same in all treatments.**
- **Oats was a poor break option for managing grassy weeds.**

Why do the trial?

To determine the comparative performance of alternative crops and pastures as pest and disease breaks in an intensive cereal phase and to evaluate their impact on following wheat crops.

In low rainfall regions of south-eastern Australia broad-leaf crops make up only a very small proportion of the total area of sown crops. In light of increasing climate variability farmers have adopted continuous cereal cropping strategies, as non-cereal crops are perceived as riskier than cereals due to greater yield and price fluctuations. At the same time, this domination of cereals is increasing the need for non-cereal options to provide profitable rotational crops, disease breaks and weed control opportunities to sustain cereal production. Currently, the most common 'break crop' is a poorly performing volunteer annual grass dominant pasture. They are often havens for cereal pests and diseases and are seen as having negative impacts on subsequent cereal grain yield and quality. For greater detail of trial management over the past four years refer to articles EPFS Summaries 2011, p111, 2012, p94, 2013, p104 and 2014, p134. GRDC granted an extension of this project to capture a third cereal year after the break options because many were still impacting on wheat production in the second cereal year

How was it done?

In year five of the trial (2015) as in the previous two years, all treatments were sown wheat, in the last season it was again Corack wheat @ 57 kg/ha with 64 kg/ha DAP and 50 kg/ha urea banded under the seed row on 13 May. All plots were broadcast with 90 kg/ha urea in late July prior to 20 mm of rain.

The whole trial was treated for weed control in the same way (118 g/ha Sakura, 1.5 L/ha Triflur X and 1.2 L/ha Sprayseed pre-seeding and Amicide 700 @ 800 ml/ha in crop) except for treatments with medics in their history which also received Lontrel Advance @ 75 ml/ha for medic control. The trial was harvested in early November.

The trial was monitored for grassy weeds and grain yield and quality. Soil water and mineral N to depth were also measured pre-seeding.

What happened?

See the other article in this section which is a detailed summary of the economic impacts of break options in three of these crop sequencing trials (including Minnipa) over the first four years of these trials. This article summarises the agronomic performance of wheat in 2015.

Soils

Pre-seeding soil water and mineral N measured in the 0- 90 cm profile were similar across all treatments (which were all sown to wheat in 2013 and 2014) with soil water averaging 94 mm and mineral N 89 kg N/ha.

Production

Just like many crops on upper Eyre Peninsula in 2105, this trial suffered from low spring rainfall. Yields varied from 2.46 t/ha through to 2.94 t/ha. For the first time in the trial, continuous wheat was not amongst the very lowest performing treatments. In general, most treatments yielded better than 2.5 t/ha with only one treatment, early sown medic in 2011 followed by oats, yielding less than 2.5 t/ha.

Table 1 Yield of Corack wheat in 2015 at Minnipa.

2011 outcome / 2012 outcome	Average of yield t/ha	Grassy Weed Seed Bank Plants/m²	2011 outcome / 2012 outcome	Average of yield t/ha	Grassy Weed Seed Bank Plants/m²
WHEAT grain / WHEAT grain	2.70	132	EARLY SOWN MEDIC hay / OATS graze	2.58	151
ANG MEDIC seed / WHEAT grain	2.85	279	CANOLA grain / FIELD PEA grain	2.76	106
VETCH+OATS hay / WHEAT grain	2.54	83	CANOLA grain / EARLY SOWN MEDIC graze	2.79	128
OATS hay / CANOLA grain	2.94	377	CANOLA grain / OATS graze	2.71	211
OATS hay / FIELD PEA grain	2.75	453	FIELD PEA grain / OATS graze	2.82	158
OATS hay / EARLY SOWN MEDIC graze	2.80	377	FIELD PEA grain / WHEAT grain	2.76	204
FALLOW / FALLOW	2.94	121	FIELD PEA grain / CANOLA grain	2.81	257
ANG SOWN MEDIC seed / WHEAT grain	2.56	332	FIELD PEA+CANOLA hay / WHEAT grain	2.71	106
SOWN MEDIC hay / MEDIC+CANOLA graze	2.46	166	SULLA graze / REG SULLA graze	2.63	113
EARLY SOWN MEDIC hay / CANOLA grain	2.75	151			
LSD (P=0.05)	*0.24*	*ns*			

Grain quality was affected by the dry finish with small grain size (an average of only 27 g/1000) and screenings averaging 11%, regardless of treatments. Protein in grain averaged over 13% for the whole trial.

Weeds were not a production issue in 2015 because the pre-seeding application of Sakura, Sprayseed and Triflur X was very effective at keeping grassy weed competition low in-crop, despite grassy weed seed banks varying from 83-453 plants/m² across treatments. Treatments with medic in their history required a Lontrel in-crop spray for their control. Grassy weed seed banks were not consistently different between treatments leading into 2015 (see table 1),

What does this mean?

The wheat crop in 2015 was the third or fourth consecutive wheat crop following breaks imposed in 2011 and 2012. For the first time in this trial crop performance was not affected by previous break history. In all previous years, wheat performance was increased by breaks which reduced grassy weed pressure. All treatments performed well in 2015 relative to the French/Schultz potential (ranging from 82 to 98%) suggesting that there were few constraints to crop production other than water. Soil mineral N and water were not affected by break history leading into the 2015 season.

However, production in 2015 was reliant on an expensive pre-seeding herbicide package to keep large grassy weed seed banks at bay in those treatments without the opportunity to run grassy weeds right down. Oats was a poor break choice in terms of managing grass weed seed banks as they generally had the highest levels over the life of the trial. A small penalty for including medics as a break in previous years was the need for an in-crop herbicide action to eliminate them as a weed in 2015.

All trials in this project are now being assessed for the impact of breaks on five year gross margins and soil condition. See article "The value of break crops in low rainfall farming systems" in this edition which summarises the four year gross margin performance of three of these trials across Southern Australia.

Acknowledgements

We would like to thank Ian Richter and Wade Shepperd for technical expertise throughout the duration of the trial over the past five years. Thank you to Chris Dyson for biometric expertise. Thanks to GRDC for funding the project, project code DAS00119.

Section Editor:
Blake Gontar
SARDI, Port Lincoln

Weeds

Barley grass management in retained stubble systems - farm demonstrations

Amanda Cook[1], Wade Shepperd[1], Ian Richter[1], Mark Klante[1], Bruce Heddle[2] and Brett McEvoy[1]
[1]SARDI, Minnipa Agricultural Centre, [2]Minnipa farmer

RESEARCH

Try this yourself now

Location:
Minnipa Agricultural Centre
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 1.23 t/ha
Soil Type
Red loam

Key messages

- **Weed seeds were found in narrow windrows and chaff dumps, ryegrass was more prevalent than barley grass which is more prone to shedding seed early.**
- **Burning reduced the viable ryegrass and self-sown cereal seed density by 85%, reducing the overall weed seed bank, but results for barley grass were lower at 38%.**
- **Conditions (i.e. temperature and humidity) and timing of burn were shown to strongly influence the effectiveness of this cultural management tactic.**
- **Burning windrows resulted in fewer weed seeds returning to the weed seed bank.**
- **There is a cost associated with windrow harvesting due to lower harvesting height requiring reducing the harvest speed with larger throughput of straw.**
- **A better understanding of burning and the weather conditions needed to sterilise barley grass seed is needed.**

Why do the trial?

The GRDC 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' project aims to improve farm profitability while retaining stubble in farming systems on upper Eyre Peninsula (EP). Weed control in stubble retained systems can be compromised where herbicide efficacy is limited due to higher stubble loads, especially for pre-emergent herbicides. Current farming practices have also changed weed behavior with later germinating barley grass genotypes now present in many paddocks on the Minnipa Agricultural Centre (MAC) (B Fleet, EPFS Summary 2011). Several MAC farm demonstrations were undertaken in 2014 to address barley grass weed issues including later germinating types and barley grass resistance to Group A herbicides.

An integrated approach to weed management aimed at lowering the weed seed bank can make use of diverse techniques such as cultivation, stubble burning, in-crop competition using higher sowing rates and possibly row orientation. The weed seed bank can be reduced within the break phase by hay making, or green or brown manuring. Other techniques used effectively in WA on ryegrass and wild radish have been narrow windrows and chaff carts. However there is limited information on the effectiveness of these tactics on barley grass in part because it is believed that most seed is shed well before harvest, limiting control.

In 2015 the monitoring of farm paddock demonstrations in low rainfall farming systems to assess control methods for grass weeds, mainly targeting barley grass, were undertaken by;

- Monitoring of narrow windrows in MAC paddocks N1 and N6W, and Bruce Heddle's paddock CE42 (windrows and chaff dumps).
- Spray topping after oat and vetch hay (MAC paddock S4) using both crop competition (high seeding rate) followed by spray topping after the hay cut.

How was it done?

Before harvest in 2014 the MAC 2366 header was fitted with a narrow windrow attachment made on farm from dimensions obtained from the GRDC website to divert chaff and straw into a 600 mm windrow. The straw chopper was disengaged. There were no issues with the windrow attachment during harvest.

Selected MAC farm paddocks were monitored for barley and ryegrass numbers and, in the 2015 season, burning temperature, seed capture and seed viability in the narrow windrows was recorded.

Research was undertaken at MAC, as well as on a local farmer's property, where Bruce Heddle modified a 60 Series John Deere harvester for weed seed capture and management using narrow windrows and a chaff cart (see EPFS Summary 2014, Barley grass in a retained stubble system – farm demonstrations, p152-154 for further detail).

The paddock CE42 has been problematic for both ryegrass and barley grass. It was sown in 2014 on 170 mm row spacing with a 100 mm row spread to maximise wheat crop competitiveness. The paddock was harvested as low as possible with the chaff fraction blown into the cart, the chopper disengaged and the windrow boards fitted to create narrow windrows. In 2014 the crop yielded approximately 3.5 t/ha with a high stubble load, presenting a challenge to burn the straw windrows and chaff piles effectively without burning the whole paddock. The paddock was lightly grazed to utilise unharvested grain for two weeks at 5 DSE/ha.

In 2015 the paddock was sown to Stingray canola at 3 kg/ha with 35 kg/ha of DAP (18:20:0:0) with knife points and press wheels at 300 mm row spacing. The chemical control applied in crop was 450 ml/ha clethodim and 500 gm/ha atrazine 900WG after early weed counts.

At MAC, paddock N1 (with previous high, medium and low input zones with different fertiliser and seeding rates, refer to EPFS Summary 2012, Zone responses to four years of repeated low, medium and high input treatments at Minnipa, p86 for details) had dense barley grass in 2014 and was returned to a pasture phase in 2015. The paddock was windrowed at harvest 2014 but the windrows were not burnt in the whole paddock. The section of paddock which had been monitored for grass weeds in 2014 was burnt on 23 April, in non-ideal conditions due to 23 mm of rainfall occurring the week before.

Paddocks N1 and CE42, which had windrows and chaff dumps (CE42 only), were assessed for grass weed seed density in-crop and in the soil seed bank. The effectiveness of windrowing and chaff dumping, as affected by burning temperatures and weather conditions, was assessed by comparing burnt and unburnt sections of narrow windrows and chaff dumps.

The weed seed soil samples were germinated in an external weed seed area established in 2015. Weed seed samples were placed in 35 cm x 29 cm black germinating trays, partially filled with sterilised soil mix and the collected weed seed bank soil was spread over the top to 1-2 cm depth, with another light coating of the sterilised soil mix spread over the top. The trays were placed in a rabbit proof open area and watered as required during the season. The trays were assessed for weed germination approximately every four weeks. The counted weeds were removed from the trays. Twenty-one check plots with barley grass seed collected from MAC N1 (sprinkled into check trays) were located across the germination area to assess timing of barley grass germination.

Chaff was collected (5 samples per dump) from 4 different sides of the dump, approximately 20 cm into the dump at approximately 1 m height, and one sample from the top of the dump to determine the weed seed species being collect at harvest.

Soil weed seed bank samples were collected in February and March 2015 along a transect across the paddock comprising 10 GPS-located sampling points. The soil sampling method used was as described by Kleemann *et al*. (2014). Prior to narrow windrows being burnt a 5 m section of chaff was removed (non-burnt area) within each paddock (Figure 1). Three subsamples of very fine chaff from in the windrow were also collected and germinated on trays. Chaff was also collected and germinated from three chaff dumps to assess the weed seeds being collected at harvest.

After burning the windrows, sampling of the three areas occurred with 10 soil core samples (using a 7 to 10 cm diameter core to 10 cm depth) from each of the following three locations

1. Burnt section of windrow (10 cores)
2. Sample from within 3 m on the non-burnt section of windrow (i.e. section raked) (10 cores)
3. Sample from middle of adjacent unburnt inter-row area (10 cores)

The 10 soil core samples were pooled or bulked so a total of 3 soil samples were collected for each of the 10 GPS locations in the paddock (i.e. burnt, non-burnt, adjacent unburnt inter-row). These 3 soil samples were spread across 3 soil trays for germination.

The paddock was monitored during the season for early and late grass weed germination by doing 6 counts of 1 m x 0.5 m quadrats at 10 GPS-located sites along a transect across the paddock.

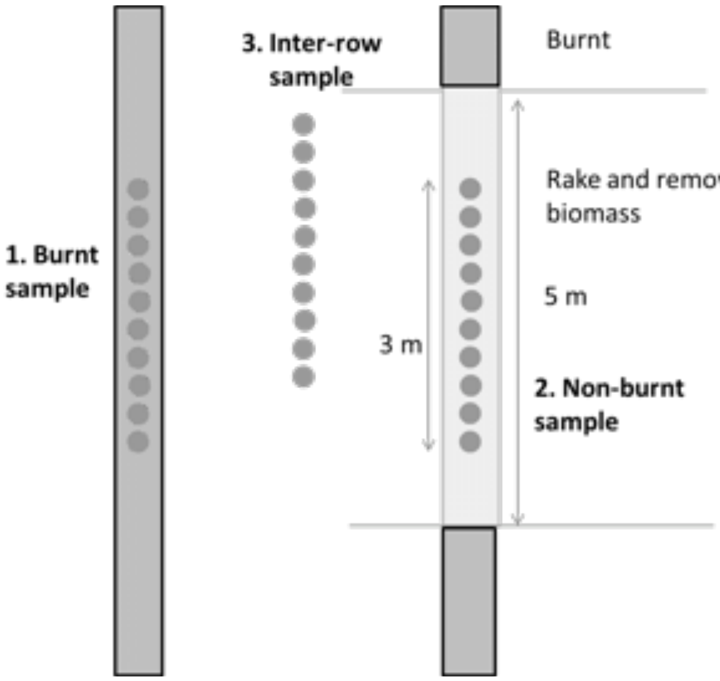


Figure 1 Sampling methodology for each of the 3 locations (1. burnt, 2. non-burnt, & 3. adjacent inter-row), (Kleemann et al. 2014). Shaded areas represent windrows.

What happened?

Bruce Heddle burnt the windrows and chaff dumps on 24 March 2015 in the late afternoon with a temperature of 22°C, the wind speed was average of 1 km/h and maximum of 8 km/h, direction was south/south easterly (swung to Minnipa direction which caused some community issues), humidity 25%, stubble height 17.5-18 cm. Using a handheld thermometer the temperature of the burning narrow windrow peaked at 620°C within 43 seconds of ignition and was maintained at between 600 and 300°C for up to 240 seconds (Figure 2). The sudden spikes in temperature appeared to be related to wind gusts while burning. These temperatures easily exceeded the 400°C required for 10 seconds required to kill weed seeds (Walsh and Newman, 2007).

In Bruce's farming system he has different strategies for chaff piles, depending on the paddock rotation for the next year:

- Wheat stubble to be cropped with canola - piles are grazed to the point they can be sown through and driven over with the sprayer without any inconvenience. If this can't be achieved, they are burnt.
- Canola stubbles to be cropped with wheat - piles are grazed to the point they can be sown through (even with 170 mm row spacings) and driven over with the sprayer without any inconvenience. Canola chaff is far too valuable as sheep feed to burn.
- Wheat stubbles to be returned to medic pasture – paddocks are conserved for lambing ewes and winter grazing with the piles left in place. Grazing over the pasture phase will see them largely degrade and gone by the time the paddock returns to wheat.
- Chaff piles in paddocks being sown to grain legumes are burnt.

Bruce's opinion is burning of chaff piles is still successful after the opening rain as long as they are ungrazed and shed the water to ensure they stay dry. Grazed and disturbed piles need to be burnt earlier to ensure they are dry and the burning is successful. Narrow windrows are not grazed and are burnt quite early in the season to ensure a hot and effective fire. The windrow and chaff dump burning was very successful and majority of straw between rows was unburnt with the paddock left well protected from wind erosion (Figure 4).

The canola windrows in MAC paddock N6W were burnt on the 14 April before a 23 mm rainfall event with a temperature of 29.5°C, the wind speed averaged 28 km/h with a maximum of 39 km/h, direction was west north westerly.

The MAC N1 paddock was burnt on 23 April in cool weather conditions after the 23 mm rainfall event on 17 April. The weather conditions were 17.5°C, humidity 56%, and wind 11 km/h in a south westerly direction. The windrows remained damp following the rain the week before, and after 6 minutes of burning the damp stubble beneath the row reached a maximum temperature of 50°C. These temperatures fall well short of the required 400°C, with most weed seeds expected to remain viable. Given the amount of residue concentrated into narrow windrows it's unlikely that they can effectively dry down after significant rainfall, limiting the effectiveness of the tactic and creating stubble handling issues at sowing from unburnt residue.

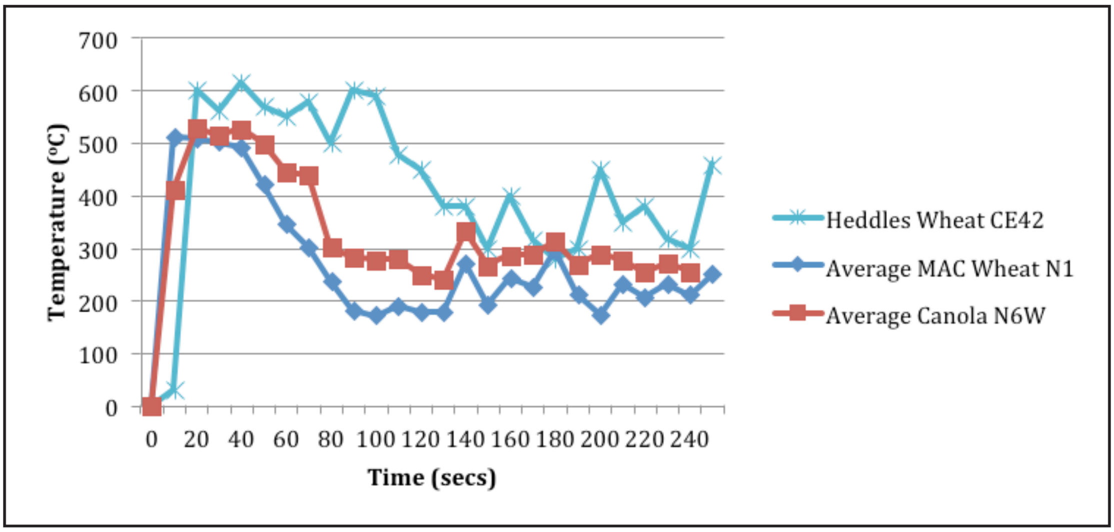


Figure 2 Burning temperatures (°C) over time (seconds) of windrows (wheat and canola) prior to seeding 2015.

Table 1 Average weed density (plants per m²) in weed seed soil banks for windrow burning, Heddle's paddock CE42 in 2015.

Treatment (refer to Figure 1)	Barley grass	Rye grass	Self-sown cereal	Canola	Medic/other broadleaved weeds
3. Inter row (before burning)	95.6	109.9	11.9	0.0	107.5
2. In row non burnt (straw removed from 5 m row - soil collected after burning)	38.2	265.2	262.8	2.4	160.1
1. In row burnt (In row soil collected after burning)	19.1	78.8	43.0	0.0	76.5
reduction in seed bank by windrow burning	50%	70%	84%	100%	52%

Table 2 Average weed density (plants per m²) in chaff (5 trays with average 57 g chaff per tray) collected from chaff dumps, Heddle's paddock CE42 2015.

Treatment	Barley grass	Rye grass	Self-sown cereal	Canola	Medic/other broadleaved weeds
Dump 1 (5 trays)	1	2022	19.0	0	2.0
Dump 2 (5 trays)	30	28	1.3	0	1.0
Dump 3 (5 trays)	17	16	4.0	0	1.0
Average of chaff dumps	16	689	8.1	0	1.3

While barley grass was the primary target in paddock CE42, ryegrass was also present with high weed infestation in the flats of the paddock. Assessments showed that there were much greater numbers of barley grass in the inter row compared to within the windrow (Table 1). It is commonly thought barley grass has a tendency to shed seed early, limiting seed capture and resulting in lower numbers in the windrow. Even though only a small number of seeds accumulated in the windrow, 50% were destroyed upon burning. Weed seed capture and control from burning was better for ryegrass, self-sown cereals and other weed species. Despite burning temperatures exceeding the recommended 400°C for 10 seconds required to kill ryegrass seed, a small proportion of seed remained viable. Chaff was sampled from chaff dumps to assess effectiveness of weed seed collection at harvest (Table 2). Results were highly variable between chaff dumps with very high collection of ryegrass in dump 1 (~2000 seeds), but considerably lower collection in dumps 2 and 3 (16-28 seeds), respectively (Table 2). Collection was much lower for barley grass (~16 seeds).

Paddock CE42 was sown to canola in 2015 and there were grass weeds present in crop early but chemical control reduced the weeds to very low numbers (Table 3).

Table 3 In-crop plant and grass weed density (plants per m²) in Heddle's paddock CE42, 2015.

	Early weed densities (plants/m²)	Late weed densities (plants/m²)
Canola	59.6	54.0
Barley grass	16.2	0.1
Rye grass	36.4	0.2

Table 4 Soil weed seed density (plants per m²), windrow burning, paddock N1.

Treatment (refer to Figure 1)	Barley grass	Rye grass	Self-sown cereal	Canola	Medic/other broadleaved weeds
3. Inter row (before burning)	262.8	15.9	0.0	0.0	31.9
2. In row non burnt (straw removed from 5 m row - soil collected after burning)	593.3	19.9	83.6	0.0	75.7
1. In row burnt (In row soil collected after burning)	430.1	0.0	11.9	0.0	171.2
reduction in seed bank by windrow burning	27%	100%	86%		

MAC N1 had high levels of barley grass in 2014 and was returned to a pasture phase in 2015. The paddock was windrowed at harvest 2014 but not all windrows were successfully burnt. The section of paddock which had been monitored for grass weeds was burnt under less than ideal conditions on 23 April, with windrows damp following 23 mm of rainfall the week before (Table 4). As a consequence, windrow burning was ineffective with many seeds remaining viable after burning (Table 4). The temperatures reached were not sufficient to kill ryegrass seed (Figure 2).

Canola windrows in paddock N6W were effectively burnt, reaching temperatures above 400°C for approximately 80 seconds. Burning canola has excellent fit within farming systems as the burn can be more easily contained to the windrow. Barley grass (6 plants/m²), ryegrass (2 plants/m²) and wild oats (2 plants/m²) were generally less prevalent, however some seed shed was evident for barley grass reducing the effectiveness of burning. This paddock will continue to be monitored in 2016.

Spray topping oats and vetch hay (paddock S4)

In 2015 a hay mix of oats and vetch was sown as a strategy to reduce barley grass in S4 by increasing crop competition by sowing at high rates. Plant counts taken on 25 June showed good crop establishment (77 vetch plants/m²; 154 oats plants/m²) with relatively few weeds present (4 barley grass plants/m²; and 3 ryegrass plants/m²).

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. The LAI showed that the hay crop was providing high level of light interception (105 umols) and shading of weeds. Measurements from nearby trial assessing influence of row spacing and seed rate on crop competition had considerably lower LAI readings (66-67 umols). Even though readings were lower for high seed rate x narrow row spacing treatments, there appeared to be some benefit on suppressing weed growth and competitiveness. A dense and competitive oaten hay could be a useful option against barley grass and ryegrass, which also provides the option of spray-topping for late weed seed set control (i.e. hay freeze).

The influence of farming management strategies on barley grass will be ongoing in these demonstration paddocks in 2016.

Figure 3 Weed seed bank germination trays at Minnipa Agricultural Centre, 2015.

Figure 4 Windows and chaff dump burning at Bruce Heddle's, March 2015.

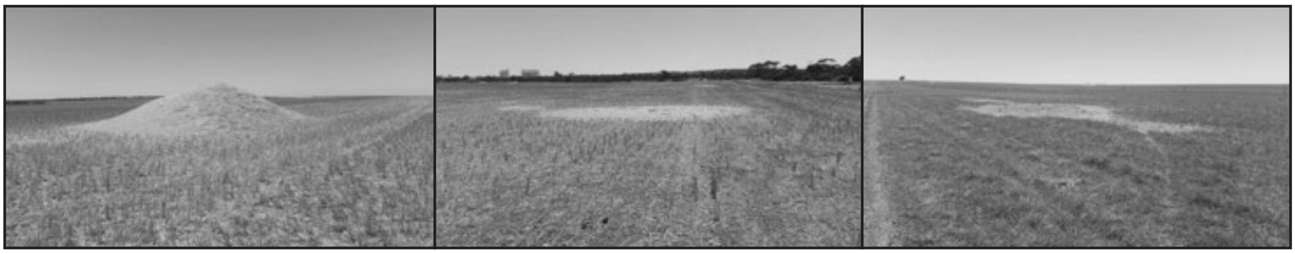


Figure 5 (left to right) Ungrazed chaff dump, chaff dump grazed for 1 week and 2014 grazed chaff dump in pasture paddock.

What does this mean?

Weed seeds were found in narrow windrow and chaff dumps in CE42, however seed capture was more effective for ryegrass and self-sown cereals, with much of the barley grass seed shed prior to harvest. Also, late germinating barley grass plants were visually shorter and were consequently less likely to be captured at harvest. Burning of narrow windrows had some success at reducing weed seed numbers, with the burn more easily contained in canola than wheat. However, in paddock N1, where narrow windrows were damp due to significant rainfall, temperatures required to kill weed seeds were unobtainable at the time of burning and consequently control was poor. This management tactic must be undertaken under optimal conditions for reducing the overall weed seed bank using no chemical methods. Like all farm operations, windrow burning requires timeliness and ideal conditions to maximise benefit. Windrow harvesting does have a cost at harvest, as harvesting lower increases fuel use or reduces speed of harvest (or both).

In 2016 ongoing paddock monitoring of alternative methods to chemical control options to manage grass weed numbers, especially barley grass, will occur in paddocks on MAC (S3N, Airport, N6W) and Bruce Heddle's for further information to be collated for upper EP farming systems.

A better understanding of burning time/temperature requirements and environmental conditions required to sterilise barley grass seed is needed, with this research planned for the coming season in conjunction with the University of Adelaide researchers.

References

Kleemann, S., Noack, S., Hooper, P., Preston, C. & Gill, G. (2014). *Harvest weed seed control – narrow windrow burning.* Hart Annual Trial Results. p69-72.

Acknowledgements

Thanks to Ben Fleet and Sam Kleeman for knowledge and help with establishing the weed germination trays, Sue Budarick for managing and scoring the trays during the year and Roanne Scholz and Rochelle Wheaton for helping set the trays up. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001) and EP Rail Levy.

Ryegrass management in a retained stubble system - farm demonstration

DEMO

Amanda Cook[1], Andrew Ware[2], Wade Shepperd[1] and Ian Richter[1]

[1]SARDI, Minnipa Agricultural Centre, [2]SARDI, Port Lincoln

Searching for answers

Location:
Yeelanna
Rainfall
Av. Annual: 395 mm
Av. GSR: 314 mm
2015 Total: 358 mm
2015 GSR: 293 mm
Yield
Potential: 3.7 t/ha (W), 2.7 t/ha (Canola), 2.4 t/ha (pulses)
Actual: 3.8-4.4 t/ha (W), 3,5 t/ha (Barley), 1.8 t/ha (Canola), 2.0 t/ha (Beans)
Soil Type
Shallow medium clay loams to acidic sands

Key messages

- **Managing herbicide resistance in ryegrass continues to be crucial in maintaining sustainable crop production on Lower Eyre Peninsula.**
- **Management strategies other than herbicides need to be deployed to ensure sustainable ryegrass control into the future.**
- **Windrow burning proved to be an effective method in reducing ryegrass seed numbers in 2015.**
- **Managing ryegrass on differing soil types will prove a challenge into the future.**
- **Information generated by this project will provide data to simulate how different management strategies can be used to manage ryegrass in a sustainable, cost effective way.**

Why do the research?

Ryegrass management is one of the key drivers of profitability in Lower Eyre Peninsula (LEP) cropping systems, and herbicides have recently been used as the main strategy for control. The intensification of cropping rotations and a decrease in livestock in farming systems has increased pressure on herbicides, resulting in the development of herbicide resistance. Other management strategies need to be assessed to manage ryegrass. The Australian Herbicide Resistance Initiative (ARHI) based at the University of Western Australia developed the Ryegrass Integrated Management (RIM) model. This model enables growers and advisors to run various ryegrass management scenarios, with the model showing the cumulative effect on ryegrass numbers and profitability of the management strategies. This model can be accessed at www.ahri.uwa.edu.au/research/rim.

The GRDC 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' project has a focus on barley grass (upper EP) and ryegrass (LEP). The research on this project has been undertaken by SARDI Minnipa Agricultural Centre staff. As part of this research a LEP farm was selected to monitor in-paddock ryegrass populations and weed management strategies. This research aims to ground-truth the effect (predicted by the RIM model) that various ryegrass management strategies have on ryegrass populations on a LEP farm with high ryegrass numbers and extend this information to EP growers and advisors to assist them in improving ryegrass management decisions using the RIM model.

How was it done?

A recently leased property south east of Cummins with six paddocks was selected to monitor the ryegrass populations under different paddock management options. The property receives approximately 400 mm of rainfall annually. It has an undulating topography where the soil types range from medium clay loams to acidic sands, with ryegrass populations being significantly larger on the acidic sands. The ryegrass population is suspected of having resistance to Group A and D (and possibly Group M) herbicides. It was previously intensively cropped in a wheat/canola rotation (Table 1), where the principle method of ryegrass control was through the application of herbicides. Paddocks were regularly burnt, with a wide cultivated firebreak (which has very high levels of ryegrass).

The six ryegrass populations were assessed across given paddock transects during the 2015 season, as well as crop plant numbers and herbicide resistance. The soil weed seed bank was assessed in 2015 as well, and this assessment will continue over the next 18 months in germination trays at Minnipa to determine the extent of seed dormancy.

The ryegrass management strategies which were implemented by the managers in 2015 include:

- use of triazine tolerant canola (low amounts of Group C herbicides used in the past),
- use of propyzamide pre-emergent (Group D) in canola,
- use of clethodim (Group A),
- using glyphosate under the windrower bar,
- windrow burning and spraying at windrowing time in the canola crops,
- later sowing of cereals in 2015 plus using Fathom barley as a competitive crop, with windrow burning after harvest for ryegrass weed seed control.

The soil weed seed bank samples were taken on the 8 and 14 April. The windrowed paddocks were soil sampled as per the methodology (Figure 1) in the article, Barley grass management in retained stubble systems - farm demonstrations. The early weed counts were done on 26 May and 1 July, when ryegrass plants were also sampled and sent for herbicide resistance testing using the Quick-Test method.

The herbicide resistance Quick-Test takes approximately 4 weeks and involves sampling plants which are growing in the paddock (from seedlings to tillering). Plants can either be sampled before herbicide application or after herbicide is applied and poor control is noticed. For more detail see www.plantscienceconsulting.com.

These ryegrass plants had not had post emergence chemicals applied. Late weed counts were done after windrowing canola and before harvest on 22 October.

What happened?

The ryegrass management strategies undertaken by the farm mangers will be entered into the RIM model in 2016 to determine the impact of these strategies on ryegrass seed set within rotations.

The weed counts taken in May (break crops) and July (cereals) show greater ryegrass weeds present on the grey acidic soils than the red clay loam soils (Table 2). The soil weed seed bank sampling showed the windrows in N5 had some ryegrass and self-sown cereal collected in the windrow, and burning achieved a high rate of seed destruction. The N5 paddock and the 80 Acre paddock had higher levels of ryegrass present in the seed bank (Table 3).

Table 1 Paddock rotataion and chemical use in 2014 and 2015.

Paddock	2015		2014		2013	2012	2011
	Crop	Rate L/ha, Chemical (Group)	Crop	Rate L/ha, Chemical (Group)			
N5	TT canola	1.3 trifluralin (D), 1.7 atrazine (C), 1.0 propyzamide (D), post - 500 clemodim (A)	Scope barley	1.5 trifluralin, 2.5 Boxer Gold (K&J)	CL canola	Wheat	Wheat
Airstrip	Wheat	1.3 trifluralin (D), 2.0 triallate (E), 0.5 metolach (K), 0.3 diuron (C)	CL canola	2.0 trifluralin (D), 1.0 propyzamide (D), 500 clemodim (A), 40 gm On Duty (B)	Wheat	Wheat	CL canola
80 Acre	Beans	1.0 terbyne (C),1.0 propyzamide (D)	Wheat	1.3 trifluralin (D), 2.5 Boxer Gold (K&J)	Wheat	CL canola	Wheat
Shearing Shed	Barley	1.3 trifluralin (D), 2.0 Boxer Gold (K& J) Post - 1.0 Boxer Gold (K)	TT canola	1.7 atrazine (C), 1.0 propyzamide, Post - 500 clemodim (A)	Wheat	Wheat	CL canola
West Well	Barley	1.3 trifluralin (D), 2.0 Boxer Gold (K&J) post - 1.0 Boxer Gold (K)	Wheat	1.3 trifluralin (D), 2.5 Boxer Gold (K&J)	Wheat	CL canola	Wheat
Salt Lake	TT canola	1.3 trifluralin (D), 1.7 atrazine (C), 1.0 propyzamide (D), Post 500 clemodim (A)	Wheat	1.3 trifluralin (D), 2.5 Boxer Gold (K&J)	CL canola	Wheat	Wheat

Table 2 Weed counts (plants/m²) in paddocks in May 2015.

Treatment	Rotation	Ryegrass (plants/m²)		Cereal (plants/m²)
		Grey acidic sand	Clay loam	
N5	Canola	1.3	0.2	
Airstrip	Wheat	2.3	1.2	148
80 Acre	Beans	50.2	0.2	
Shearing Shed	Barley	0.3	0.0	125
West Well	Barley	17.7	3.8	116
Salt Lake	Canola	17.6	3.0	

Table 3 Weed counts (plants/m²) in soil weed seed banks for paddocks, 2015.

Treatment	Barley grass	Ryegrass	Self-sown cereal	Canola	Medic/Other broad leaved weeds
Inter row (before burning)	0.0	0.7	0.0	0.0	1.7
In row non burnt (straw removed from 5 m row - soil collected after burning)	0.1	9.8	38.0	0.0	1.5
In row burnt (In row soil collected after burning) % reduction in seed bank	0.0	0.1 99%	0.0 100%	0.0	0.5 64%
N5 Straw/chaff in row	0.2	3.2	1.6	0.1	0.7
Salt Lake	0.2	1.2	1.2	0.0	1.3
80 Acre	0.1	7.2	0.2	0.0	1.7
Shearing Shed	0.0	0.0	0.0	0.0	2.0
West well	0.2	2.7	0.7	0.0	2.2

Table 4 Herbicide resistance (using Quick-Test) in paddocks, 2015.

Chemical Group	A DENS	A DIMS				B IMIS	C
Chemical	Axial	Select			Factor	Intervix	Atrazine
Rate (ml/ha)	300	350	500	700	180	750	2000
N5 paddock transect	80% RRR						
N5 60 acre	20% RR						
Airstrip paddock transect	40% RR	25% R	15% R	15% R	20% R		15% R
Airstrip creek line	40% RR	10% R					
80 Acre	75% RRR	10% R				15% RR	
Shearing Shed paddock transect	25% RR					50% RR	
Shearing Shed dam and creek	55% RR	20% R					
West Well	60% RR	50% RR	20% R			55% RR	15% R
Salt Lake transect	70% RR	20% R					15% R
Salt Lake gully area	70% RR	20% R					20% R
Salt Lake power pole (high chemical usage area)	90% RR	80% R	5% R				

Resistance-rating: RRR - indicates plants tested have strong resistance, RR - indicates medium-level resistance, R - indicates low level but detectable resistance, S - indicates no detection of resistance

Herbicicide resistance tests taken in-season using the Quick-Test method showed many of the paddocks have resistance to Group A herbicides present, including resistance to some of the newer chemicals and modes of action (Table 4).

It was thought the herbicide resistance may be moving from areas with high chemical weed control use (within the dam and fire break areas) via the waterways with the movement of weed seeds during periods of intense rainfall. The results from the Quick Test show higher levels of resistance across the paddock transects than the areas in creeklines, gullies and dams.

The ryegrass plants were tested for glyphosphate resistance but this was not detected in any of the samples (data not shown).

What does this mean?

Research conducted over a number of years by the Australian Herbicide Resistance Initiative and the University of Adelaide weeds research program has found that keeping ryegrass numbers low is critical not only to reduce the immediate yield loss caused by ryegrass competing with crops, but also as part of sustainable weed control to reduce weed seed set and the potential increase of resistant ryegrass (Preston *et al.*, 2015, Storrie, 2014). Herbicides will continue to form a crucial role in keeping numbers low. However, as resistance to herbicides continues to develop, other practices need to be used to keep numbers to manageable levels.

Resistance tests conducted as part of this project have shown that this property is typical of many on the LEP, as verified by Boutsalis *et al*. (2015) in the 2014 EP survey, with resistance developing to Group A and B herbicides in most paddocks and also likely in Group D (although unable to be tested by this project).

The paddocks monitored as part of this project demonstrates how effective strategies such as windrow burning can be in reducing weed seed numbers. Soil samples have been have been collected to assess weed numbers present at the end of the season and will determine how effective the other management strategies such as different chemical groups and later sowing employed in 2015 were in influencing the overall ryegrass populations in paddocks.

The data collected on this farm throughout 2015 will provide the information needed to be able to simulate (through RIM) the ryegrass population dynamics on LEP, and then allow for a number of management strategies, such as herbicide applications, crop rotation, weed seed capture and others, to be evaluated to provide growers with options on how best to manage ryegrass into the future.

One of the key findings from the monitoring work conducted in 2015 showed that ryegrass populations were lower than expected and strongly influenced by differences in soil type. This may mean that ryegrass could be managed better if methods (involving precision agriculture) can be developed to map and manage soil types differently.

References

Preston C., Boutsalis P., Kleemann S., Saini R. and Gill G., 2015, *GRDC Grains Research Update,* Adelaide, p175-178.

Storrie A.M. (ed), 2014, *Integrated Weed Management in Australian Cropping Systems*, GRDC.

Boutsalis, P., Kleemann, S., Fleet B., Gill G., and Preston, C., 2015, *Weed restistance on Eyre Peninsula in 2014, Minnipa Agricultural Centre Field Day 2015,* p18-21.

Acknowledgements

A big thank you to Sue Budarick for establishing and managing the weed germination trays. This work has been funded by the EP Rail Levy and GRDC Maintaining profitability in retained stubble systems project - upper Eyre Peninsula, EPF00001.

Seeding rate by row spacing for barley grass management

RESEARCH

Amanda Cook, Wade Shepperd, Ian Richter, and Nigel Wilhelm
SARDI, Minnipa Agricultural Centre

Searching for answers

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: 3.0 t/ha (W)
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

Key messages

- **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.**

Why do the trial?

Controlling barley grass in upper Eyre Peninsula (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 DAP (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.

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).

Figure 1 Left, 30 cm (12") ribbon @ 60 plants/m² and right, 18 cm (7") ribbon at 240 plants/m².

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/m²	Row spacing (cm)	Early Barley grass (plants/m²)	Early Rye grass (plants/m²)	LAI (umols)	Late grass weeds DM (t/ha)	Late Barley grass (plants/m²)	Late Ryegrass (plants/m²)	Late Wild oats (plants/m²)
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*

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/m²	Row spacing (cm)	Plant establishment (plants/m²)	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*

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 PreDictaB™ 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.

The initial barley grass weed pressure within the trial area was much lower than expected with all plots having less than 10 plants/m². 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/m². 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.

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).

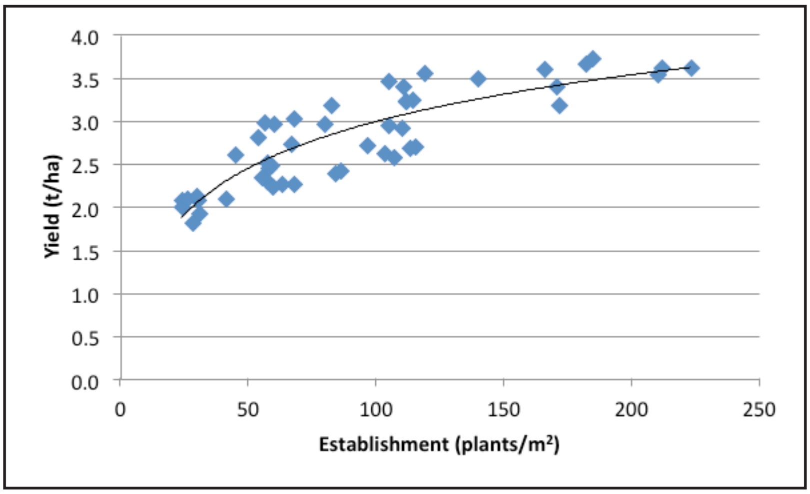


Figure 2 Plant establishment and grain yield at Minnipa in 2015.

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).

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.

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.

In the 2015 season the 18 cm (7”) systems showed better plant establishment in drier seeding conditions 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).

Registered products: see chemical trademark list.

Row orientation and weed competition

Amanda Cook, Nigel Wilhelm, Wade Shepperd and Ian Richter
SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

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: 3.0 t/ha (W)
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

Key messages

- **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. 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.**

Why do the trial?

Controlling barley grass in upper Eyre Peninsula (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 the 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, *et. al.*, 2015).

A trial was established at Minnipa Agricultural Centre (MAC) 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 MAC 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 were counts taken on 26 June.

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	9.8	6.9
	30	156	45.9	4.64	2.33	9.9	6.3
LSD (P=0.05)		*9*	*2.8*	*0.30*	*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*

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 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 oats were very low in numbers and did not affect the trial results (data not presented).

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%*

What does this mean?

These results support previous trial work at Minnipa Agricultural Centre (Cook, *et. al.*, 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 no 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).

GRDC Grains Research & Development Corporation
Your GRDC working with you

EPARF EYRE PENINSULA Agricultural Research Foundation

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Overdependence on agrochemicals – UNFS barley grass trial

Barry Mudge
Barry Mudge Consulting for Upper North Farming Systems

Searching for answers

Location:
Port Germein
Chris and Graham Pole
Upper North Farming Systems
Rainfall
Av. Annual: 326 mm
Av. GSR: 227 mm
2015 Total: 307 mm
2015 GSR: 211 mm
Yield
Potential: 2.7 t/ha (W) (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
21 m x 1.8 m x 4 reps
Yield Limiting Factors
Dry period post seeding, grassy weeds, low N nutrition, root disease?

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 carryover. One of the purposes of this trial is to provide background information for modelling barley grass carryover 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 (CWF00020).

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 rainfall 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 broad leaved weed spray was used across all treatments to remove any competition effects from broad leaved 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 carryover. 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.

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

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 (Table 1).

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 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 higher in the non-herbicide treated plots. At tillering stage, there was no difference in weed numbers or biomass between the sowing rate treatments.

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 difference in the quality of grain between the various treatments, although weed seed numbers in the non-herbicide treated plots were visually greater.

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/m²)	81	140	125	*20*
Barley grass (plants/m²)	41	42	6	*8*
Ryegrass (plants/m²)	30	26	9	*8*
Total weeds (plants/m²)	71	68	15	*19*
Tillering				
Crop biomass (g/m²)	111.3	118.9	130.7	*21.1*
Weed biomass (g/m²)	29.5	25.1	4.5	*9.8*
Total weeds (plants/m²)	156	162	33	*55*
Total weed tillers (number)	515	502	96	*188*
Anthesis				
Crop biomass (g/m²)	546	497	646	*68*
Weed biomass (g/m²)	126.6	112.5	20.1	*12.7*
Total weed panicles (number)	193	195	53	*28*
Harvest				
Crop yield (t/ha)	1.56	1.56	2.07	*0.15*
Test weight (kg/hL)	79.9	80.1	80.1	*ns*
Screenings (%)	2.1	2.9	2.7	*0.55*

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.

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 m² 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/m² present at tillering (compared with the herbicide-treated plots and at the high seeding rate).

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

At the higher seeding rate of 80 kg/ha (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.

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 (g/m^2)	108.3	124.5	136.2	*18.0*
Weed biomass (g/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 (g/m^2)	637	718	796	*55*
Weed biomass (g/m^2)	98.7	69.0	11.2	*34*
Total weed panicles (number)	154	114	23	*34*
Harvest				
Crop yield (t/ha)	2.83	3.03	3.50	*0.18*
Test weight (kg/hL)	65.1	65.6	64.8	*ns*
Screenings	2.1	1.6	2.2	*ns*

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 (g/m^2)	127.4	134.6	135.8	*ns*
Weed biomass (g/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 (g/m^2)	634	653	646	*ns*
Weed biomass (g/m^2)	79.8	57.1	11.5	*18*
Total weed panicles (number)	137	105	28	*45*
Harvest				
Crop yield (t/ha)	2.54	2.56	3.07	*0.18*
Test weight (kg/hL)	69.2	67.1	69.9	*ns*
Screenings	2.2	3.3	2.1	*ns*

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=0.05)***
Tillering				
Crop biomass (g/m²)	29.2	20.8	24.3	*ns*
Total weed tillers (number)	515	501	442	*ns*
Anthesis				
Weed biomass (g/m²)	126.6	98.7	79.8	*30.2*
Total weed panicles (number)	193	154	137	*ns*

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=0.05)***
Tillering				
Crop biomass (g/m²)	25.1	13.3	13.3	*6.4*
Total weed tillers (number)	502	315	356	*137*
Anthesis				
Weed biomass (g/m²)	112.5	69.0	57.0	*31.9*
Total weed panicles (number)	195	114	105	*58*

There was no clear difference 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 carryover 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 carryover 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 carryover 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 the project Overdependence on Agrochemicals (CWF00020).

Registered products: see chemical trademark list.

Managing clethodim-resistant ryegrass in canola

RESEARCH

Sam Kleemann, Peter Boutsalis, Rupinder Saini, Gurjeet Gill and Chris Preston
School of Agriculture, Food & Wine, University of Adelaide

Searching for answers

Location:
Roseworthy, SA
Rainfall
Av. Annual: 445 mm
Av. GSR: 330 mm
Total: 470 mm (2014), 349 mm (2015)
GSR: 311 mm (2014), 241 (2015)
Soil Type
Sandy loam over medium calcareous clay - Red brown earth

Key messages

- **Resistance to clethodim in annual ryegrass is increasing in South Australia and makes it difficult to control in canola.**
- **Pre-emergent herbicides alone are insufficient to effectively manage ryegrass in canola.**
- **Hybrid cultivars of canola are far more competitive and used with effective pre-emergent herbicides can assist ryegrass management.**
- **Crop-topping and windrow burning in canola offer an opportunity to reduce ryegrass seed set.**

Why do the trial?

There is increasing prevalence of annual ryegrass with resistance to clethodim (Select) across southern Australia. A survey of herbicide-resistant weeds undertaken across the EP in 2014 identified ryegrass resistant to clethodim in the south but not the north (Table 1; Boutsalis 2015). Resistance to several herbicides was greater in the south because of increased prevalence of ryegrass and heavier reliance on cropping.

The loss of clethodim is making management of ryegrass far more difficult in break crops where traditionally growers expect greatest control. In an effort to achieve acceptable control, higher rates of clethodim (≥500 ml/ha) have become widespread industry practice; however the sustainability of this approach is being questioned with reports of crop damage in canola. As a consequence growers are reluctant to use higher rates in canola and are finding it increasingly more difficult to control in this important crop phase. In addition, the legacy effect of more ryegrass in the following wheat phase is placing greater selection pressure on our new pre-emergent herbicides, with resistance now confirmed to Avadex Xtra (triallate) and Boxer Gold (prosulfocarb + S-metolachlor; Table 1).

Here we report results from trials undertaken at Roseworthy to evaluate alternative approaches for the control of clethodim-resistant ryegrass in canola.

How was it done?

Roseworthy herbicide evaluation trial, 2014

At Roseworthy, a field trial was carried out during 2014 to evaluate the performance of pre-emergent and post-emergent herbicide options for the control of clethodim-resistant ryegrass in triazine tolerant (TT) and Clearfield (CLF) hybrid canola. Annual ryegrass seedlings of the field population were sampled at 1-2 leaf growth stage and screened for resistance to clethodim (Select) and butroxydim (Factor).

Herbicide treatments were developed for experimental purposes only and several are not registered (identified as Products A, D, E in Table 3).

Table 1 Annual ryegrass populations resistant to herbicides for the Eyre Peninsula survey in 2014. Populations are considered resistant if 20% of individuals survived the herbicide. *Source: Peter Boutsalis GRDC project CSU00020.*

Herbicide	Southern EP	Northern EP
	Populations resistant (% tested)	
Trifluralin	51	10
Propyzamide	0	0
Sakura	0	0
Avadex Xtra	3	0
Boxer Gold	1	0
Diclofop-methyl (Hoegrass)	73	10
Axial	32	0
Clethodim	7	0
Intervix	53	39

Table 2 Crop management and herbicide application details for Roseworthy trials in 2014 and 2015.

Crop details and herbicide management	
Herbicide evaluation (2014)	
Canola cultivars	TT-ATR Stingray & CLF-45Y82
Sowing date	23 May
Sowing rate (kg/ha)	3
Herbicide application timing	22 May (IBS), 23 May (PSPE) & 2 July (POST)
Crop suppression & herbicides (2015)	
Canola cultivars	TT-ATR Stingray, Hyola 559TT & Hyola 750TT
Sowing date	14 May
Target density (plants/m²)	35
Herbicide application timing	14 May (IBS) & 17 July (POST)

Roseworthy crop suppression × herbicides trial, 2015

In addition a trial was undertaken at Roseworthy in 2015 comparing different TT-canola cultivars in their ability to suppress ryegrass seed production in combination with per-emergent herbicides. The trial evaluated three TT-canola cultivars: ATR-Stingray (open-pollinated); Hyola 559TT (a hybrid); and Hyola 750TT (a high biomass hybrid). There were three herbicide management strategies; no herbicide (untreated control); atrazine (1.5 kg/ha) IBS + clethodim (500 mL/ha) POST; and propyzamide (Rustler @ 1 L/ha) IBS + clethodim (500 ml/ha) + butroxydim (80 g/ha) + atrazine (1.1 kg/ha) POST. Sowing rate was adjusted according to seed size (1000 grain weight) to achieve similar target density for cultivars (35 plants/m²).

A standard knife-point press wheel system was used to sow the trials on 25 cm row spacings. Sowing and fertiliser rates were undertaken as per district practice (Table 2). Pre-sowing herbicides were applied within a few hours of being incorporated by sowing (IBS), post-sowing pre-emergent (PSPE) applications were applied the following day after sowing, before emergence (results are not presented) and post-emergent (POST) treatments were applied when the ryegrass had reached the 3-4 leaf growth stage.

Assessments included control of annual ryegrass (reduction in plant density and seed set), crop safety and yield.

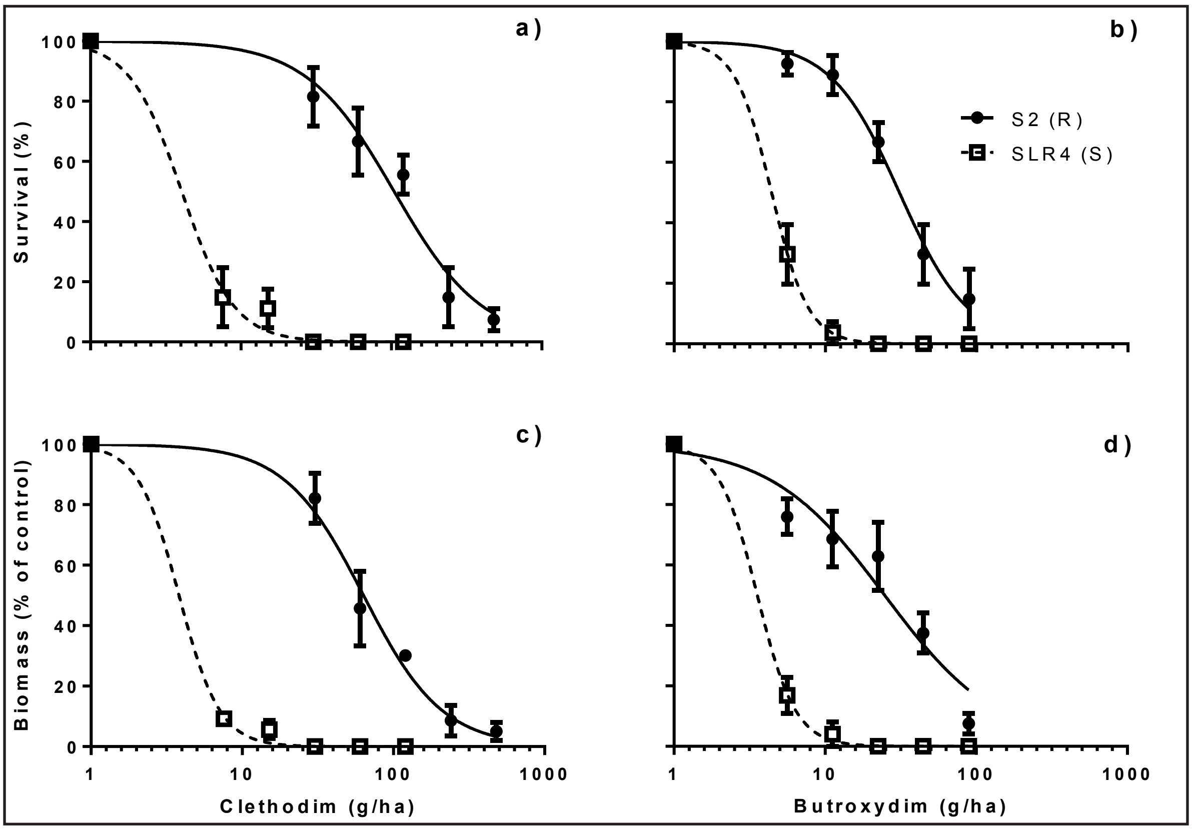


Figure 1 (a, b) Survival and (c, d) biomass (% of control) of resistant (●, S2) and susceptible (❑, SLR4) ryegrass biotypes to clethodim (Select) and butroxydim (Factor) at Roseworthy, SA. Bars are standard errors of the mean.

What happened?

Herbicide screening showed the Roseworthy field population of annual ryegrass (S2) to be resistant to clethodim and butroxydim (Figure 1). The rate of clethodim required for 50% reduction in survival (LD50) and biomass (GR50) was more than 26-fold and 17-fold higher for resistant S2 population when compared with the susceptible control (SLR4).

The susceptible population was easily controlled with butroxydim, whereas the resistant S2 population required 7-fold more herbicide to obtain equivalent control.

Not surprisingly clethodim struggled to effectively control the field population (S2) in TT-canola during 2014 (Table 3). Propyzamide (Rustler) was the best of the stand-alone pre-emergent herbicide options examined, although weeds that emerged through this treatment were highly competitive and reduced yield. Addition of clethodim to propyzamide tended to stunt these weeds and reduced their competitiveness. The reduced rate of butroxydim (80 g/ha), which can be used in canola, compared with pulse crops (160 g/ha), makes this product less effective on ryegrass with low levels of butroxydim resistance.

Pre-emergent herbicides performed better in the CLF canola than in the open-pollinated TT-canola due to increased competition provided by the CLF hybrid (Table 4). However, ryegrass has widespread resistance to the imidazolinone herbicides and this was evident at Roseworthy, as was some resistance to trifluralin. This limited the options available for controlling ryegrass in CLF canola. Propyzamide applied PRE with clethodim POST was one of the better treatments despite resistance to clethodim being present. None of the experimental herbicides evaluated (Products A, D & E) were overly effective against ryegrass as either standalone or as mixtures applied PRE or POST.

Table 3 Ryegrass plant numbers, seed production and grain yield for TT-canola at Roseworthy, 2014, following herbicide treatments to control clethodim-resistant ryegrass.

Treatment		Ryegrass control		Grain yield (t/ha)
IBS	POST	(plants/m²)	(seeds/m²)	
Atrazine (1.5 kg/ha)	Clethodim (500 ml/ha)	522ab	6785a	1.69abc
Atrazine (1.5 kg/ha)	Clethodim (500 ml/ha) + Atrazine (1.5 kg/ha)	361a	2956a	1.88a
Atrazine (1.5 kg/ha)	Clethodim (500 ml/ha) + Butroxydim (80 g/ha)	282a	3274a	1.84ab
Product A		864b	51743cd	1.15de
Propyzamide (1 L/ha)		354a	32781bc	1.49cd
Propyzamide (1 L/ha)	Clethodim (500 ml/ha)	324a	13396ab	1.74abc
Atrazine (1.5 kg/ha)	Product D	876b	62142d	1.00de
Atrazine (1.5 kg/ha)	Product E	308a	10996a	1.61bc
Product E		869b	51192cd	1.26d

Means with different letters within a column are significantly different (P=0.05).

Table 4 Ryegrass plant numbers, seed production and grain yield for CLF-canola at Roseworthy, 2014, following herbicide treatments to control clethodim-resistant ryegrass.

Treatment		Ryegrass control		Grain yield (t/ha)
IBS	POST	(plants/m²)	(seeds/m²)	
Trifluralin (2 L/ha) + Avadex X (2 L/ha)	Intervix (570 ml/ha) + clethodim (500 ml/ha)	632ab	5404a	1.71abc
Trifluralin (2 L/ha) + Avadex X (2 L/ha)	Intervix (570 ml/ha) + clethodim (500 ml/ha) + Butroxydim (80 g/ha)	128a	7915a	1.79a
Product A		1697d	54347d	1.41bcd
Propyzamide (1 L/ha)		553ab	17270ab	1.65abcd
Propyzamide (1 L/ha)	Clethodim (500 ml/ha)	385ab	3663a	1.84a
Trifluralin (2 L/ha)	Product D	1206cd	33299a	1.44bcd
Trifluralin (2 L/ha)	Product E	589ab	28159bc	1.61abcd
Product E		1643d	27107bc	1.36d

Means with different letters within a column are significantly different (P=0.05).

Weeds

Table 5 Influence of canola cultivar and herbicide treatment on seed set of clethodim-resistant ryegrass at Roseworthy in 2015.

Herbicide treatment	**ATR-Stingray**	**Hyola 559TT**	**Hyola 750TT**	
	Ryegrass seed heads (spikes/m²)			**Mean**
No herbicide (untreated control)	890	767	576	**744a**
Atrazine pre + clethodim post	148	63	72	**94b**
Propyzamide pre + clethodim + butroxydim + atrazine post	95	65	49	**70b**
mean	**378a**	**298b**	**232b**	
Interaction	0.35			
Cultivar	<0.001			
Herbicide treatment	<0.001			

Means with different letters within a column are significantly different (P=0.05).

Enhanced competitiveness of hybrid canola against ryegrass was further validated by a suppression trial undertaken at Roseworthy in 2015. Both the standard hybrid (Hyola 559TT) and high biomass canola (Hyola 750TT) were far more effective at reducing seed set of ryegrass relative to ATR-Stingray (Table 5). Simply changing from an open-pollinated to a hybrid canola variety resulted in as much as a 50% reduction in ryegrass seed set. Propyzamide followed by clethodim plus butroxydim in combination with competitive hybrids (Hyola 559TT and Hyola 750TT) resulted in the lowest number of ryegrass spikes at harvest (49-65 spikes/m²). In contrast, there was twice the number of ryegrass spikes (95 spikes/m²) for the same herbicide treatment but with the far less competitive cultivar ATR-Stingray.

Although there were clear and significant differences in weed control between herbicide treatments and cultivars, canola yields were subdued by the hot and dry spring conditions. The early finish to the season did not suit the longer season cultivars and Hyola 750TT was affected by frost. The effects of herbicide treatment ($P<0.001$) and cultivar ($P<0.042$) were significant on canola yield, but the highest yield was only 1.17 t/ha for Hyola 559TT treated with propyzamide and mixture of clethodim plus butroxydim and atrazine.

What does this mean?

Currently there are no effective herbicides to control clethodim-resistant ryegrass in canola. Therefore, the most effective strategy is to start with an effective pre-emergent herbicide and then use clethodim and butroxydim to stunt any ryegrass present in the crop. These weakened survivors are much more vulnerable to competition and growing a more competitive hybrid canola cultivar will further improve the efficacy of the pre-emergent herbicides.

Alternative practices will have to be adopted in canola to manage ryegrass in the rotation. The most effective of these at present are crop-topping with glyphosate (Weedmaster DST) and windrow burning. It is essential to use one of these strategies where clethodim-resistant ryegrass is present.

Acknowledgements

This research was funded by the GRDC (Projects UA00144 & CSU00020). We also wish to thank PacSeeds for providing the canola seed, and staff from UA Malinee Thongmee and Ben Fleet for providing technical support.

Registered products: see chemical trademark list.

Onion weed control in medic pastures – a herbicide evaluation

Andy Bates[1] **and Brian Dzoma**[2]

[1]Bates Agricultural Consulting; [2]SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

Location:
Kyancutta
Brett and Natasha O'Brien
Rainfall
Av. Annual: 316 mm
Av. GSR: 248 mm
2015 Total: 278 mm
2015 GSR: 253 mm
Yield
Actual: Medic dry matter on 24 August up to 3.2 t/ha
Paddock History
2014: Axe
2013: Medic
Soil Type
Sandy loam
Plot Size
6 m x 1.5 m x 3 reps
Yield Limiting Factors
Nil

Key messages

- **Onion weed is a significant pest and competitor of medic pastures. In mixed farming systems, control in the pasture phase is often reliant on cultivation.**
- **None of the herbicides evaluated in this trial provided adequate onion weed control in the medic pasture phase without unacceptable reduction in medic biomass.**
- **The use of non-selective herbicides and their mixes, combined with strategic cultivation if required, is still the most effective short term strategy in reducing the impact of onion weed on crop/pasture systems on Eyre Peninsula (EP).**

Why do the trial?

Onion weed (*Asphodelus fistulosusis*) is a significant pest of crops and pastures on many soil types on upper EP. Onion weed that germinates in the pasture phase often results in thick stands of large plants that require repeated herbicide application and/or cultivation to control prior to a crop phase. Cultivation prior to sowing is a widespread practice to control the weed and reduce the residues to manageable levels. However, cultivation can expose the soil to erosion.

Onion weed in pastures regularly sets seed prior to the end of the growing season, ensuring the seed bank is replenished and the weed persists in every phase of the rotation. A key strategy to reduce the impact of onion weed, and the need for cultivation, is to reduce growth and seed set in the pasture phase of the rotation. Non-selective herbicides can control actively growing onion weed plants, but pasture growth is also affected.

Previous trials by the UNFS group, MDB NRM, and PIRSA have shown the following herbicides can provide adequate control of onion weed in non-selective situations:

- Paraquat and double knocks of paraquat
- Glyphosate plus metsulfuron methyl mixtures (+/- paraquat second knock)
- Glyphosate plus LVE ester 2,4-D plus metsulfuron methyl,(+/- paraquat second knock)
- Chlorsulfuron
- Spray Seed
- Alliance

This trial was established to investigate herbicide control of autumn/winter germinating onion weed in the pasture phase, while maintaining the productivity of the medic pasture. This trial evaluated the herbicide control of young actively growing onion weed in a vigorous medic pasture. The herbicides, with the exception of paraquat, were chosen to minimise the impact on the medic biomass production.

How was it done?

The replicated trial (3 replicates) was established on a sandy loam paddock south of Kyancutta. The paddock was sown to cereal in 2014, and early opening rains encouraged onion weed to emerge in autumn in the following medic phase of the rotation. Medic establishment was also good following the opening rain event. Herbicide treatments were applied to the replicated trial on 29 May 2015 with a tractor mounted 3-point linkage shrouded sprayer (water rate @ 100 L/ha). Most of the onion weed was less than 10 cm high. Onion weed counts were taken from each plot prior to herbicide application and at the end of the trial.

Observations on weed control and effect on the medic growth were recorded 17 days after treatment, 31 days after treatment and 61 days after treatment. Medic dry matter cuts were taken 85 days after treatment.

Table 1 Herbicide treatments applied in 2015 and costs ($/ha).

Herbicide	Active Ingredient	Application Rate	Chemical Group	Approx $/ha
Nail 240EC	240 g/L carfentrazone-ethyl	50 ml/ha	G	8.20
Ecopar	20 g/L pyraflufen-ethyl	600 ml/ha plus BS1000	G	25.05
Ecopar plus MCPA Agritone 750	20 g/L pyraflufen-ethyl	400 ml/ha	G	19.17
	750 g/L MCPA	330 ml/ha	I	
Brodal Options	500 g/L diflufenican	150 ml/ha	F	6.60
Bromicide 200	200 g/L bromoxynil	1.4 L/ha	C	26.60
Agtryne MA	275 g/L terbutryn	500 ml/ha	C	6.75
	150 g/L MCPA		I	
Buttress	500 g/L 2,4-DB	2 L/ha	I	38.00
Buttress	500 g/L 2,4-DB	3 L/ha	I	57.00
Raptor WG	700 g/kg imazamox	45 g/ha plus BS1000	B	37.20
Kyte 700 WG	700 g/kg imazethapyr	70 g/ha plus BS1000	B	8.20
BroadSword	800 g/kg flumetsulam	25 g/ha plus BS1000	B	13.13
Gramoxone	250 g/L paraquat	600 ml/ha	L	3.36

What happened?

Most herbicide treatments caused some early visual effect on the onion weed, but physical symptoms had diminished by the time of the third assessment, 61 days after treatment. The Gramoxone treatment was the only herbicide that resulted in commercially adequate control of onion weed for the whole season. Even though a "relatively low" herbicide rate was applied, the level of onion weed control was high at 95% (Figure 1).

Bromicide 200, Buttress (2 L/ha), Broadsword and Kyte all provided better weed control than the control (Figure 1), but levels of control were below that considered commercially acceptable (range of 25-38% control). None of the other treatments performed statistically better than the control.

Early medic growth was reduced, especially where Gramoxone, Ecopar + MCPA, Bromicide, Agtryne MA and Nail were applied, but the visual effect reduced as the season progressed. Dry matter cuts (taken mid flowering/ early podding) showed that the Gramoxone treatment significantly reduced medic biomass by 46% of the control (Figure 2), and was the only treatment that was significantly different from the control ($P<0.003$).

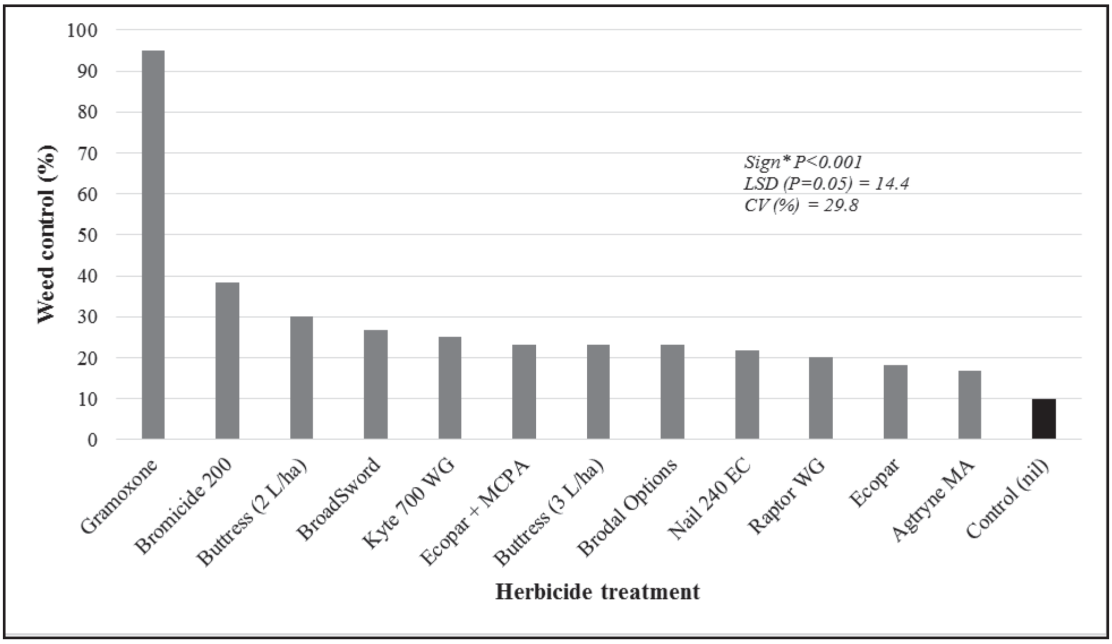


Figure 1 Weed control (%) at Kyancutta in 2015.

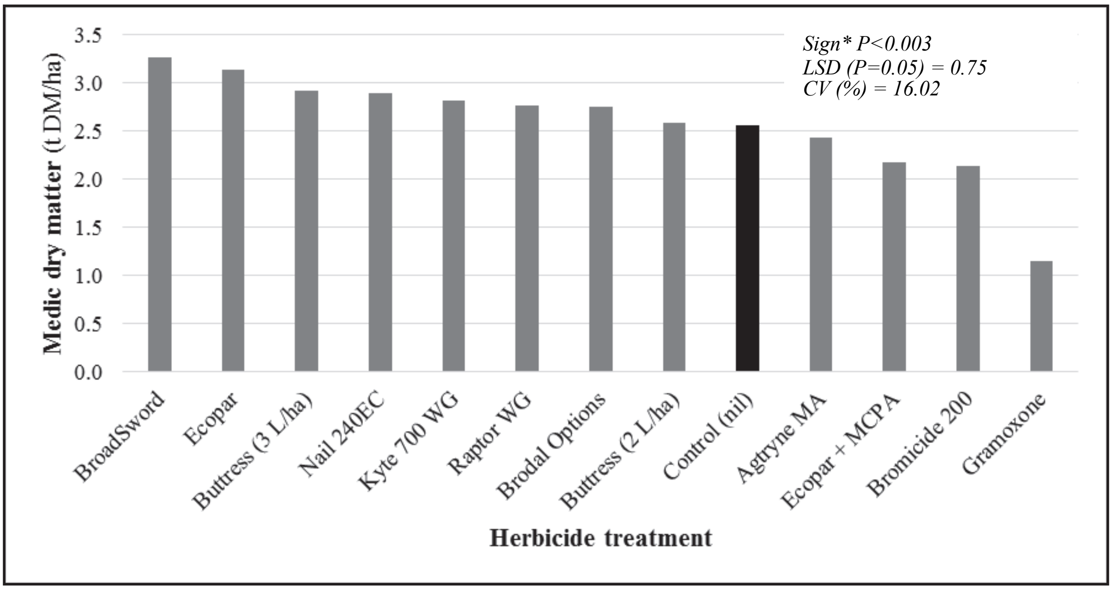


Figure 2 Medic dry matter (tDM/ha) following herbicide treatments in 2015.

What does this mean?

Gramoxone provided the best season-long onion weed control (95%), but also had the largest impact on medic biomass. The use of Gramoxone to control onion weed after the break of the season is risky as pasture quantity, and groundcover levels can be reduced and erosion risk increased on sandy soils. No other herbicide tested provided acceptable control of young actively growing onion weed.

By the end of the growing season, the Gramoxone treatment was the only herbicide that had a significant impact on medic biomass production when compared with the nil treatment. Some other treatments had an early impact on medic health and growth, but biomass had largely recovered by the time of final biomass cuts.

The selective control or suppression of onion weed in medic pasture appears difficult to obtain with the herbicides used in this trial. At this stage, the strategy of non-selective herbicide application after the medic has set seed, again if required in summer, and in autumn prior to sowing, appears to be the practice that helps minimise some seed set, preserve ground cover in the pasture phase of the rotation, and minimise erosion risk.

Further investigations into alternative herbicide application techniques are planned to minimise the role of cultivation in onion weed control.

Acknowledgements

Thanks to Tash and Brett O'Brien for the use of their property. This trial was funded by the EPNRM Board through the National Landcare Program. Trial Products were supplied by Bayer Crop Science (Brodal Options), Nufarm (MCPA Agritone 750ai, Kyte 700 WG, BroadSword, Buttress, Bromicide 200), Crop Care (Alliance, Agtryne MA, Nail 240, Raptor WG), Syngenta (Gramoxone 250), Sipcam (Ecopar).

Registered products: see chemical trademark list.

Section 6

Section Editor:
Jessica Crettenden
SARDI, Minnipa Agricultural Centre

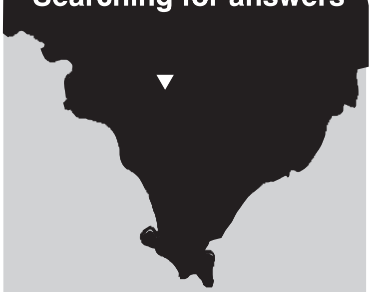
Livestock

Reducing sheep methane emissions through improved forage quality on mixed farms

RESEARCH

Brian Dzoma[1], Gonzalo Mata[2] and Andrew Toovey[2]
[1]SARDI, Minnipa Agricultural Centre; [2]CSIRO Agriculture, Perth, WA

Searching for answers



Location: Minnipa Ag Centre
Rainfall
Av Annual: 325 mm
Av GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Livestock
Enterprise type: Mixed cropping and livestock
Type of stock/breed: Merino sheep

Key messages

- **For the 3 phases of methane measurement reported, methane emission intensity (L CH4/hr/100g ADWG) was significantly lower for lambs on a better quality forage with high metabolisable energy, digestibility and crude protein.**
- **Feedlotting is an option that gives producers the flexibility to finish lambs when pasture availability is limited or light soils are at risk of erosion.**
- **Spray-topping cereal crops is a good management strategy for weed control and feed management for livestock, however, livestock productivity gains can be compromised when spray-topped cereals are grazed without offering lambs better quality fodder supplements.**

How was it done?

Trial details, forage intake and liveweight data from the 2014 winter and spring (Phases 2 and 3) are presented in the EPFS Summary 2014, p175-178.

The 2015 winter trial involved evaluating the performance of animals in a feedlot as opposed to a grazing system. The feedlot option was chosen as 'normal farm practice' for nutritional management of animals and protection soils at risk of wind erosion through overgrazing during key times of the year. The trial commenced on 12 May 2015 with a 100 merino lambs (July 2014 drop) placed in feedlots on two treatments (slow growth diet and a fast growth diet, Table 1). Hay was offered to the lambs ad lib, in hay rings and grain was fed through lick feeders. The lambs, with an average liveweight (LW) of 44 kg, were split into two groups of 50 animals, with each group further split into two replicates of 25 lambs per feedlot, of which 20 were randomly selected for methane measurements in the polytunnel.

The 2015 spring trial involved evaluating the performance of lambs on green forage (lucerne, supplemented by medic hay), a mature forage oats crop and a spray-topped forage oats crop. The grazing trial commenced on 27 October 2015 with 180 merino lambs (July 2015 drop) with an average LW of 30 kg, split into groups of 60 lambs per treatment, with each group further split into two replicates of 30 lambs, of which 25 were randomly selected for methane measurements in the polytunnel.

After a total of 30 days on the treatments, methane measurements were conducted in conjunction with CSIRO (WA) staff and their mobile polytunnel, starting on 10 June 2015 and 25 November 2015 for the winter and spring trials respectively. During the measurement days, lambs from each replicate were moved into the polytunnel for three hours of gas sampling. After exiting the polytunnel, the lambs were put in the yards for an overnight fast and weighed the following morning to get their final LW measurement.

What happened?

Dry matter intake and liveweight gains

The lambs on the 'fast growth' 2015 winter feedlot treatment consumed 1.84 kg versus 1.74 kg DM/head/day on the 'slow growth' treatment (Table 2). There was about 25% wastage of the grass pasture hay mainly because the lambs were being selective on the poor quality hay offered, but it did not affect total intake at the end of the 30 day trial.

Table 1 Treatment details, fodder/pasture quality and availability at the start of the grazing period.

	Treatment	Diet		Food on offer (kg DM/ha)	Dry matter (%)	Crude protein (% DM)	DM* Digestibility (%)	ME** (MJ/kg DM)
Winter 2015 (feedlot)	Slow growth diet	Grass pasture hay, + grain mix of 50% barley and 50% oats	Grass pasture hay	675	90.4	8.5	47.4	6.5
			Barley	360	91.7	14.5	87.5	13.3
			Oats	360	94.3	14.0	76.6	13.8
	Fast growth diet	Medic hay + grain mix of 70% barley and 30% lupins	Medic hay	580	88.0	22.5	66.1	9.8
			Barley	573	91.7	14.5	87.5	13.3
			Lupins	245	92.8	29.2	87.9	14.6
Spring 2015	Lucerne	Lucerne + medic hay	Lucerne	1100	32.6	23.5	67.1	10.1
			Medic hay	250	88.0	22.5	66.1	9.8
	Oats 1	Spraytopped oats	Hay	4600	66.2	4.3	63.3	9.3
			Grain	700	95.4	13.8	81.1	14.2
	Oats 2	Mature unharvested oats	Hay	4420	62.7	4.6	56.8	8.1
			Grain	2100	95.7	10.7	78.6	14.0

**Dry matter, **Metabolisable energy*

Feedlot data (winter 2015) indicated a significant response (P<0.001) in total LW gain and average daily liveweight gain (ADWG) between the two treatments. ADWG for lambs on the 'fast growth' diet was higher (209 g/head/day) than the lambs on the 'slow growth' diet (140 g/head/day) (Figure 1). This was largely attributed to the fact that the 'fast growth' diet (medic hay, lupins and barley) had higher crude protein (CP), digestibility and metabolisable energy (ME).

For the spring 2015 grazing trial, the lambs on the lucerne pasture were also offered medic hay as there was not enough lucerne biomass (approximately 1000 kg DM/ha) to support the lambs for 30 days and it contributed 20% of the total DM intake. Their total DM intake (1.70 kg DM/head/day) was higher than the lambs on the oats treatments (Table 2). The lambs foraging on the spray-topped oats had the lowest DM intake and this was largely attributed to the fact that there wasn't enough grain in the heads and also less bulk than the mature oats crop. Harvest cuts were done from the pasture exclusion cages and the spray-topped oats and the mature oats crop had grain yields of 0.7 t/ha and 2.1 t/ha respectively.

A statistical analysis of LW gain and ADWG for the 2015 spring grazing trial also indicated a significant response (P<0.001) among the three treatments. ADWG for the lambs on lucerne was higher (114 g/head/day) than lambs on the forage oats (Figure 1). Lambs on the forage spray-topped oats lost weight, losing an average of 37 g/head/day, and this was correlated to the low DM intake (1.16 kg DM/head/day) and less grain in the forage offered.

Methane production (Phase 2, 3 & 4)

Phases 2 and 3 (winter and spring 2014) grazing trial data, pasture intake and liveweight gains are summarised in EPFS Summary 2014, p 175-178).

Methane production was calculated over the three-hour period that the sheep were placed in the polytunnel, and the figures provided a comparative estimate of hourly methane emissions between the respective forage treatments. Methane emission intensity, (defined as the amount of methane produced per unit of livestock product), was assessed based on the LW performance of the sheep in their respective treatments and was standardized relative to100 g daily weight gain over the grazing period.

Table 2 Forage intake (kg DM/head/day) for winter (feedlot) and spring (grazing) in 2015.

	Winter 2015 (Feedlot)		Spring 2015		
Forage intake (kg DM/head/day)	**Slow growth**	**Fast growth**	**Lucerne**	**Spray-topped oats**	**Mature unharvested oats**
Hay	0.75	0.81	0.35	0.81	0.95
Grain	0.99	1.03	0	0.35	0.41
Lucerne	0	0	1.35	0	0
Total forage intake	**1.74**	**1.84**	**1.70**	**1.16**	**1.36**

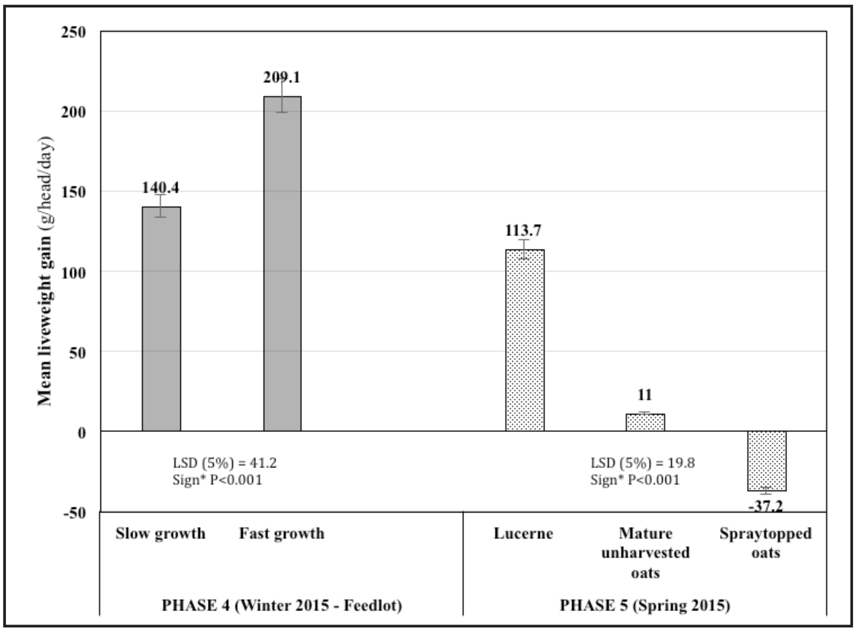


Figure 1 Mean liveweight gains (g/head/day) for winter (feedlot) and spring 2015.

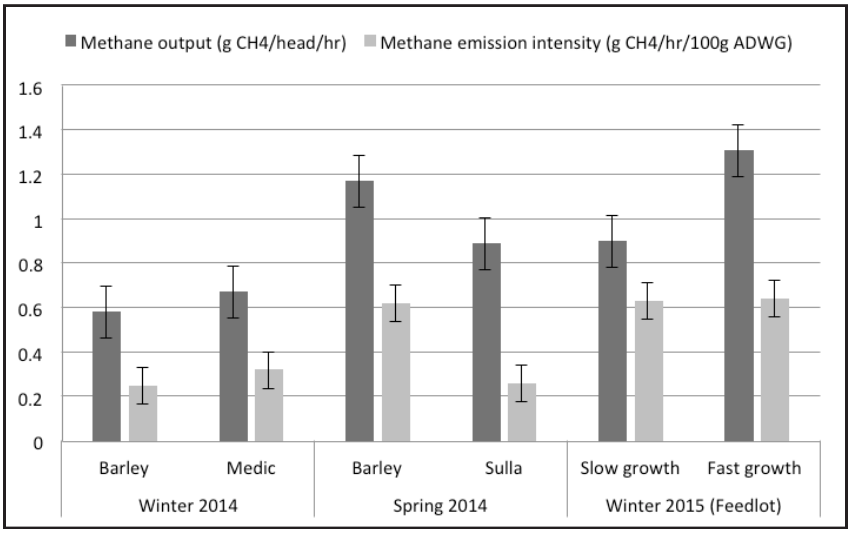


Figure 2 Methane output (g CH4/head/hr) and emission intensity (g CH4/hr/100g ADWG) for Phases 2, 3 and 4.

There was a significant response ($P<0.001$) of methane production (output and intensity) to the forage treatments in all of the phases. In terms of methane output (g CH4/head/hr) the lambs on the medic pasture produced 13% more methane than the ones grazing a young barley crop (Phase 2); lambs on a mature standing unharvested barley crop produced 24% more methane than the ones on sulla (Phase 3); and the lambs in the feedlot on the 'fast growth' diet produced 31% more methane than their counterparts on a 'slow growth' diet (Figure 2). The highest emission intensity (g CH4/hr/100g ADWG) was recorded in the feedlot trial (phase 4) from the 'fast growth' treatment (0.64 g).

Lambs grazing on the young barley crop during winter 2013 had the lowest methane emission intensity (0.25 g) as shown in Figure 2.

What does this mean?

A 30 kg lamb growing at 200 g/day requires 1.3 kg DM/day of forage with 14-16% CP and 10.5-11 ME (MJ/kg DM). As a general rule, the pasture or forage that is optimal for finishing weaned lambs should have a DM digestibility of about 70% and have more than 50% green matter (Jolly, 2006). These requirements are hard to achieve particularly during the late spring, and late autumn feed gaps. For the 2015 spring grazing trial, only the lucerne treatment provided enough CP and ME and therefore proved to be a better option to maximise animal productivity. The lucerne was a poor crop and did not get enough moisture during early spring when it was starting to grow vigorously, therefore opportunities exist to target even higher LW gains when a more productive crop is established. Both oats treatments (mature and spray-topped) had very low CP and ME and therefore can be considered as maintenance forages, unless the lambs are supplemented with higher quality hay (medic, sulla, lucerne) and/or grains (lupins, peas).

Acknowledgements

Thanks to Mark Klante, Brett McEvoy and John Kelsh for managing the livestock and setting up trial infrastructure; Jessica Crettenden for livestock handling and sheep data management, and Roy Latta for his technical expertise. This project is supported by funding from the Australian Government Department of Agriculture – Action on the Ground program (Project Code: AOTGR2-0039 Reducing sheep methane emissions through improved forage quality on mixed farms).

References

Jolly S (2006) *Best practice for production feeding of lambs: a review of the literature.* Meat and Livestock Australia Final Report, Project SCSB.091.

Livestock grazing behaviour in large Mallee paddocks

Michael Moodie[1], Zac Economou[2], Mark Trotter[2], Ali Frischke[3] and James Murray[3]

[1]Mallee Sustainable Farming, VIC, [2]University of New England, NSW, [3]Birchip Cropping Group, VIC

RESEARCH

Try this yourself now

Location:
Nandaly - Brady Farms
Mallee Sustainable Farming and Birchip Cropping Group
Rainfall
Av. Annual: 330 mm
Av GSR: 210 mm
2015 Total: 205 mm
2015 GSR: 130 mm
Soil Type
Light (sand) to heavy (clay loam)
Soil Test
pH ($CaCl_2$): 5.9-7.6
Organic C% (0-10 cm): 0.26-0.77
Colwell P (mg/kg): 16-22
EC 1:5 dS/m (0-120 cm) 0.18-0.49
Livestock
Enterprise type: Self replacing Merino
Stocking rate: Summer 3.7 DSE/ha; Winter 5.6 DSE/ha
Type of stock/breed: Two year old merino ewes

Key messages

- **For the first time sheep grazing behaviour in a Mallee paddock was monitored and mapped using GPS tracking collars.**
- **Sheep grazed the stubble paddock evenly as they sought out spilt grain during the summer fallow, but they preferred to graze on sandy soil types first.**
- **While grazing a vetch pasture in the same paddock, livestock spent 50% of the time grazing only 25% of the paddock and 25% of the paddock was not utilised.**
- **At least $4000 profit was foregone from the paddock through the under-utilisation of the vetch pasture.**
- **Within-paddock fencing technology in large Mallee paddocks has the potential to capture this potential profit by improving feed utilisation.**

Why do the trial?

Livestock are an integral component of Mallee farming systems. However, the integration of cropping and grazing remains a major management challenge, as paddock sizes tend to be large to benefit efficient cropping practices. Furthermore, Mallee paddocks are also characterised by extreme soil variability and these variable soil types support different levels of feed availability and have different susceptibilities to soil erosion. As a result, farmers report that they are not able to utilise all of the feed on offer within a paddock without reducing groundcover below critical levels. In situations in which farmers are forced to extract maximum productivity, soil erosion often results on the most vulnerable soil types such as sand dunes.

Advances in technology such as portable fencing systems and virtual fencing potentially offer a solution to the issue of grazing large Mallee paddocks with high soil variability. However, to effectively design and deploy these innovative grazing techniques, the grazing behaviour of livestock in these paddocks needs to be understood and quantified. This project has begun to address this knowledge gap by quantifying sheep grazing habits in a large Mallee paddock with variable soil types.

How was it done?

A flock of two-year-old merino ewes (approximately 200) was monitored over a summer and winter grazing period during 2015 using Global Positioning System (GPS) tracking collars. Prior to the commencement of grazing, 25 animals within the flock were fitted with UNE Tracker II GPS collars. Livestock monitoring data was supported with on-ground assessment of vegetative soil cover and feed quantity over both grazing periods.

The project was undertaken in a 107 ha paddock near Nandaly in the Victorian Mallee which had a range of soils (deep sands to clay loams) commonly associated with Mallee paddocks. The summer grazing period commenced on 14 January 2015 and concluded on 24 February 2015. The paddock was sown to barley in 2014, and livestock grazed the stubble and grain from lodged heads and grain spilt during harvest. No green plants (volunteer barley or summer weeds) were present when the livestock were introduced into the paddock. The paddock was sown to a vetch pasture in autumn and the flock was re-introduced into the paddock on 28 July 2015. The sheep grazed the paddock until 17 September 2015.

At the conclusion of each grazing period, the collars were removed and the data downloaded from the GPS devices. Data was then analysed for the purpose of quantifying variable grazing pressure. Speed thresholds from behavioural modelling techniques were developed to identify when the sheep were grazing, travelling or camping.

What happened?

Summer grazing

Utilisation of paddock zones (light, moderate and heavy soil types) was compared at 5-day intervals over the summer grazing period (Figure 1). Initially the sheep spent most time grazing the lighter soil types in the paddock before moving on to the other zones. This may suggest preferences for certain zones or soil types before feed became limiting and utilisation of other areas became necessary. By the end of the summer period, paddock utilisation was relatively even.

During summer, grazing speeds and distance travelled were very high as the sheep constantly searched for spilt grain. The amount of spilt grain declined from around 80 kg/ha when the sheep were introduced to approximately 20 kg/ha when they were removed 40 days later. Very little green pick was available during the grazing period and as a result they lost condition over this time. There also appeared to be a change in animal behaviour, with an approximately 5% decrease in daily time spent grazing when spilt grain levels dropped to around 40 kg/ha. There may be some value in using this type of data (assuming it could be delivered in real-time) for managing livestock in stubbles where the feed value of spilt grain is difficult to determine.

There was a very slight decline in groundcover over the summer grazing period, but on average, groundcover levels remained well above critical levels of 50%. There were already some parts of the paddock at 50% when the sheep were introduced and in an ideal system, grazing would have been avoided in these zones to reduce the risk of erosion.

Winter grazing

Grazing intensity was much more spatially variable on the sown vetch pasture in winter than on the cereal stubble in summer. Figure 2 shows that the sheep concentrated grazing on the western end of the paddock during the first 10 days after which paddock utilisation by the livestock slowly increased over time. However, during any 10-day period, livestock spent 50% of the time grazing only 25% of the paddock and a further 25% was not utilised.

Spatially variable grazing led to under-utilisation of pasture on the eastern end of the paddock. Figure 3 shows vetch dry matter accumulation at two of the 29 monitoring locations. On the western edge (site 12), dry matter did not accumulate between the first four monitoring dates, probably because grazing intensity matched pasture growth rate. However, on the eastern end of the paddock (site 16) dry matter accumulated at a consistent rate and when the sheep were removed, approximately 2.5 t/ha vetch still remained. This represents a significant under-utilisation of the feed base with a subsequent loss of potential income from either increased stocking rates or harvest of the excess feed for fodder.

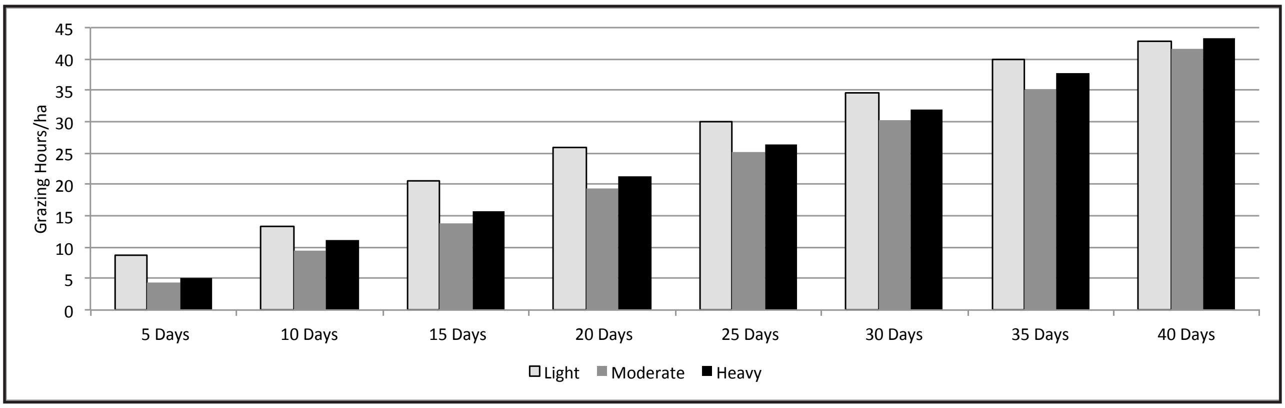


Figure 1 Cumulative utilisation of the three soil type zones (light, moderate, heavy) over the summer grazing period.

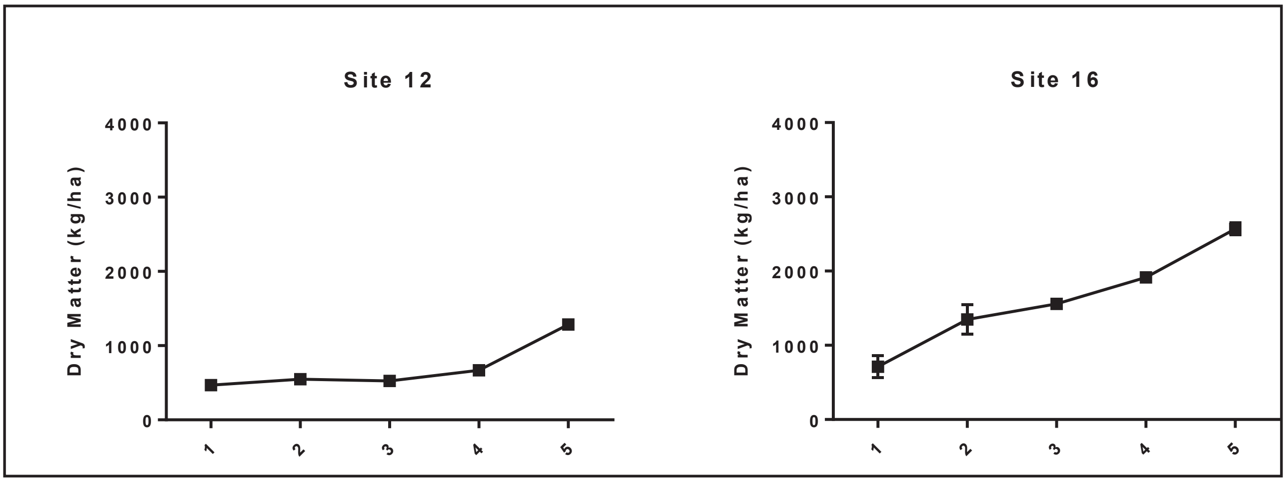


Figure 3 Dry matter accumulation of vetch over the grazing period at monitoring site 12 and 16 which are located on the respective western and eastern ends of the paddock.

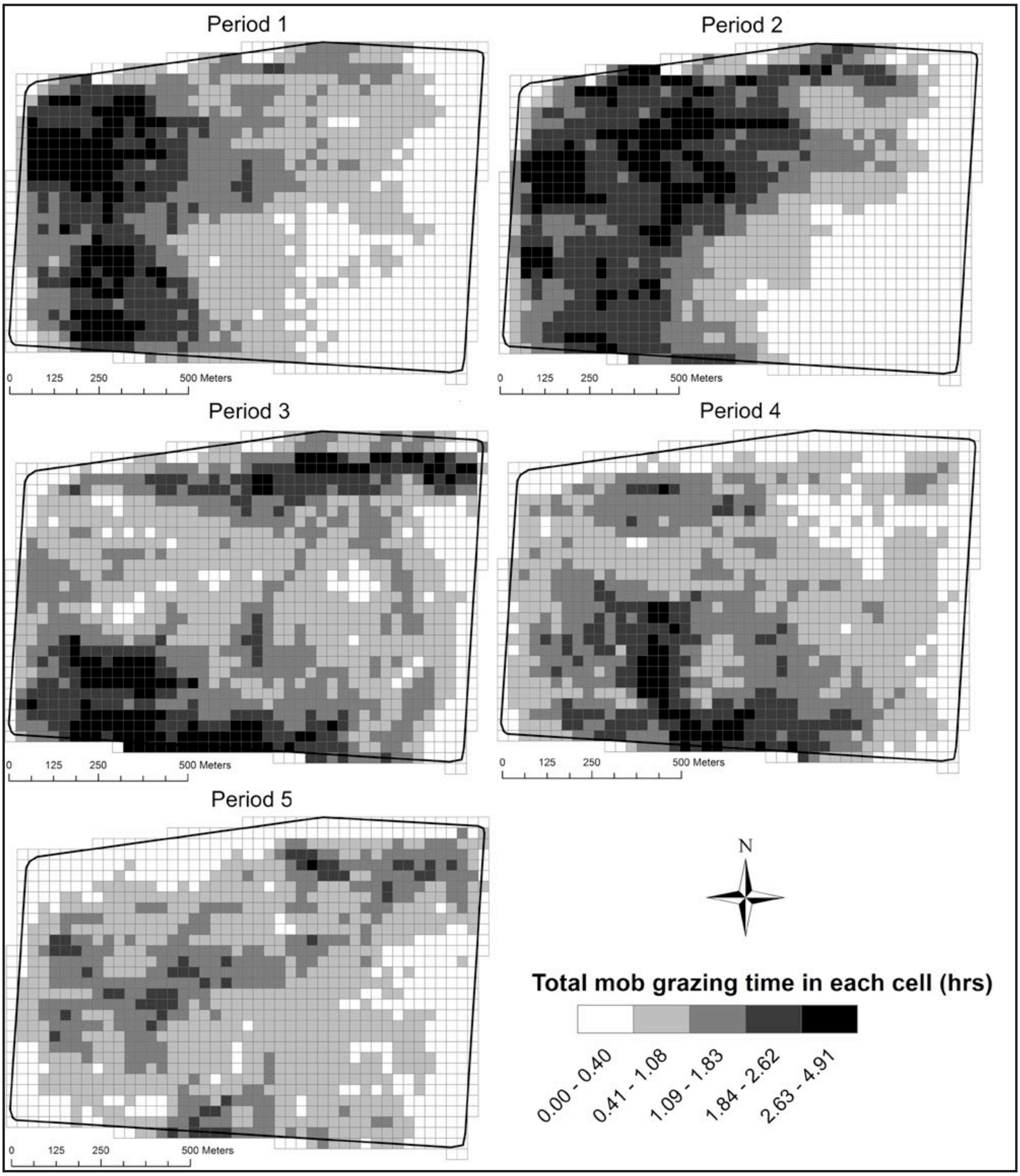


Figure 2 Grazing residency index (hours spent grazing) in 30 x 30 m cells for 10 day intervals over the winter grazing period.

What does this mean?

Farmers already recognise that livestock graze large Mallee paddocks unevenly, but this project began to put some hard numbers on the extent of the variability in spatial paddock utilisation. During summer, when feed was limiting, the paddock was fully utilised, but sheep spent about 40% of their time grazing just 25% of the paddock. This means that large areas were very lightly grazed, with animals travelling long distances across the field.

This contrasted with the winter grazing period in which sheep concentrated 50% of grazing on 25% of the paddock. A further 25% of the paddock was left unutilised which represents a significant economic opportunity foregone that could be addressed using cost-effective within-paddock fencing or virtual fencing. Two hundred ewes with lambs at foot grazed the paddock, or 5.6 dry sheep equivalent (DSE) per hectare. However, as grazing occurred on only 75% of the area, the stocking pressure on the utilised part of the paddock was 7.3 DSE/ha. It is logical that, with improved grazing management an additional 65 ewes with lambs could have been fed. Alternatively, a quarter of the paddock could have been cut for hay. If 1.5 t/ha of vetch hay were cut from 25% of the paddock, an additional $150/ha of profit would have been made on a quarter of the paddock or the equivalent of approximately $4000 additional profit.

Currently there is no easy solution to overcoming the problem of uneven grazing by livestock in large paddocks. Management actions such as moving water points, increasing mob sizes and rotating sheep in and out of paddocks regularly are likely to improve paddock utilisation but will not fully resolve the issue. Rapid fencing systems such as portable electric fencing have been used effectively by some Mallee farmers, but require resources to erect and dismantle. The development of such new technologies as virtual fencing could drastically improve the utilisation of large Mallee paddocks and the data from this project can start making an economic case for investing in more flexible fencing technologies.

Acknowledgements

This project is supported by Mallee Catchment Management Authority, Mallee Sustainable Farming, University of New England and BCG through funding from the Australian Government's National Landcare Programme. GRDC funded Grain & Graze 3 (SFS00028) provided additional support.

Mallee grain and grazing oat evaluation

Alison Frischke[1] and Pamela Zwer[2]
[1]Birchip Cropping Group, Victoria, [2]SARDI, Adelaide

RESEARCH

Try this yourself now

Location:
Berriwillock
Garry and Ash Summerhayes
Rainfall
2015 Total: 241 mm
2015 GSR: 141 mm (decile 1)
Yield
Potential 0.62 t/ha (W)
Actual: average 0.52 t/ha
Paddock History
2014: Wheat
2013: Chickpeas
2012: Barley
Soil Type
Sandy loam
Soil Test
pH($CaCl_2$): 8.9, Colwell P: 15 mg/kg, PBI: 120
Plot Size
1.8 m x 12 m x 4 reps
Yield Limiting Factors
Nil stored soil moisture at sowing, decile 1 season

Key messages

- **There were no feed value differences between grazing-hay varieties. Feed value was low, but still useful feed for ewes with young lambs at that time of year.**
- **There was no difference between varieties in biomass production at anthesis (hay). Biomass was reduced by 15 per cent when grazed.**
- **Yallara and new variety WA02Q302-9 had the greatest dual purpose value. They had higher grain yields and little yield penalty after grazing, providing a degree of flexibility to be able to respond to the season, and manage for livestock and hay or grain markets.**

Why do the trial?

Oats are very versatile and have long been used in Mallee paddock rotations for grazing, hay production and grain for feeding animals, but of late they have not usually been grown for grain value. Oats became more popular in 2015 when attractive contracts for milling oats were offered prior to sowing, largely driven by demand from China.

In 2015 the GRDC Grain & Graze 3 program set out to evaluate a selection of grazing/hay oat varieties. There were no current evaluation trials for oats in the southern Mallee, nor had there been any local evaluation of oat variety response to grazing since 2012 at Corack.

The aim of this trial was to evaluate the grazing value, hay and grain yield of grazing/hay oat varieties in the southern Mallee.

How was it done?

A randomised grazing/hay oat trial was sown by direct-drilling at Berriwillock on 24 April 2015, following 13.4 mm of rain. Varieties included Wintaroo, Mulgara, Brusher, Tungoo, Yallara and WA02Q302-9 (a new variety), and were sown with a target plant density of 200 plants/m^2. Fertiliser applied was Granulock Supreme Z + Impact @ 50 kg/ha at sowing, and later top-dressed with urea at @ 45 kg/ha at GS20 on 9 July.

Varieties used in the grazing/hay trial are normally recommended for May sowing and grain production (rather than early sowing in March-April and grazing potential), but were chosen for their suitability for a low-medium rainfall environment with quick early dry matter production and early-mid growing season length.

Weeds, pests and diseases were controlled to best management practice. Grazing of grazing/hay oat varieties was simulated when the crop was at GS24 (16 July), using a line trimmer to cut the crop to 6 cm high.

Assessments included crop biomass at grazing time and anthesis, as well as grain yield and quality parameters. The trial was harvested on 10 November 2015.

What happened?

Dry seasonal conditions meant that emergence was patchy and early growth was slower than normal. Overall, grain yields for (ungrazed) grazing/hay varieties averaged 0.52 t/ha, compared with 0.76 t/ha for an adjacent milling oat variety trial.

Crop growth was slow so grazing didn't occur until 12 weeks after sowing, just prior to the canopy closing. They were grazed high enough to ensure some green stem and leaf remained to assist with plant recovery, which is important when there is lower rainfall and shorter season length. This meant the amount of feed available was light and variable. There were no differences between varieties (P=ns, CV%=28.2), although feed ranged from 103-175 kg/ha (or 155-263 grazing days) (Figure 1). Despite the lower growth, the grazing value of the oats would still be very useful for ewes with young lambs at that time of year.

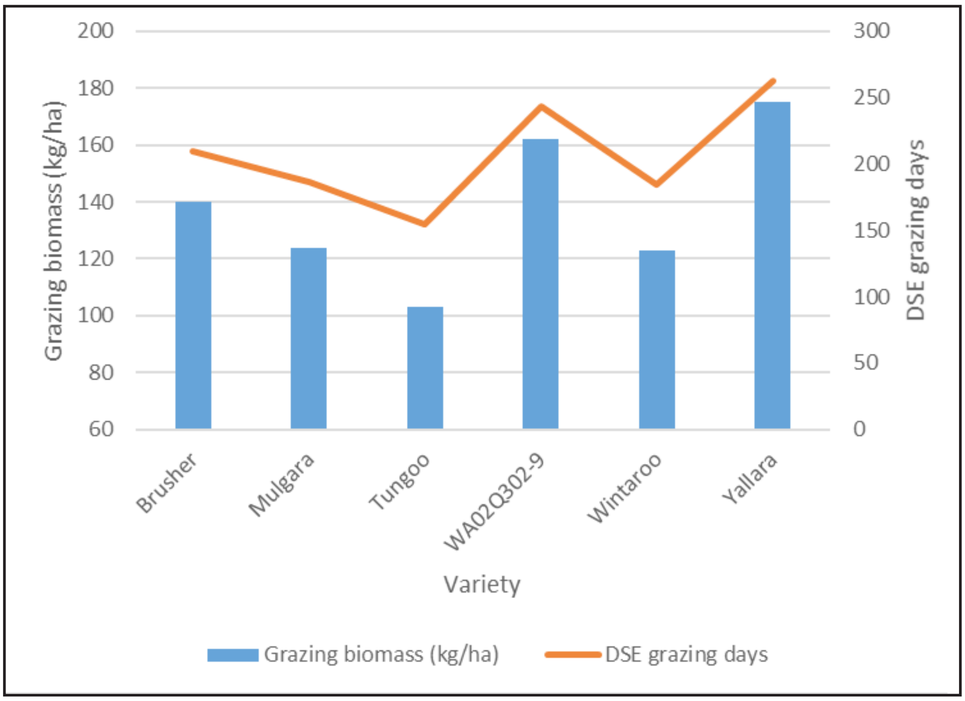


Figure 1 Grazing biomass and DSE grazing days of oat varieties, Berriwillock 2015.

Table 1 Hay and grain value of oat varieties, Berriwillock 2015.

Variety	**Grazing treatment**	**Hay biomass at anthesis (kg/ha)**	**Grain yield (t/ha)**
Brusher	Grazed	1786	0.38
	Ungrazed	2180	0.51
Mulgara	Grazed	1985	0.50
	Ungrazed	2032	0.68
Tungoo	Grazed	1527	0.08
	Ungrazed	2000	0.10
WA02Q302-9	Grazed	1525	0.63
	Ungrazed	2067	0.63
Wintaroo	Grazed	1895	0.31
	Ungrazed	2036	0.49
Yallara	Grazed	1836	0.60
	Ungrazed	2120	0.69
	Significant difference		
	Variety	ns	P<0.001
	Grazing	P<0.001	P<0.001
	Variety x grazing	ns	P=0.003
	LSD (P=0.05)		
	Variety	*235.7*	*0.053*
	Grazing	*136.1*	*0.031*
	Variety x grazing	*333.3*	*0.075*
	CV%	12.1	11.1

Dry seasonal conditions meant that emergence was patchy and early growth was slower than normal. Overall, grain yields for (ungrazed) grazing/hay varieties averaged 0.52 t/ha, compared with 0.76 t/ha for an adjacent milling oat variety trial.

Crop growth was slow so grazing didn't occur until 12 weeks after sowing, just prior to the canopy closing. They were grazed high enough to ensure some green stem and leaf remained to assist with plant recovery, which is important when there is lower rainfall and shorter season length. This meant the amount of feed available was light and variable. There were no differences between varieties (P=ns, CV%=28.2), although feed ranged from 103-175 kg/ha (or 155-263 grazing days) (Figure 1). Despite the lower growth, the grazing value of the oats would still be very useful for ewes with young lambs at that time of year.

There was no difference between varieties in biomass production at anthesis, averaging 2073 kg/ha across ungrazed varieties. Hay biomass was reduced by 15% in grazed oats, averaging 1759 kg/ha of hay - a reduction of 314 kg/ha (Table 1).

Grain yield was highest for Yallara and the new variety WA02Q302-9, followed closely by Mulgara - all early-mid maturing varieties. Tungoo, a mid-late maturing type, suffered with the season and produced the lowest yield.

Grain yield was reduced by grazing, but only by 100 kg/ha. It is common to have smaller grain yield penalties in poorer seasons.

New variety WA02Q302-9 was able to maintain grain yield after grazing, while Brusher, Mulgara and Wintaroo incurred grain yield penalties. Yallara, while losing 90 kg/ha in grain production, was still one of the best grazed varieties.

What does this mean?

Attractive milling oat contracts offered in 2015 meant oats became a favourable option for growers in locations that are higher risk for pulse and oilseed production. Oats generally have lower input costs; with fewer pest threats they do not incur the cost of high pesticide use needed for management of other break crops.

Having two oat varieties (Yallara and new variety WA02Q302-9) express potential for dual purpose use - early winter grazing, and hay and grain production - provides a degree of flexibility to respond to the season at hand and manage for livestock and hay or grain markets.

These varieties are CCN resistant, but CCN intolerant: they will ensure that CCN does not multiply in the paddock, but will be affected if CCN is present. Yallara has leaf rust resistance, but depending on the pathotype could be MR to S for stem rust. However, rust is species specific, so oat rust will not affect wheat or barley.

The National Oat Breeding Program is focusing on releasing oats with added health benefits, including higher fibre beta-glucan levels for lower cholesterol re-absorption such as Mitika. In the future they aim to release varieties with low avenin (gluten protein in oats) which will elevate oat products as an alternative for gluten-free (wheat) diets. This will increase the markets for oats around the world.

Acknowledgements

This research was funded by the GRDC as part of the Grain & Graze 3 project (SFS00028). Grain was provided by the National Oat Breeding Program at SARDI.

The response of lactating and non -lactating ewes to human presence and lamb handling

RESEARCH

Dr. Cameron Ralph[1], Prof. Alan Tilbrook[1] and Jessica Crettenden[2]
[1]SARDI, Roseworthy Campus, [2]SARDI, Minnipa Agricultural Centre

Searching for answers

Location:
Minnipa Agricultural Centre
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Livestock
Enterprise type: Self-replacing sheep
Type of stock/breed: Merino

Key message

- **This study aims to investigate the association between behavioural and physiological stress responses in lactating and non-lactating ewes, which will assist producers and researchers to make better decisions about ewe management and welfare.**

Why do the trial?

Decisions about animal welfare are driven by our understanding of animal emotion and perception. Females perceive events differently when they are lactating and this has major implications for their welfare and for our management decisions. There is a natural state of stress hyporesponsiveness in lactating females and this is important for the wellbeing and mental health of the dam (Slattery and Neumann, 2008) which, in turn, contributes to her maternal behaviour and ability to safely rear the offspring.

Previous studies have shown that isolation and restraint stress does not evoke a stress response (indicated by increased plasma cortisol) in lactating ewes but it does in non-lactating ewes (Ralph and Tilbrook, 2016). Therefore, the response of a ewe to a stressor is likely determined by stage of reproduction and the nature of the stressor. This project will develop information that will enhance this understanding in Merino ewes and will enable producers and researchers to make better decisions about ewe management and welfare.

How was it done?

Three groups of six ewes were selected from a mob of 400 merino ewes to use in the trial. Ewes were selected according to their mothering temperament and their pregnancy and birth status in 2015. The three groups included;

- Group 1 (good mothers): Ewes who were perceived to be ‘good’ mothers were categorised at lambing time when the lamb was caught for measurement at 0-48 hours of age by observing the dam’s temperament. Good mothers were also determined by the health and survival of the lamb. Ewes selected had good records of maternal temperament and rearing lambs within the previous 4 years. All ewes had single lambs.
- Group 2 (poor mothers): Ewes who were perceived to be ‘poor’ mothers were categorised at lambing time by their flightiness nature and abandonment of their lamb when it was caught for measurement at 0-48 hours of age. Generally these lambs were weak and undernourished. Ewes also had a history of being a poor mother and abandoning lambs within the previous 4 years. All ewes had single lambs.
- Group 3 (dry ewes): Dry ewes selected for this group were scanned dry and had not had a lamb in 2015, but had reared a lamb within the previous 4 years.

Maiden ewes were avoided in this trial as they can tend to have a flighty nature with their first lamb and their temperament therefore may not be reflective of usual behaviour, which would have made good or poor mothers difficult to select. The average age of the ewes was 4.3 years at the time of measurement.

Week 1

Ewes were segregated from the main mob when lambs were approximately 8 weeks of age, and fed a specialised ration of sheep nuts, medic hay and lupins that could be supplemented during the trial situation.

Week 2

After a week, the ewes and lambs were put into yards in the shearing shed where they became accustomed to the supplementary feed and new surroundings. They were provided with clean water and ad lib hay every day. The lambs were present in the pens (separated for each treatment group) with their mothers and were able to move about freely and suck without restriction.

Week 3 and 4

To collect sterile blood samples from the ewes, a catheter was inserted into the sheep's jugular vein. Catheter lines were checked daily and flushed out with heparinized sterile saline (50 units/ml). Testing began the day after catheters were inserted.

The experiment was carried out over two days, separated by a week. Different stressors were imposed on all animals on each of the experimental days. One stressor was the presence of a novel human for 2 minutes in the pen, which was repeated every hour on the hour for 4 hours. The other stressor was the removal of the lamb from the pen for 2 minutes, every hour for 4 hours. On each experimental day blood samples (5 ml) were collected every 15 minutes for 6 hours. After 2 hours of sampling, the stressor treatment was imposed for the remaining 4 hours. Once the sample was collected, it was placed into collection tubes. Plasma was harvested from the blood by centrifugation at 4˚C for 10 min at 3000 rpm and stored at -20˚C until assay. Plasma concentrations of cortisol were determined by radioimmunoassay.

At the conclusion of the experiment all ewes and lambs were returned to their normal flock.

What happened?

Differences between cortisol and oxytocin levels from the blood sampling are in the process of being analysed, however initial results indicate that there are differences in the stress response between treatment groups.

What does this mean?

Results from this study will be utilised to understand the association between behavioural and physiological stress responses in lactating and non-lactating ewes. It will provide some insight into the instinctive biological role of the dam to maintain homeostasis and promote survival by protecting her offspring, and will assist producers to recognize the drivers of good maternal temperament. This research will be important for future breeding decisions of sheep flocks and could provide valuable information as to why some ewes are better mothers and can rear more lambs than others.

Acknowledgements

We gratefully acknowledge Dr Kate Plush for her assistance and Mark Klante, John Kelsh, Brian Dzoma, Brett McEvoy, Naomi Scholz and Roanne Scholz for their livestock management and trial coordination support. The project was carried out through in-kind support from SARDI, the SheepCRC and the Grain and Graze 3 project funded by GRDC (SFS00048).

References

Slattery DA, Neumann ID. *No stress please! Mechanisms of stress hyporesponsiveness of the maternal brain*. J Physiol. 2008;586(2):377-385.

Ralph CR, Tilbrook AJ. *The hypothalamo-pituitary-adrenal (HPA) axis in sheep is attenuated during lactation in response to psychosocial and predator stress.* Domestic Animal Endocrinology, 2016, Volume 55, 66 – 73.

Livestock

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Section Editor:
Brian Dzoma
SARDI, Minnipa Agricultural Centre

Section 7

Soils

RESEARCH

Stubble and nutrient management trial to increase soil carbon

Harm van Rees[1], Trent Potter[2], Amanda Cook[3] and Jeff Baldock[4]
[1]CropFacts Pty Ltd, Mandurang; [2]Yeruga Crop Research, Naracoorte; [3]SARDI, Minnipa Agricultural Centre; [4]CSIRO, Adelaide

Searching for answers

Location:
Minnipa Agricultural Centre
Paddock South 2/8
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 2.8 t/ha
Paddock History
2015: Mace wheat
2014: CL Grenade wheat
2013: Mace wheat
2012: Scout wheat
Soil Type
Red sandy loam
Plot Size
12 m x 3 m x 4 reps

Key messages

- **Average trial yield was 2.8 t/ha, approximately 1 t/ha below the nitrogen unlimited potential as identified by Yield Prophet® during the season.**
- **No significant differences in yield were found between stubble treatments (stubble retained, worked or removed) and nutrient treatments (normal practice, normal practice plus additional nutrients to enhance stubble breakdown).**
- **After three years of trial work, no significant differences in soil carbon were found between the stubble and nutrient treatments.**

Why do the trial?

The soil organic matter content of most Australian soils used for crop production is either decreasing or remaining stable. Trials have demonstrated that No-Till stubble retention systems are adding to the partially broken-down particulate organic carbon fraction but are not contributing to the stable humus fraction. Without an increase in soil humus the important functions of soil organic matter (i.e. improved soil water holding capacity, increased nutrient supply (nitrogen and cations), pH buffering capacity and better soil structure) are unlikely to be realised.

What is humus and how can it be increased?

Humus consists of the remains of bacteria and other micro-organisms that consume and break down plant material returned to the soil from a crop or pasture. This plant material consists mainly of carbon (C). For soil microbes to consume this material they also need nitrogen (N), phosphorus (P) and sulphur (S) otherwise they cannot thrive and multiply. Australian soils are inherently low in nutrients and in most soils there is insufficient N, P and S for soil micro-organisms to rapidly break down the plant material returned to the soil. To increase the stable humus fraction of organic carbon in the soil, we need to supply soil microbes with additional N, P and S; this may have to be supplied as extra fertiliser.

How much N, P and S need to be supplied to stubble to form humus?

Dr Clive Kirkby, from CSIRO, has been working on this question and found that:

- In humus 1000 kg of C is balanced with 80 kg N, 20 kg P and 14 kg S.
- Dr Kirkby argues that for soil micro-organisms to breakdown stubble and form humus, we need to add sufficient nutrients (N, P and S) to feed these micro-organisms (Kirkby *et al.* 2011).
- For micro-organisms to efficiently break down wheat stubble to humus additional nutrients have to be added. Wheat stubble has a low nutrient:C ratio and 1 tonne of cereal stubble needs to be balanced with 5.8 kg N, 2.2 kg P and 0.9 kg S.

The DAFF and GRDC funded trial is examining existing, new and alternative strategies for farmers in the cereal sheep zone to increase soil C. The trial will be used as base line data for C accumulation in soils and to:

- discuss the various forms of soil organic C (SOC, plant residues, particulate, humus and resistant fractions),
- investigate how management affects each of these pools and how humus can be increased over the medium to long term ,
- communicate how soil organic matter affects soil productivity (through nutrient and water supply, and improvements in soils structure).

Identical trials are being run by eight farm groups in SE Australia (Victoria: Mallee Sustainable Farming, Birchip Cropping Group, Southern Farming Systems; NSW: Farmlink, Central West Farming Systems; SA: Hart and Eyre Peninsula Agricultural Research Foundation, both through Ag Ex Alliance; and Tasmania: Southern Farming Systems) so information can be collected on different soils and climates in the Southern Region.

How was it done?

The trial commenced in autumn 2012 at which time soil samples were collected to establish the initial stocks and composition of soil C. 2015 was the fourth year of the trial and soil samples were again collected for soil C analysis prior to sowing the 2015 crop. Soil samples were also collected pre-sowing for Yield Prophet® (0-10, 10-40, 40-70, 70-100 cm) to determine soil available N and soil moisture.

In March-April of each year the stubble management treatments: (i) stubble left standing, (ii) stubble worked in with single operation of the seeder before sowing and (iii) stubble removed by raking and burning were imposed.

Nutrient application treatments at seeding were: (i) normal practice for P at sowing and N in crop as per Yield Prophet® and (ii) normal practice PLUS extra nutrients (N, P, S) required to break down the measured wheat stubble from the 2014 crop. Based on the initial 2015 stubble load of 6.8 t/ha, the extra nutrients (39 units N, 15 units P and 6 units S) required to break down the stubble were applied on 16 April with a rainfall event. The extra nutrients (plus treatment) were applied as DAP (18:20:0:0) @ 75 kg/ha, ammonium sulphate (21:0:0:24) @ 25 kg/ha and urea (46:0:0:0) @ 51 kg/ha. Treatments were replicated 4 times.

The trial was sown in drier conditions on 12 May with Mace wheat @ 60 kg/ha and a base fertiliser of DAP (18:20:0:0) @ 50 kg/ha. The trial area was sprayed on 8 May with 1.2 L/ha glyphosate and Cavalier at 100 ml/ha. Pre seeding chemical applications at seeding on 12 May were Roundup Attack @ 1.2 L/ha and Boxer Gold @ 2.5 L/ha. On 27 July, Tigrex was applied at 750 ml/ha and 100 ml/ha Lontrel. Emergence counts, flowering date, grain yield and grain quality were measured.

What happened?

Crop performance 2015

Emergence counts were taken on 21 May with an average of 163 plants/m^2 (range of 125 to 207 plants/m^2) which was good given the dry start to the season and variability with germination in other trials. The 2015 season was a decile 5 but drier seeding and early seasonal conditions did not allow early plant growth and the season finished quickly with a hot October long weekend. Flowering occurred (GS 65- when 50% of heads have anthers) on 15 September. The trial was harvested on 11 November. There were no differences between treatments in yield. There was a small increase in protein and screenings ($P<0.001$) for those treatments that received additional nutrients (Table 1).

Yield Prophet was used early in the season (3 July) to predict if extra N fertiliser was required to achieve potential yield given the drier seasonal conditions. Due to the dry conditions an extra 20 kg N/ha was applied on 9 July spread over all treatment plots, and 20 kg/ha was applied again on 3 August with rainfall events.

Soil Carbon 2012 to 2015

At the start of each season additional nutrients were applied to aid in the breakdown of stubble to soil organic matter.

After three years of implementing the stubble and nutrient management strategies, soil C content at Minnipa ranged between 1.1 and 1.3% for the topsoil (0-10cm) and 0.7 and 0.9% for the subsoil (10-30 cm). There was no difference in SOC content between the 2012 and 2015 measurements (Figure 1).

To measure the change in the amount of soil C over time, the soil mass per unit volume of soil has to be taken into account – in other words the amount of soil C is reported for a defined soil mass

Table 1 Grain yield and quality as affected by stubble treatments and additional nutrients at Minnipa 2015.

Stubble treatment	Nutrition treatment	Yield (t/ha)	Protein (%)	Screenings(%)
Stubble removed	normal practice	2.60	10.7	6.1
Stubble removed	normal practice plus N,P&S	2.90	12.1	10.2
Stubble standing	normal practice	2.73	10.7	8.7
Stubble standing	normal practice plus N,P&S	2.84	11.6	8.9
Stubble worked	normal practice	2.88	10.3	6.6
Stubble worked	normal practice plus N,P&S	2.97	11.8	11.8
P value Stubble treatment		*ns*	*ns*	*ns*
Nutrient treatment		*ns*	*P<0.001*	*P<0.001*

Soils

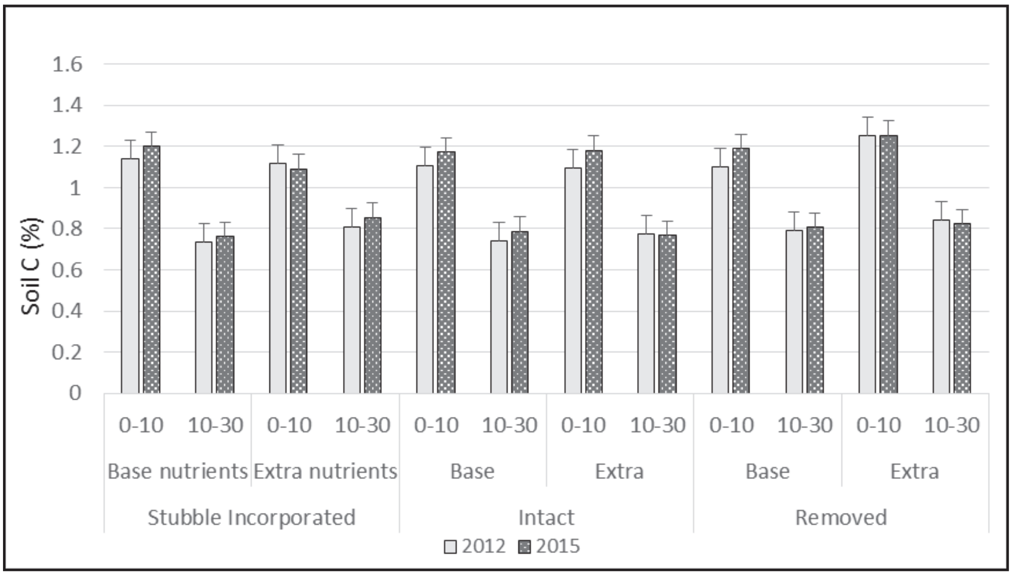


Figure 1 Soil organic carbon content (%) for the top and subsoil after three years of stubble and nutrient application treatments.

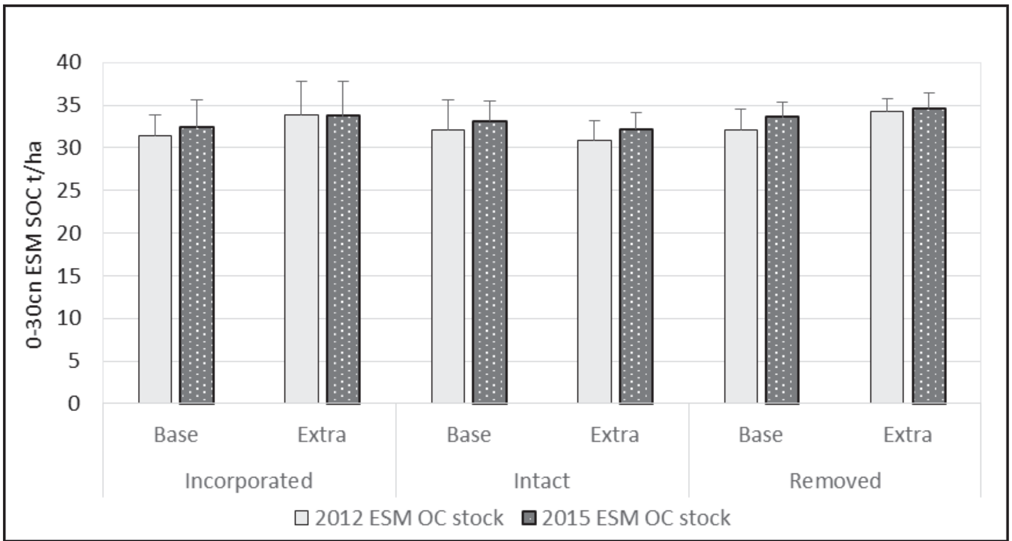


Figure 2 Equivalent soil mass C stocks (t C/ha) in 2012 (start of the trial) and 2015 after three years of stubble and nutrient application treatments at Minnipa.

(ESM, equivalent soil mass). The concept of ESM compensates for variations in the way samples were collected and also allows for variations in soil bulk density, resulting from different tillage practices.

Soil C stocks at Minnipa ranged from 30 to 35 t C/ha (Figure 2). However, there was no difference between soil C stocks for the different stubble and applied nutrient treatments between 2012 and 2015.

What does this mean?

It was expected that the imposed treatments to increase soil organic matter would take several years to become noticeable, especially in low rainfall areas. Even after three good seasons at Minnipa with excellent crop production there were no differences in soil C stocks between the stubble and nutrient supply treatments.

The same result applied to the other seven trial sites located in SE Australia. This work shows that increasing soil C stocks is a long-term process, and three years was not long enough to measure significant changes with the practices selected. This is consistent with a recent review indicating the largest gains in soil C stock were seen 5 to 10 years after adoption or change in practice (Sanderman et al. 2009). They also reported that improved management of cropland (e.g. no-till or stubble retention) resulted, on average, in a relative gain in SOC of 0.2- 0.3 t C/ha/year compared with conventional management across a range of Australian soils. The Minnipa soil C trial will be re-measured again on the completion of the 2016 season after five years of trial work.

Acknowledgements

Funding for this trial is provided from DAFF and GRDC, and project management through Ag Ex Alliance and EPARF. Yield Prophet is an on-line modelling service based on APSIM that provides simulated crop growth based on individual paddock information and rainfall, and is registered to BCG.

References

Kirkby, C., Kirkegaard, J., Richardson, A., Wade, L., Blanchard, C. and Batten, G. (2011). *Stable soil organic matter: A comparison of C:N:P:S ratios in Australian and other world soils*. Geoderma, 163, 197-208.

Sanderman, J., Farquharson, R., Baldock, J., (2009) *Soil carbon sequestration potential: A review of Australian Agriculture*. CSIRO p1-89.

How does changing management practices influence soil carbon stock and other production factors?

Jodie Reseigh, Michael Wurst and Amanda Schapel
Rural Solutions SA, PIRSA

RESEARCH

Searching for answers

Location:
Elbow Hill
Greg Williams
Rainfall
Av. Annual: 278 mm
Rainfall 2012: 256 mm
Rainfall 2013: 325 mm
Rainfall 2014: 259 mm
Soil Type
Australian soil classification:
Calcarosol
South Australian soil classification:
A4 Calcareous soil

Location:
Cleve
Mark and Andrea Hannemann
Rainfall
Av. Annual: 422 mm
Rainfall 2012: 312 mm
Rainfall 2013: 479 mm
Rainfall 2014: 479 mm
Soil Type
Australian soil classification:
Chromosol
South Australian soil classification:
D1 Loam over clay on rock

Location:
Cowell
Bevan and Cindy Siviour
Rainfall
Av. Annual: 350 mm
Rainfall 2012: 369 mm
Rainfall 2013: 459 mm
Rainfall 2014: 404 mm
Soil Type
Australian soil classification:
Sodosol
South Australian soil classification:
D1 Loam over clay on rock

Key messages

- **The project established 13 demonstration sites in the Upper North and eastern Eyre Peninsula, SA to investigate the effect of selected management practices on soil organic carbon (SOC).**
- **Despite the lack of consistent evidence for the effectiveness of different management practices on SOC stocks, selected management practices have led to increases in ground cover and perennial plant numbers.**
- **It may take many years to see change in SOC stock, let alone significant change.**
- **In the short-term (2 years) measures of plant productivity (ground cover and perennial plant number) were more sensitive to management change compared to soil carbon (C) stocks and may represent valuable short-term monitoring tools to inform longer-term soil C outcomes.**

Why do the trial?

The aim of the trial was to investigate the effect of four different management practices on soil C stock in the Upper North and Eyre Peninsula (EP) of South Australia.

Background

Increasing landholder interest in soil C during 2010/11 (after the introduction of the C tax), in particular how management practices affect soil C; how soil C is measured, plus a range of other questions, led the Upper North Farming Systems (UNFS) group to apply for funding from the Australian Government. The project investigated the effect of four management practices that have been proposed to increase sequestration of C in soils: rotational grazing; management of unviable cropping land; management of degraded land and management for increased perennials.

How was it done?

Twelve landholders (a total of thirteen sites) were identified in the Upper North and on eastern EP (Figure 1) based on their (i) interest in participating in a trial to increase SOC on their property through implementation of one of the four management practices; (ii) commitment to undertake management actions aimed at increasing SOC; (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 SOC undertaken on their property.

All landholders involved in the trial were mixed farmers, with cereal (predominately wheat and barley) and livestock (sheep, cattle) enterprises. Annual rainfall varied across the study area from 278 to 422 mm (winter dominant).

Demonstration sites were monitored and soil sampled in 2012 prior to the implementation of any change in management, with management practices commencing in 2012/13. Sites were monitored annually for pasture and surface cover, plant biomass, frequency of perennials and the soil was re-sampled in 2014 to monitor soil carbon changes. In total, thirteen demonstration sites were established; ten were located in the Upper North, and three on EP. The discussion below relates specifically to the EP sites.

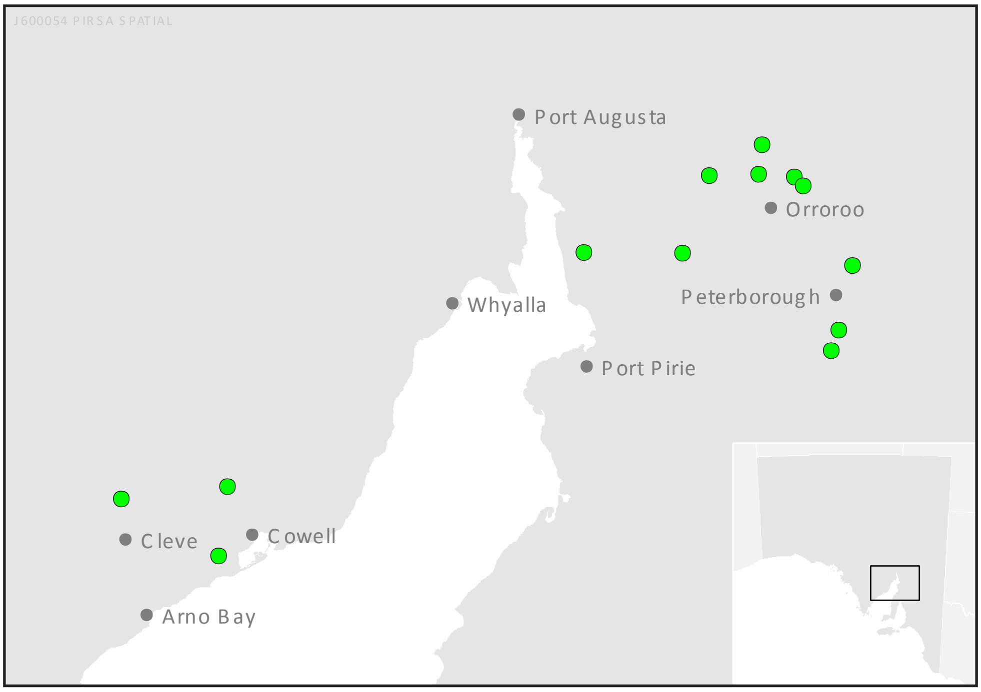


Figure 1 Trial site locations in the upper north and eastern Eyre Peninsula of South Australia.

Rotational grazing - Williams

The Elbow Hill area was settled in the 1880s and was cleared for cropping. Since then the farm and trial paddock have 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. The trial 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 (~ 1 DSE/ha).

Fences were repaired or replaced in 2013 to make the paddocks stock proof, and central watering points constructed with watering yards consisting of a single trough with high water flows allowing 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 days rest depending on seasonal conditions.

Degraded land – Hannemann

The local area has been cropped since settlement and prior to 1997, the demonstration site paddock was traditionally cropped for two years followed by a one year self-regenerating pasture. Since 1997, the paddock has been continuously cropped, with stubbles of the previous year's crop grazed over summer, generally for a period of six weeks at 13 DSE/ha. Crop yields declined and the area close to the creek became waterlogged during winter, due to a rising water table.

In March 2012, gypsum was spread over the upper slopes of the paddock at 2.08 t/ha. The paddock was sprayed in early May 2013, to control a range of annual grasses and broadleaved weeds, and sprayed again following 39 mm of rain in mid-May.

Immediately after spraying perennial pastures were planted, 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. 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.

Land managed for increased perennials - Siviour

The local area has a history of regular cropping. Before the current owners purchased the property (2010), the paddock was continuously cropped with wheat for four years. The demonstration site was previously three paddocks with three different rotational histories. 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 and ploughed to control woody weeds, including blanket weed and annual saltbush (*Atriplex species*). The demonstration site was again sprayed in January 2013, to control summer weeds. Following good opening rains in May 2013, the demonstration site was sprayed and cultivated with a one way disc and then broadcast with Puccinella (*Puccinellia species*) at 5 kg/ha and Tall Wheat grass (*Thinopyrum elongatum*) at 10.5 kg/ha in June. Fertiliser was spread at 70 kg/ha of DAP in June 2013. The area was grazed at 1.5 DSE/ha during January and February 2014, and at ~1.9 DSE/ha from March to May 2014.

Table 1 Summary of the impact of management practice on the change (2012-2014) in measured variables. Each site is represented by a symbol:◄►No change, ↑ increase, ↓ decrease

Management practice	SOC stock	Erosion risk	Ground cover	Perennial plants
Rotational grazing	↓*	◄►	↓	↑
Degraded land	↓	◄►	◄►	↑
Introduction and/or increase perennials	◄►	◄►	↓	↑

** Changes of < 2.0 Mg C/ha are expected within natural variability*

Measurements

At each demonstration site, a sampling site was selected for monitoring of the following variables:

- soil organic carbon stocks
- erosion risk
- ground cover
- numbers of perennial plants

Sampling sites were selected based on landform, soil type (if more than one was present at a demonstration site), site history, and representativeness of vegetation (if present). Sampling sites were approximately 250 x 250 m to allow for field sampling of variables at various scales.

What happened?

Results show that over the short-term (2 years) SOC was relatively insensitive to management change but other variables (e.g. ground cover, numbers of perennial species etc.) were more sensitive. The results were site specific, likely reflecting local climate conditions and the way in which new management practices were implemented and adapted. Longer-term monitoring is required to determine impact on soil C.

Rotational graze - Greg Williams

Ground cover and soil C stocks declined from 2012 levels (79.3% to 64.1% and 20.5 to 18.2 Mg C/ha), however, the decline in SOC stock (-2.3 Mg C/ha) is not significant. The decline in ground cover is attributed to the decile 1 rainfall in the period August 2013 to early January 2014. A large increase in the numbers of perennial plants (5.3 more plants/m^2) from baseline levels (0 plants/m^2) was recorded as a result of implementing rotational grazing (Table 1).

The implementation of a grazing method (such as rotational grazing) which increases pasture productivity should result in: i) increased organic matter (OM) inputs into the soil; ii) increased trampling of OM by grazing animals which enhances the physical breakdown and incorporation of OM into the soil [1]; iii) reduced erosion; iv) and improvements or maintenance of ground cover. Furthermore, the combination of rotational and perennial species (generally deeper and more extensive root systems than annual species), should lead to increased organic carbon (OC) inputs over the longer term (>10 years) and decrease surface erosion due to greater surface cover through dry months. Additionally, OC decomposition may decrease due to the perennial plants ability to use rainfall that falls outside of the traditional growing season (summer rain).

These results are generally consistent with the theory that rotational grazing increases pasture productivity; however the increases need to be observed over a longer period (> 2 years) as productivity variables vary seasonally and are highly dependent on seasonal conditions. The theoretical increase in SOC following the implementation of rotational grazing was not observed, however other variables measuring pasture productivity: numbers of perennial plants, increased consistent with the theory that rotational grazing increases pasture productivity.

Degraded land – Mark and Andrea Hannemann

A decrease in SOC stocks of -4.9 Mg C/ha, from baseline levels was recorded as a result of implementing these management actions. However increases in ground cover (2.7%) and numbers of perennial plants (1.5 more plants/m^2) were observed.

Remediating degraded land through the addition of amendments, and planting of perennial plants has a very high chance of increasing SOC through increased above and below ground biomass [2]. However, it may take a number of years for increases to be realised due to the slow process of remediation. Eventually with increased above ground biomass production, loss of OC from photo-degradation of surface litter will be reduced. Nevertheless, this will be a trade-off as the soil temperature will decrease and soil moisture will increase which will result in increased decomposition of OC by microbial activity.

The results are inconsistent with the theory that retirement of degraded land increases SOC stocks. The observed decrease in SOC stocks, may be attributed to the site being cultivated and sown to pasture which may have resulted in a loss of C and increased decomposition rates [3]. Other variables related to pasture productivity both ground cover and numbers of perennial plants increased.

Land managed for increased perennials - Bevan and Cindy Siviour

SOM stocks increased (2.1 Mg C ha-1) but not significantly. Any changes in SOC stock ~ 2.0 Mg C ha-1 are expected within natural variability. A dramatic increase in the number of plants/m^2 was recorded in 2014 with an increase of 48.1 plants/m^2 and an increase in ground cover of 15.4%.

The introduction of perennial species to areas that have been retired from cropping, which typically become dominated by annual weed species resulting in large losses in productivity and lower returns of OC to the soil, should result in increases in SOC (at least in the area surrounding the shrubs/plants) as they have greater net primary production (NPP), requiring low nutritional inputs and partitioning more C to their root systems than agricultural plants [4].

The results are consistent with the theory that increasing the number of perennial plants in areas which have been retired from cropping leads to an increase in primary production and also show trends consistent with the theory with respect to increases in soil C.

What does this mean?

Improvements in some plant productivity variables were observed for all management practices, implying an increase in C inputs to the soil, and a reduced risk of C losses from the soil, providing the theoretical potential to increase SOC stocks over time. Trials such as these have an important role in establishing the most likely management practices which will lead to improvements in variables (ground cover, perennial plant number) and ultimately SOC stocks.

Longer-term monitoring (>2 years) is required to measure the SOC changes that may result from rotational grazing, management of unviable or degraded land, and approaches to increase perennials.

Research into the effects of management on SOC stock requires further work. The effects of management change are likely to vary depending on variables including how management change is implemented, soil type and climatic conditions.

Where research on the effects of management change on SOC stock has been undertaken:

i. ithe effect of rotational grazing on SOC stocks findings are conflicting with some research reporting an increase (e.g. [5] and [6]) and others reporting no significant change in SOC stock (e.g. [7], [8] and [9]), which is consistent with this trial;
ii. retirement of degraded land and the planting of perennial plants in the US increased SOC [2], this trial recorded a decline in SOC attributable to the implementation of management; and
iii. management for increased perennials through the cessation of cultivation and the planting of pasture has a positive effect on SOC stocks (e.g. [7], [8], [9]), whereas this trial observed no change from baseline levels.

The established demonstration sites provide opportunities to determine the value of short-term measures of management change (e.g. ground cover) to inform longer-term impacts on soil C, and to monitor SOC change over the longer term. SOC stock increases take time but the benefits of even small increases of SOC can improve soil health and productivity.

Acknowledgements

The project is supported by Upper North Farming Systems, through funding from the Australian Government and CSIRO, Eyre Peninsula Natural Resources Management Board and Rural Solutions SA (project code AOTGR1-0044).

References

1. G.E. Schuman, J.D. Reeder, J.T. Manley, R.H. Hart, and W.A. Manley, (1999) *Impact of grazing management on the carbon and nitrogen balance of a mixed-grass rangeland.* Ecological Applications, 9: 65-71.
2. J. Sanderman, R. Farquharson, and J. Baldock, (2010) *Soil Carbon Sequestration Potential: A review for Australian agriculture.* CSIRO: Canberra.
3. 3. K. Chan, A. Oates, D. Liu, R. Pragnell, G. Poile, and M. Conyers, (2010) *A farmer's guide to increasing soil organic carbon under pastures.* Industry & Investment NSW: Wagga Wagga.
4. D. Rasse, C. Rumpel, and M.-F. Dignac, (2005) *Is soil carbon mostly root carbon? Mechanisms for a specific stabilisation.* Plant and soil, 269: 341-356.
5. R.T. Conant, J. Six, and K. Paustian, (2003) *Land use effects on soil carbon fractions in the southeastern United States. I. Management-intensive versus extensive grazing.* Biology and Fertility of Soils, 386: 386-392.
6. W.R. Teague, S.L. Dowhower, S.A. Baker, R.J. Ansley, U.P. Kreuter, D.M. Conover, and J.A. Waggoner, (2010) *Soil and herbaceous plant responses to summer patch burns under continuous and rotational grazing.* Agriculture, Ecosystems & Environment, 137: 113-123.
7. J. Sanderman, J. Reseigh, and M. Wurst, (in press) *Impacts of rotational grazing on soil carbon in native grass-based pastures.*
8. B.R. Wilson and V.E. Longeran, (2013) *Land-use and historical management effects on soil organic carbon in grazing systems on the Northern Tablelands of New South Wales.* Soil Research, 51: 668-679.
9. K.Y. Chan, A. Oates, G.D. Li, M.K. Conyers, R.J. Prangnell, G. Poile, D.L. Liu, and I.M. Barchia, (2010) *Soil carbon stocks under different pastures and pasture management in the higher rainfall areas of south-eastern Australia.* Soil Research, 48: 7-15.

UNFS Upper North Farming Systems
CSIRO
Australian Government
Government of South Australia
Eyre Peninsula Natural Resources Management Board
RURAL SOLUTIONS SA

Will controlled traffic improve crop production outside the wheel tracks?

Nigel Wilhelm
SARDI, Minnipa Agricultural Centre

RESEARCH

Searching for answers

Location:
Minnipa Ag Centre
Paddock S7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 2.7 t/ha
Paddock History
2014: Medic pasture
2013: Medic pasture
Soil Type
Calcareous red sandy loam
Plot Size
50 m x 3 m x 4 reps

Key message

- **Heavy trafficking did not reduce the grain yield of wheat in 2015 and crop development appeared faster with some trafficking.**

Why do the trial?

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

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

This article summarises the first season’s wheat performance after increasing severity of trafficking was imposed on a red calcareous sandy loam at Minnipa Agricultural Centre. Three other trials similar in design and monitoring have also been implemented across the LRZ – on a deep sand at Loxton (SA), a brown loam near Swan Hill (Vic) and on a deep red earth at Lake Cargellico (NSW). All these trials will be maintained for at least the five year life of the project.

How was it done?

The trials were designed and implemented to be the same at all four sites. Each trial consists of five treatments replicated four times:

1. Control (no heavy vehicle trafficking).
2. One pass of a 30 tonne vehicle prior to seeding when soil was dry.
3. One pass of a 30 tonne vehicle prior to seeding when soil was moist.
4. Three passes of a 30 tonne vehicle prior to seeding when soil was moist.
5. Deep ripping (to loosen any historical trafficking).

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

The trafficking treatments simulate the effect of compaction caused by trafficking of heavy vehicles, with three passes when the soil is moist as an extreme (soil is always softer when wet so compacts more for the same vehicle weight). A deep ripping treatment was included because we cannot be sure if there is still compaction from previous trafficking in our control areas and the ripping was designed to disrupt any of this historical compaction. Trials were located on farms with soils typical for their district and where wheel track patterns for the previous five years (at least) were the same and were identifiable. The trials are being sown and managed with the farmers’ equipment. Treatments were imposed under the wings of the farmer’s seeder so that the whole trial could be seeded and managed without any heavy vehicle trafficking occurring on these treated areas. All plots were cored after the imposition of treatments and are being regularly assessed for soil physical and chemical condition.

At Minnipa, trafficking treatments were imposed in April 2015 with a 20 tonne single axle chaser bin, with the wet passes and deep ripping following 30 mm of rainfall. Deep ripping was imposed under moist conditions with a narrow profile straight leg ripper to 30 cm on 50 cm row spacings. Scepter wheat at 50 kg/ha and with 60 kg/ha of DAP was sown without prior cultivation on 25 May into marginal seeding conditions. The farm’s Horwood Bagshaw precision seeder (knife points) was used and the trial was sown as part of the whole paddock and managed similarly. The trial was laid out so that two treated plots were sown in each pass, one under each wing of the seeder.

Table 1 Grain yield and yield components of Scepter wheat after trafficking and deep ripping at Minnipa in 2015.

	Grain yield (kg/ha)	Establishment (plants/ m²)	Heads per plant	No of grains per head (g)	1000 grain weight	Grain protein (%)
Control	2602*	124	2.30	43.4	21.8	15.7
One pass on dry soil	2742	122	2.44	41.6	22.2	15.3
One pass on wet soil	2548	127	2.37	41.5	20.0	15.9
Three passes on wet soil	2488	100	2.60	44.2	22.8	16.1
Deep rip	1976	84	2.10	45.3	25.1	14.0
LSD (P=0.05)	*244*	*16*	*ns*	*2.4*	*2.8*	*1.0*

** Control is the average of 13 plots: extra quadrats were taken from the seeder runs between treated plots for grain yield only*

Crop performance was monitored at establishment, for early and late dry matter production and at maturity (grain yield, quality and yield components). Soil in every plot was sampled for moisture, fertility and physical condition pre-sowing and will continue to be monitored. Grain harvest was conducted by hand to avoid trafficking from a header on treated plots.

Crops will continue to be sown and managed with farm equipment for the next three years, with rotation options to be the same as the rest of the paddock. Trafficking treatments will not be re-applied.

What happened?

Trafficking on dry soil had little visual impact on the soil but three passes on wet soil depressed the soil surface by at least 5 cm. Deep ripping left the surface more cloddy than the control with the surface raised by at least 10 cm.

Despite the parallelogram design of the Horwood Bagshaw Precision seeder, sowing depth varied markedly between extreme treatments. Three trafficking passes on wet soil reduced sowing depth from 54 mm in the control to only 25 mm due to the tightness in the surface layers. Deep ripping resulted in sowing depth averaging 103 mm because the profile was so loose and the variability in placement was also higher. Seeding depths in the single pass treatments were similar to the control.

Emergence was slower after three passes or deep ripping but similar to the control after single passes. Final plant populations were also similar in the control and single pass treatments (averaging 124 plants/m²) but were reduced to 100 plants/ m² after three passes and to only 84 plants/m² after deep ripping (Table 1).

Once plants started to tiller, the crop after a single pass on wet soil appeared the most vigorous and by mid-tillering had produced nearly 50% more biomass per hectare than the control (which averaged 458 kg DM/ha). Growth after a single pass on dry soil or after three passes on wet soil was similar to the control. Plants after deep ripping were fewer and weaker, resulting in 60% less biomass than the control. Nutrient analysis of these whole shoots showed that levels of all essential elements were in the adequate range and similar for all treatments except for deep ripping which had higher calcium, magnesium and manganese levels than the control but lower (but still adequate) zinc.

A single pass on wet soil also appeared to speed the time to flowering while deep ripping delayed it, relative to the control. At a stage when the controls had one third of their heads emerged, the crop after three passes on wet soil had nearly 50% of heads emerged but deep ripping had only 10%. By flowering, shoot biomass was similar in all treatments (at approximately 6,500 kg DM/ha) except after deep ripping, which was 22% less than the control.

Despite the late sowing and dry spring (only 33 mm of rain in September and October) the controls averaged 2.6 t/ha, which was very similar to the yields with all trafficking passes. Only the crop after deep ripping yielded less than the control, at 2.0 t/ha (Table 1). Yield components were very similar for all treatments (Table 1), except grain size was better after deep ripping. All trafficking treatments resulted in very similar crops to the control at maturity. Plants after deep ripping were too few to match the grain yield of the other treatments despite larger grain size. Grain proteins were all high in the trial and similar to the control except for deep ripping which was nearly 2% lower than the control.

Deep ripping did not fully achieve our aim of investigating crop production with compaction completely removed from the top 30 cm of soil because the farm seeder did not adequately compensate for the loosened profile and seeding depth was double the control. This severely reduced establishment and wheat growth throughout the season. The end result was that wheat after deep ripping yielded 600 kg/ha, or 30% lower, than the control. This detrimental impact of deep ripping appeared to be largely due to the reduced plant numbers caused by deep sowing. We expect that in future seasons, the deep ripping treatment will be a more rigorous examination of the impact of removing historical compaction on crop production because the profile will continue to settle with time.

What does this mean?

Consideration of CTF can be divided into two broad components. One is the operational and logistical impacts of conducting all field operations on permanent, unseeded (and hence compacted) wheel tracks with equipment which has matching path and axle widths. There are potentially both positive (e.g. better traction, more timely operations) and negative (e.g. weed nursery and erosion risk) impacts of permanent wheel tracks. This aspect of CTF is being considered by this GRDC funded project but not as part of the four R sites. The R sites are focused on investigating the other major component of CTF which is whether crop production will improve if heavy vehicle traffic is removed from the cropped area of LRZ paddocks, because the heavy vehicles are causing compaction which is detrimental to plant growth. The case in medium and high rainfall zones is that there are clear net benefits from both components and cropping can be expected to be more productive and profitable under a CTF system in these two zones. The case for the LRZ has not yet been made, chiefly because it has not been fully investigated before in this zone.

In this trial, in the first year of crop production following implementation of these trafficking treatments, wheat has produced similar yields to the untrafficked control, despite sowing depth being shallower after the most extreme trafficking which resulted in a lower plant population. These early results suggest that wheat is relatively insensitive to the compaction caused by heavy vehicles on this red calcareous sandy loam in a low rainfall environment, compared to the existing conditions in the paddock. In fact, early growth of wheat was best after one pass on wet soil and development was more rapid after trafficking, suggesting that some extra compaction may have actually benefited wheat growth. This trial will be continued for the next three years at least and we will continue to monitor the impact of trafficking imposed in 2015 on subsequent crop production and soil condition. In future seasons, we are hoping the deep ripping treatment will allow us to assess whether current levels of compaction in the paddock are already restricting crop production.

Harvest data from the other three R sites are still being processed. When all are completed, a comparison will then be made of the impact of trafficking in four typical, but very different low rainfall environments.

Acknowledgements

Thanks to MAC farm staff for the implementation and management of the R site and to Ian Richter and Naomi Scholz for undertaking the monitoring of crop performance and soil condition. GRDC is the major funder of this project, which is managed by the Australian Controlled Traffic Farming Assocation (project code ACT00004).

Australian Controlled Traffic Farming Association Inc

GRDC Grains Research & Development Corporation Your GRDC working with you

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Soils

New opportunities for soil wetting agents on repellent soils

Stephen Davies[1], Glenn McDonald[1], Geoff Anderson[1], Liam Harte[1], Grey Poulish[1], Richard Devlin[2] and Rebecca Jenkinson[2]

[1]Department of Agriculture and Food, Western Australia, [2]Living Farm

RESEARCH

Location:
Meckering and Kojonup, WA
Darren Morrel, Jono Clifton
Southern DIRT (Kojonup)
Rainfall
Meckering
Av Annual: 367 mm
Av. GSR: 304 mm
2015 Total: 249 mm
2015 GSR: 168 mm
Kojonup
Av Annual: 459 mm
Av. GSR: 382 mm
2015 Total: 395 mm
2015 GSR: 231 mm
Yield
Potential (W): Meckering 2.4 t/ha; Kojonup 3.7 t/ha
Actual: Meckering 1.36 t/ha; Kojonup 3.84 t/ha (B)
Soil Type
Pale deep sand (Meckering)
Loamy gravel (Kojonup)
Plot Size
2 m x 20 m x 3 or 4 reps
Yield Limiting Factors
Frost, early finish, soil acidity, soil water repellence

Key messages

- **Banding soil wetting agents with the seed, through existing liquid banding systems and with less risk of poor placement, can improve crop establishment on water repellent soils and often has an equivalent effect to placement on the furrow surface.**
- **Some soil wetting agents are compatible with UAN, fungicides and other liquid applications and can be applied through existing liquid in-furrow banding systems improving their adoptability. This indicates soil wetting agents could be useful as a carrier for liquid nutrients.**
- **The impact of banded wetters on grain yield can vary with season, soil types and other yield constraints, therefore it is recommended growers trial them on their own farms and soil types.**

Why do the trial?

The aim of the trial was to assess the effectiveness of wetting agents when applied in formulations with UAN and when banded with the seed compared to banded on the furrow surface.

Soil wetting agents include in their formulations a penetrant (surfactant) compound that will aid water infiltration into repellent soil but some also have water absorbing compounds (humectants) that help hold and retain soil moisture and sometimes nutrients in the topsoil. Soil wetting agents can be applied as blanket applications through a boom spray but this is costly as rates of 10-50 L/ha are often required and the benefits have been soil type specific and last only 1-2 years. Banding soil wetting agents involves applying them through nozzles usually as a continuous stream on top of the furrow following the press wheels to improve the consistency of soil wetting in the furrow. This is much cheaper as application rates are typically 1-2 L/ha. There is some evidence that banding soil wetters near the seed can also be effective at improving establishment but this requires further research to confirm the impacts. In previous research soil wetters have been shown to improve establishment and yield on water repellent sands (Blackwell *et. al.* 2014) but the results can often be inconsistent (Davies *et. al.* 2015). Less research has been undertaken on water repellent loamy gravel soils. These soils contain 20% or more ironstone gravel and typically have a sandy loam matrix in the topsoil, they are often called forest gravels and are found in the south-west medium-high rainfall zone of WA.

How was it done?

In 2015 replicated small plot experiments were established at Meckering, on repellent pale deep sand, and at Kojonup on +/- repellent loamy gravel (Table 1). Commercial soil wetting agents were tested and were applied either on top of the furrow, behind the press wheels (furrow banded) or applied 'with' the seed, banded 5-15 mm below the seed. The soil wetters were applied as a continuous stream at a water rate of 90-100 L/ha. Soil water repellence was assessed at each site and the crop was assessed for establishment and grain yield.

What happened?

Rainfall in March and April prior to seeding at both sites (Table 2) meant that there was some soil moisture present at the time the crop was sown but, due to the soil water repellence, the topsoils still had many dry patches. At Meckering rainfall was low throughout May and June and terminal drought was severe with only 8.6 mm in September and less than 2 mm in October (Table 2). October rainfall was also low at the Kojonup site which received only 4 mm (Table 2).

Table 1 Summary of seeding details, soil type, growing season rainfall (GSR Apr-Oct), soil water repellence rating and treatments applied, for five trials over three sites with water repellent soil established in 2015.

Soil Type, Location & GSR (mm)	Variety, Rate & Sowing Date	Experiment and Treatments	Soil Water Repellence (0-5 cm)	
			MED*	Rating
Pale deep sand, Meckering **GSR = 184**	Mace wheat, 75 kg/ha, 9 May	SOIL WETTERS on SAND 1) Control (nil banding) 2) Water only banded on furrow or with seed 3) Wetter 1 – penetrant banded on furrow or with seed 4) Wetter 2 – penetrant & retainer banded on furrow or with seed 5) Wetter 3 – penetrant & retainer banded on furrow or with seed All wetters banded at 2 L/ha	2.4	Severe
		UAN and WETTERS on SAND 1) Control (nil banding) 2) UAN banded on furrow or with seed 3) Wetter 1 banded on furrow or with seed @ 2 or 4 L/ha 4) Wetter 1 + UAN banded on furrow or with seed @ 2 or 4 L/ha	1.5	Moderate
Loamy (forest) gravel, Kojonup **GSR = 251**	Hindmarsh barley, 110 kg/ha, 13 & 14 May	SOIL WETTERS on LOAMY GRAVEL 1) Control (nil banding) 2) Water only banded on furrow 3) Wetter 1 – penetrant & retainer banded on furrow at 1 or 2 L/ha 4) Wetter 2 – penetrant banded on furrow at 1 or 2 L/ha 5) Wetter 3 – retainer & penetrant banded on furrow at 1 or 2 L/ha 6) Wetter 4 – penetrant & retainer banded on furrow at 1 or 2 L/ha	4.1	Very Severe
		UAN and WETTERS on LOAMY GRAVEL 1) Control – water banded on furrow or with seed 2) UAN banded on furrow or with seed 3) Wetter 1 banded on furrow or with seed 4) Wetter 1 + UAN banded on furrow or with seed 5) Wetter 2 banded on furrow or with seed 6) Wetter 2 + UAN banded on furrow or with seed	4.0	Very Severe
	Hyola 525 RT Canola, 2.5 kg/ha, 5 May	SOIL WETTERS for CANOLA on LOAMY GRAVEL 1) Water only banded on furrow or with seed 2) Wetter 1 – penetrant banded on furrow or with seed 3) Wetter 2 – penetrant & absorber banded on furrow or with seed 4) Wetter 3 – penetrant & absorber banded on furrow or with seed All wetters banded at 2 L/ha	3.2	Very Severe

**Molarity of ethanol droplet test uses solutions of different concentrations of ethanol, which acts as a surfactant, reducing the surface tension of the water. The higher the concentration (molarity) of ethanol in the solution needed to get a droplet to enter a repellent soil in 10 seconds the higher the soil water repellence. A rating of 0.2-1.0 represents low water repellence, 1.2-2.2 moderate water repellence, 2.4-3.0 severe water repellence and >3.2 very severe water repellence.*

Table 2 Monthly, annual and growing season (GSR; May-October) rainfall for Meckering and Kojonup trial sites, 2015.

Site	2015 Monthly Rainfall (mm)											Ann. Rain (mm)	GSR (mm)
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Meckering	7.2	26.4	16.2	17.6	27.4	71	42.2	8.6	1.4	31.4	0	249	168
Kojonup	0	50	60.5	24.5	43	79	48	32.5	4	22.5	31	395	231

**No rainfall was received in January at either site.*

Wetting agent placement and rates

At Kojonup wetting agents were banded on the furrow surface at two application rates of 1 and 2 L/ha onto very severely water repellent loamy gravel. The crop was sown into variable moisture on 13 May 2015, with subsequent rainfall of 8 mm on 19 May 2015 and 3 mm on 31 May 2015. Barley plant numbers were improved by 51-73% (63-90 plants/m²; Table 3). Grain yields were increased by 15-29% (0.53-1.02 t/ha; Table 3). For most of the wetters there was no benefit from using the higher application rate.

Soil wetter placement was assessed on water repellent pale deep sand at Meckering and repellent loamy gravel at Kojonup.

At the Meckering site seed banded soil wetters improved wheat establishment by 30-40% (27-36 plants/m²) but soil wetters banded on the furrow did not significantly improve establishment (Table 4). Despite these improvements in establishment, grain yields were not improved by the soil wetting agents and in fact yields were reduced in some instances (Table 4). The site did experience severe terminal drought stress, receiving only 8.6 mm of rainfall in September and 1.4 mm in October on a soil type with low water holding capacity (Table 2). The drought stress may well have been exacerbated by a subsoil acidity constraint with soil pH ($CaCl_2$) of 4.3 and 4.2 in the 10-20 and 20-30 cm layers, respectively, and possibly by subsoil compaction. In addition to terminal drought the site was frosted and frost damage was evident. Given this, it is not surprising that the greater plant numbers in the wetter treated plots did not end up translating to a yield advantage. The biggest improvement in plant numbers occurred when wetters were banded with the seed, but in these treatments there was a yield decline. This typically occurs when the higher biomass from larger plant numbers results in the crop suffering from more severe terminal drought due to higher demand for water leaving less water for grain fill.

Table 3 Impact of soil wetting agents and the rate of application on barley establishment and grain yield on repellent loamy gravel at Kojonup, 2015.

Treatment	Crop Establishment (plants/m²)		Grain Yield (t/ha)	
	Wetter @ 1 L/ha	Wetter @ 2 L/ha	Wetter @ 1 L/ha	Wetter @ 2 L/ha
Control (Nil)	123		3.45	
Water only (Control)	117		3.48	
Wetter 1	195*	179	4.24*	4.41*
Wetter 2	186*	187*	4.47*	4.27*
Wetter 3	213*	206*	4.35*	4.17*
Wetter 4	163	191*	3.98*	4.08*
LSD (P=0.05)	*63*	*0.42*		

** denotes increase relative to the untreated controls.*

Table 4 Impact of soil wetting agents and their placement, banded either on the furrow surface and or near the seed, on crop establishment and grain yield.

Treatment	Crop Establishment (plants/m²)		Grain Yield (t/ha)	
	Furrow	Seed	Furrow	Seed
Meckering, Pale Deep Sand – Wheat 2015				
Control (Nil)	90		1.06	
Water only (Control)	86	81	1.04	1.08
Wetter 1-2 L/ha	103	123*	1.00	0.92*
Wetter 2-2 L/ha	98	126*	0.95	0.81*
Wetter 3-2 L/ha	86	117*	0.88*	0.87*
LSD (P=0.05)	*13*	*0.11*		
Kojonup, Loamy (forest) gravel – Canola 2015				
Control (Nil)	33		2.93	
Water only (Control)	34	35	2.92	3.04
Wetter 1-2 L/ha	45	56*	3.19*	3.37*
Wetter 2-2 L/ha	51*	54*	3.26*	3.44*
Wetter 3-2 L/ha	45	44	3.10	3.31*
LSD (P=0.05)	*15*	*0.22*		

** denotes a difference from the control treatment*

Table 5 Impact of soil wetting agents and their placement (banded either on top of the furrow or near the seed) on crop establishment and grain yield. Soil wetting agents were applied either on their own or in formulations with UAN.

Treatment	Crop Establishment (plants/m²)		Grain Yield (t/ha)	
	Furrow	Seed	Furrow	Seed
Meckering, Pale Deep Sand – Wheat 2015				
Control (nil)	102		1.26	
UAN	126	133*	1.36	1.38
Wetter - 2 L/ha	140*	183*	1.26	1.11*
Wetter - 4 L/ha	168*	184*	1.19	1.08*
UAN + Wetter - 2 L/ha	144*	166*	1.30	1.09*
UAN + Wetter - 4 L/ha	174*	192*	1.25	1.14*
LSD (P=0.05)	*29*	*0.12*		
Kojonup, Loamy (forest) gravel – Canola 2015				
Water only (Control)	161	173	3.97	3.99
UAN	173	143	3.84	4.05
Wetter 1	192	188	4.31*	4.11
UAN + Wetter 1	189	165	4.56*	4.21
Wetter 2	209	212	4.30*	4.39*
UAN + Wetter 2	212	178	4.60*	4.05
LSD (P=0.05)	*ns*	*0.29*		

** denotes a difference with 90 or 95% confidence; ns denotes no significant differences.*

At the Kojonup site the placement of soil wetters on canola establishment and yield was assessed. Banded wetters improved crop establishment by 18-21 plants/m², an increase of 54-70%. Use of banded soil wetters improved canola yields by 260-510 kg/ha, and a grain yield increase of 9-17% (Table 4). In this experiment banding the soil wetters with the seed significantly (P<0.05) improved the grain yield compared with banding the wetter on the furrow (Table 4).

Wetting agents in formulation with UAN

At the Meckering site soil wetter on its own or in formulation with UAN significantly (P<0.05) improved wheat plant numbers by 38-90 plants/m², an increase of 37-88% (Table 5). There was a trend towards higher plant numbers when the soil wetter was banded with the seed compared to when it is applied to the top of the furrow (Table 5). Similar to the other soil wetter trial at Meckering the improvement in plant numbers in this experiment did not increase the grain yield due to the seasonal conditions and perhaps other soil constraints, and where soil wetter was banded with the seed, grain yield tended to decline by 10-14% (Table 5).

In contrast to the crop response at the Meckering site, soil wetters on their own and in formulation with UAN did not significantly increase plant numbers but did improve grain yield of barley at the Kojonup site when banded on the furrow (Table 5). Grain yield was increased by 8% (0.3 t/ha) from furrow banded wetter applied on its own and by 0.59-0.63 t/ha, an increase of 15-16% when applied in combination with UAN (Table 5).

What does this mean?

Given the improvement in plant numbers as a result of using soil wetting agents on the pale deep sand at Meckering, it is disappointing that this did not translate into a yield improvement and in fact for wetter treatments banded with the seed there was a yield decline. Frost and severe terminal drought, exacerbated by the presence of subsoil constraints limited yield but there is little evidence of why there was a yield decline. There was a no difference in screenings across all the treatments, and they were low ranging from 1.5-2.5%. It is possible that frost or heat stress reduced the number of viable grains and this impact was bigger for the wetter treatments which had earlier and more consistent establishment and development.

In other studies banded soil wetters have resulted in yield improvements on deeper sands (Blackwell *et. al.* 2014), and in general yield usually is improved as a result of higher plant numbers and biomass. Yield responses of 8-36% have been measured in response to banded wetters on yellow deep sand at Binnu and pale deep sands near Badgingarra in moderate-low rainfall seasons (Blackwell *et. al.* 2014; Davies *et. al.* 2015). Soil wetting agents with water retention compounds have been shown to have benefits over penetrant only wetters in seasons which have leaching rains (Blackwell *et.al.* 2014).

In contrast crop yield responses on the repellent loamy gravels have been impressive and more consistent than those on deep sand. Canola yield increases have ranged from 0.3-0.5 t/ha and barley yield increases from 0.3-1.0 t/ha. In another experiment in 2015 near Kojonup on this soil type in which a broader range of treatment options was assessed, banded soil wetters increased barley yield by 0.7 t/ha for furrow banded and 1.0 t/ha for seed banded (Davies *et. al*. 2016). The cost of banding wetters typically ranges from $6-12/ha, and in these studies the yield response of barley on loamy gravel to the 1.0 L/ha rate was equivalent to that achieved at double the rate, 2 L/ha, so cost of the treatment is low relative to the potential yield benefit.

The results of these experiments indicate some useful developments in the use of soil wetting agents:

- Banding soil wetters with the seed can effectively increase plant numbers on repellent soils but should be used with caution on pale deep sands with poor water holding capacity and greater overriding soils constraints such as aluminium toxicity and compaction. Amelioration of these constraints may improve the reliability of the response to soil wetting agents;
- Some soil wetters are compatible with UAN and other liquid nutrients making their testing and adoption easier using existing liquid systems on seeders;
- Soil wetters can give large and quite consistent yield responses on loamy forest gravels in WA for both canola and cereals.

As a result of these findings ongoing research will focus on:

- Residual benefits of soil wetters, particularly on water repellent loamy gravels, and impact on a cropping rotation using longer term trials;
- Benefit of soil wetters on nutrient uptake and effectiveness when used in formulations with liquid fertilisers;
- Placement of banded soil wetter in relation to the seed row – how close does it need to be to the seed to be effective and how do the wetters improve soil wetting of the seed zone;
- Use of soil wetters in combination with lime and deep ripping on repellent soils with the aim of realising a greater yield benefit from the use of soil wetters when other soil constraints are also treated.

References

Blackwell P, Hagan J, Davies S, Bakker D, Hall D, Roper M, Ward P, Mathews A (2014) *Smart no-till furrow sowing to optimise whole-farm profit on non-wetting soil.* 2014 Agribusiness Crop Updates, Perth WA.

Davies S, McDonald G, Betti G, Anderson G, Harte L, Poulish G, Bakker D, Devlin R, Jenkinson R (2016). *Assessing options for managing water repellent gravels.* 2016 Grains Research Updates, 29 February-1 March 2016, Perth, Western Australia.

Davies S, Zaicou-Kunesch C, Kupsch M, Devlin R (2015). *Assessing agronomic options for managing wheat on water repellent soils*. 2015 Agribusiness Crop Updates, 24-25 February 2015, Perth, Western Australia.

Acknowledgements

Thanks to GRDC and DAFWA for funding the soil water repellence project: DAW00244 'Delivering enhanced agronomic strategies for improved crop performance on water repellent soils in WA'. This project is part of the GRDC's Soil Constraints West Initiative. We acknowledge the support of SouthernDIRT grower group, Tim Boyes (AgVivo consulting), Matt Sherriff (SACOA), Wayne Foot (SST), and John Hawkesford (Chemsol). We acknowledge and thank the host growers, their families and staff: Jono Clifton, Kojonup and Darren Morrell, Meckering. Thanks to Liam Ryan and Paul Blackwell (DAFWA) for peer review.

Overcoming subsoil constraints to increase soil carbon on Eyre Peninsula soils

Brett Masters and David Davenport
Rural Solutions SA, Port Lincoln

RESEARCH

Searching for answers

Location:
Crossville, Ungarra & Cockaleechie
Francis Beinke, Jamie Phillis, Terry Young, Geoff and Jim Holman

Rainfall
Cummins
Av. Annual: 422 mm
Av. GSR: 341 mm
2015 Total: 359 mm
2015 GSR: 302 mm
Cleve
Av. Annual: 401 mm
Av. GSR: 289 mm
2015 Total: 461 mm
2015 GSR: 329 mm

Yield
Cummins
Potential: 4.1 t/ha (W), 3.1 t/ha (C), 2.8 t/ha (L)
Cleve
Potential: 5.1 t/ha (B)

Paddock history
2014: Wheat (Holman)
2014: Barley (Phillis)
2014: Wheat (Young)
2014: Wheat (Beinke)

Soil Type
Beinke, Crossville - Hard setting sandy clay loam with socic subsoil layers
Phillis, Ungarra - Shallow sandy loam over high sodic red light clay on carbonate
Young, Ungarra - Sand over sodic clay
Holman, Cockaleechie - Acidic loamy ironstone soil on sodic clay

Plot Size
20 m x 8 m x 3 reps

Yield Limiting Factors
Very low rainfall from September to October on all sites.
Hot windy days in the first week of October causing moisture stress at flowering on lower EP sites

Key messages

- **Subsoil constraints can be addressed through application of appropriate soil modification and ameliorants.**
- **Results to date have varied.**
- **Biomass responses to treatments do not always translate to increased yields.**

Why do the trial?

- To identify how soil organic carbon (SOC) levels can be increased on Eyre Peninsula soils with low SOC levels.
- To determine if treatments to increase SOC also deliver yield increases relative to soil constraints, limiting delivering improved productivity and offsetting carbon dioxide emissions to the atmosphere.
- To improve amelioration techniques - deep ripping on poorly structured soils and the addition of clay to sandy soils, have delivered inconsistent results on Eyre Peninsula (EPFS Summary 1999, p72, EPFS Summary 2000, p105, EPFS Summary 2005, p129, EPFS Summary 2010, p154, EPFS Summary 2011, p166, EPFS Summary 2014, p207).

How was it done?

Four replicated trial sites and three demonstration site were established in 2014 (Table 1).

Trials were monitored throughout the 2014 season with data collected on plant emergence, spring dry matter and crop yield (EPFS Summary 2014, p201). Results from 2014 were mixed, however clear yield benefits were recorded with the addition and deep incorporation of clay and organic matter at Terry Young's Ungarra site. The addition of organic matter also provided a biomass response on the sodic soil at Phillis', however there was no yield benefit at harvest. This is consistent with other trials where increased dry matter production did not necessarily lead to a yield benefit, particularly where there is a dry finish to the season. These trials were further monitored during the 2015 season.

What happened?

Good rains and mild conditions in April created ideal conditions for sowing and crop germination at all sites. Sites were sown and managed by the landholder as part of the larger paddock. Young's was the only site with significant differences in crop emergence between treatments. Plant densities were much higher than the control on plots that had a soil ameliorant (clay or organic matter) added ($P<0.05$). Crop germination was better on clay + spade + organic matter plots compared to unincorporated clay and spade + organic matter plots with no clay (Figure 1).

Regular rainfall events kept the soil profile damp with no evidence of waterlogging. Following dry matter cuts taken in September, rainfall was sporadic with below average rainfall recorded at all sites in September and October. Trials were harvested using SARDI small plot harvesters in December.

Beinke
Biomass data was highly variable with poorer growth on the 10 t/ha surface applied gypsum treatment. Whilst the dry matter levels were lower in the 10 t/ha gypsum treatments than the nil gypsum or 5 t/ha gypsum treatments, the differences were not significant and were not any better than the control. There were no differences in grain yields ($P>0.5$).

Soils

Table 1 Summary of replicated trial sites in 2014.

Co-operator / Location	Soil type	2015 Crop	Measurements	Treatments
Beinke, (FB) Crossville	Alkaline red brown earth	Barley	Plant emergence, Dry matter, Crop yield	Untreated, surface applied gypsum (5 and 10 t/ha), deep ripping, deep ripping + gypsum (10 t/ha), deep ripping + 10 t/ha gypsum + 10 t/ha organic matter (pea straw).
Phillis, (JP) Ungarra	Alkaline red brown earth	Lentils	Plant emergence, Dry matter, Root DNA, Crop yield	Untreated, surface applied gypsum (5 and 10 t/ha), deep mixing, deep mixing + 10 t/ha gypsum + 10 t/ha organic matter (vetch hay).
Young, (TY) Ungarra	Neutral sand over clay	Wheat	Plant emergence, Dry matter, Root DNA, Crop yield	Untreated; spaded; shallow clay (250 t/ha clay); deep incorporated clay, deep incorporated organic matter (10 t/ha vetch hay); deep incorporated clay + organic matter (10 t/ha vetch hay).
Holman, (JH) Cockaleechie	Acidic loamy Ironstone	Canola	Plant emergence, Dry matter, Crop yield	Untreated, surface lime (3 t/ha), deep ripping, deep ripping + lime, deep ripping + lime + organic matter (10 t/ha lupin chaff).

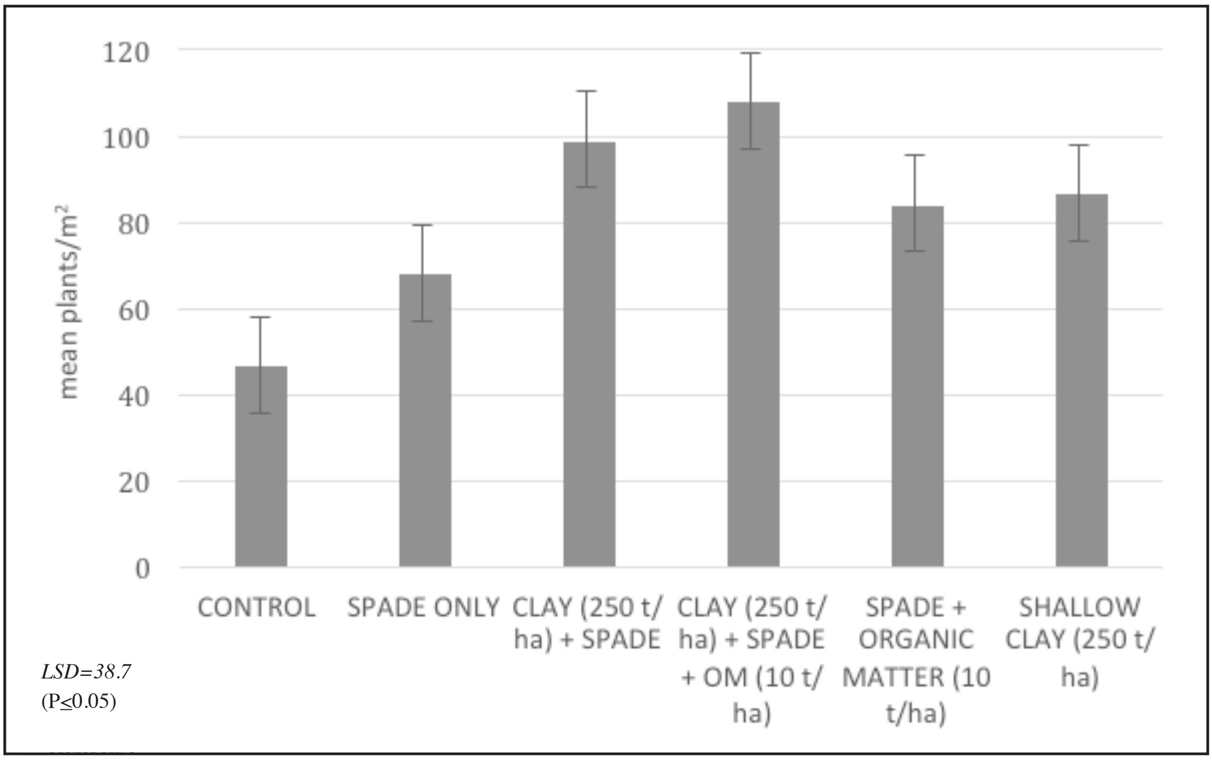


Figure 1 July wheat plant density at Young site, Ungarra in 2015.

Table 2 October lentil biomass, Phillis site, Ungarra.

	Mean biomass (t/ha)
Surface gypsum (10 t/ha)	1.73a
Surface gypsum (5 t/ha)	2.25ab
Control	2.60abc
Rip + gypsum (10 t/ha)	3.44cd
Rip + gypsum (10 t/ha) + organic matter (10 t/ha)	3.77d
LSD (P=0.05)	*0.951*

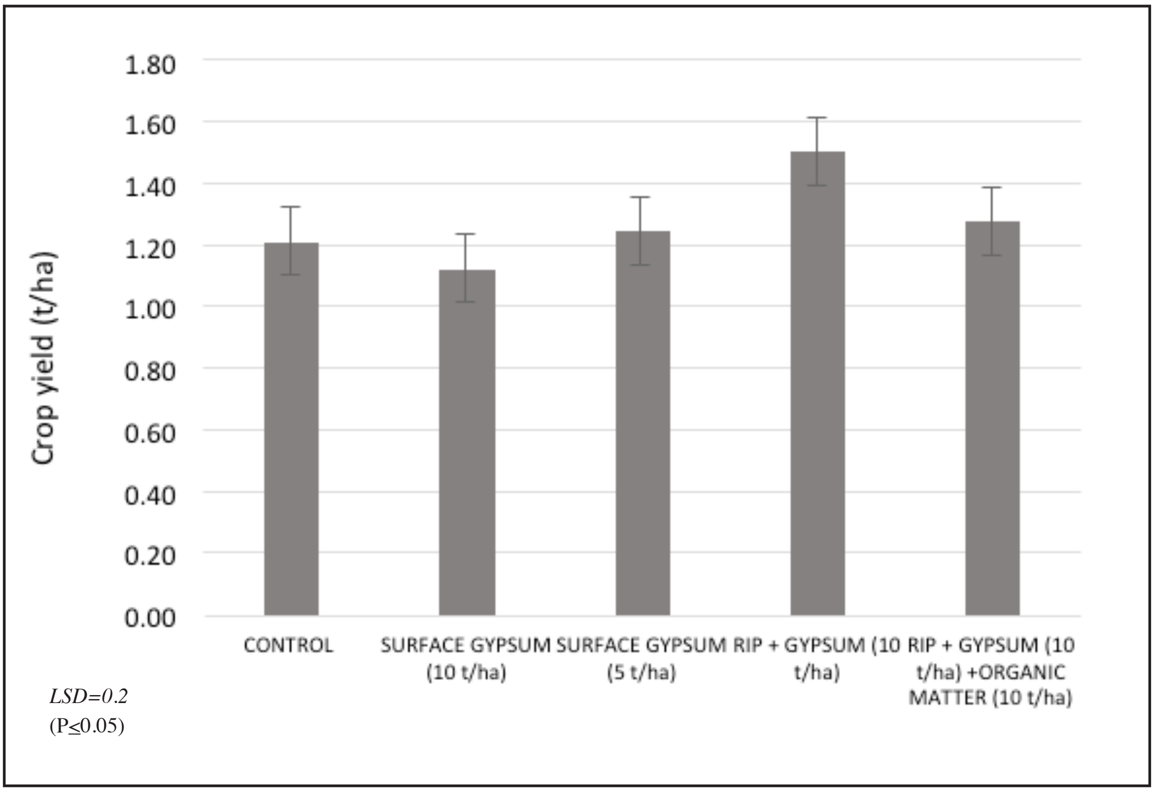


Figure 2 Lentil yield at Phillis site, Ungarra in 2015.

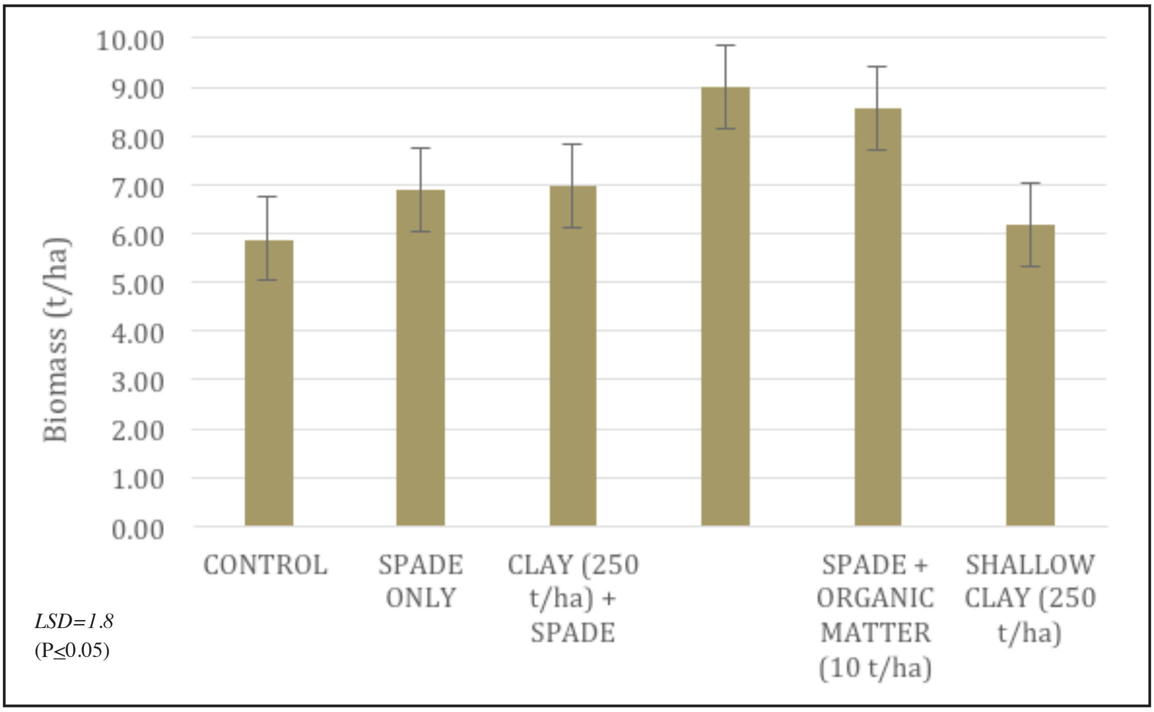


Figure 3 October biomass at Youngs site, Ungarra in 2015.

Phillis

There was biomass benefit from ripping gypsum into the soil. However, the only yield benefit was found by ripping in 10 t/ha of gypsum compared to the same amount surface applied gypsum treatments but no difference compared to the control. The ripping + gypsum + organic matter treatment was greater ($P<0.004$) than the control (Table 2).

However, the higher biomass did not lead to an increase in yield, with ripping + gypsum being the only treatment to have significantly higher grain yields (Figure 2).

Young

The addition of organic matter delivered increases in biomass production compared to those treatments without organic matter (Figure 3).

The highest crop yield was in the clay, spaded and organic matter treatment (3.17 t/ha) while the control had the lowest yield (1.78 t/ha). Spading treatments delivered significant yield increases compared to unspaded treatments (Figure 4).

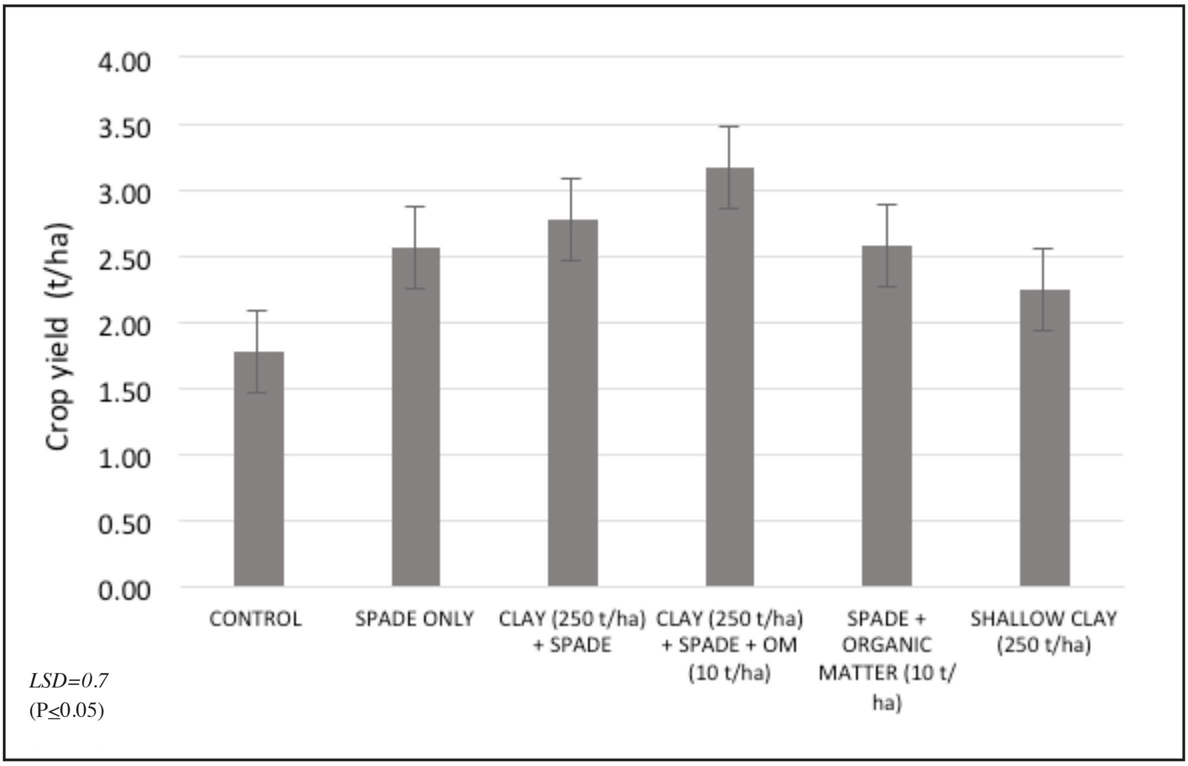


Figure 4 Wheat yield at Young's site, Ungarra in 2015.

Holman

The biomass data collected was highly variable with none of the treatments performing better than the untreated control (P>0.5). There was also no significant grain yield response to the treatments imposed at this site.

What does this mean?

There have been a number of factors that impacted on results this season. Seasonal rainfall – "ideal" growing conditions at Beinke's and Holman's to the middle of spring may have reduced the impact of subsoil constraints. The dry finish and hot days in early October may have had a greater impact on treatments with higher biomass and also on flowering wheat and lentil crops at Ungarra.

After two seasons it would appear that the treatments applied to the Beinke and Holman sites are yet to deliver major production increases. Biomass increases from some treatments (e.g. ripping + gypsum + organic matter) have been observed at the Phillis site but have yet been able to deliver significant yield increases. Results from the Young site support earlier work which has shown that while clay incorporation into sandy soils can deliver yield increases, further increases can be realised by incorporating clay and organic matter into the bleached, sandy subsoil horizons. There was also a benefit from ripping with gypsum applications compared to surface applied gypsum at Phillis'.

Soil analysis is currently being conducted on the sites to identify changes to soil characteristics. Further monitoring of these sites will occur to further investigate;

- How long before responses from soil applied ameliorants can be expected?
- How long the potential gains may last?
- What are the implications for soil carbon?
- What are the costs/benefits of these treatment options?
- Are there adjustments to current treatments that may provide better outcomes?

Acknowledgements

The authors would like to thanks the landholders involved in this project; Francis Beinke, Jamie Phillis, Terry Young and Geoff and Jim Holman. We would also like to thank Rebecca Tonkin and Amanda Schapel for undertaking statistical analysis of the dry matter and yield data. This project is supported by Natural Resources Eyre Peninsula with funding from the Australian Government.

Government of South Australia
Eyre Peninsula Natural Resources Management Board

Government of South Australia
Department of Environment, Water and Natural Resources

Australian Government | National Landcare Programme

Section Editor:
Andrew Ware
SARDI, Port Lincoln

Section 8

Pastures

Identifying the causes of unreliable N fixation by medic based pastures

Brian Dzoma[1], Ross Ballard[2], Nigel Wilhelm[1,2] and Ian Richter[1]
[1]SARDI, Minnipa Agricultural Centre, [2]SARDI, Waite Research Precinct

RESEARCH

Searching for answers

Location:
Piednippie
Rainfall
Av. Annual: 300 mm
Av. GSR: 220 mm
2015 Total: 215 mm
2015 GSR: 179 mm
Paddock History
2015: Mace wheat
2014: Pasture - oats
2013: Mace wheat
Soil Type
Calcareous grey sand
Plot Size
10 m x 1.5 m x 3 reps

Location:
Pinbong
Rainfall
Av. Annual: 320 mm
Av. GSR: 225 mm
2015 Total: 286 mm
2015 GSR: 260 mm
Paddock History
2015: Medic
2014: Mace wheat
2013: Mace wheat
Soil Type
Red sandy loam
Plot Size
10 m x 1.5 m x 3 reps

Key messages

- **Nodulation and shoot dry matter in medics is depressed by poor phosphorus (P) nutrition and in-crop application of certain herbicides.**
- **Applying P when establishing a medic pasture boosts shoot and root dry matter and improves root health.**
- **The timing of application of certain herbicides can have an important effect on maximum shoot dry matter.**
- **High soil nitrogen levels can reduce nodulation in medic pastures.**

Why do the trial?

Annual medics (*Medicago spp.*) are self-regenerating pasture species that are well suited to crop rotations on neutral to alkaline soils. In southern Australia's semi-arid agricultural zones, medics provide feed for livestock, improve soil fertility through nitrogen fixation and act as a disease break for many cereal root pathogens.

Current farming systems are facing a decline in soil fertility under intensive cereal and canola cropping, and reports of lowering protein levels in wheat have become common throughout the cropping districts of southern Australia, including those where medic-based pastures are the most common.

Many medic pasture phases are now being managed to produce vigorous medic dominant pastures using a range of herbicides and pesticides to control weeds and pests. However, it appears that some of these pastures are not producing high N reserves for the following cereal crops. The broad aim of this SAGIT funded project is to assess the impact of soil nutrition, current herbicides, adjuvants and rhizobial inoculants on nitrogen (N) fixation by medics under field conditions typical of the upper Eyre Peninsula. These results should also be relevant to other low rainfall Mallee systems.

Table 1 Treatment details.

Treatment	Active ingredient	Chemical group	Application rate (units/ha)
Post-emergence			
Agritone 750	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Broadstrike	800 g/kg Flumetsulam	B	25 g + uptake oil
Ecopar	20 g/L Pyraflufen-ethyl	G	400 ml
Agritone 750	750 g/L MCPA	I	330 ml
Propyzamide 500 WP	500 g/kg Propyzamide	K	1000 ml
Verdict*	520 g/L Haloxyfop	A	75 ml + uptake oil
Clethodim	240 g/L Clethodim	A	375 ml + uptake oil
Agritone 750 - Late ^	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Chemical residues			
Intervix	33 g/L Imazamox; 15 g/L Imazapyr	B	5 ml
Logran	750 g/kg Triasulfuron	B	0.125 g
2,4-D Amine	625 g/L 2,4-D (as dimethylamine salt)	I	10 ml
Control	No inoculum, no fertiliser, no herbicide		
Nutrition	Delivered as:		
Nitrogen	Urea	100 kg	
Phosphorous	Phosphoric acid	10 kg	
Sulphur	Gypsum	100 kg	
Zinc	Zinc sulphate	2 kg	
Manganese	Manganese sulphate	3 kg	

**Verdict applied at Piednippie and Clethodim at Pinbong*
^ Late Agritone treatment applied when medic plants were 5-7 cm in diameter

How was it done?

Two replicated field trials were established in different biophysical regions of the Eyre Peninsula; one representative of typical mallee environments in SE Australia (Greg Scholz - Pinbong) on a grey highly calcareous sandy soil (Brent Cronin - Piednippie). Background rhizobia populations, soil moisture and soil fertility were determined prior to seeding. Treatments to simulate herbicide residues (Table 1) were imposed on 28 April 2015 and the trials were later sown on 13 May 2015 (Pinbong) and 14 May 2015 (Piednippie) with all nutrition treatments applied at sowing. Both trials were sown as a split plot design with the main plots being two contrasting and commercially popular medic varieties (Angel and Herald), and management options (nutrition, herbicides and inoculants) applied to both varieties. Post emergence herbicide treatments were applied after the third trifoliate leaf stage on 8 July 2015 (Pinbong) and on 30 July 2015 (Piednippie) at a water rate of 100 L/ha, with the exception of a late Agritone 750 treatment that was later imposed when medic plants were 5-7 cm in diameter (24 August 2015). Plots were kept weed free as much as possible.

Sampling at the end of September 2015 estimated medic productivity and samples will be used to estimate N_2-fixation by the ^{15}N natural abundance technique. The number of viable nodules, root health and root weight were also measured at this time. Contribution to N reserves in the soil will also be measured by sampling for mineral N in the root zone in autumn 2016.

What happened?

Cold conditions after sowing mid-May slowed establishment and early dry matter production. Whilst there were subtle differences in the performance of Herald strand medic and its mutant hybrid Angel which has tolerance to sulfonylurea herbicide residues, larger differences were measured between herbicide and nutrition treatments, hence results below are presented as the average of both varieties. Plant density was not affected at either site by the treatments imposed, including the herbicide residue simulations.

Piednippie

A growth response to phosphorous (P) and zinc (Zn) was visible during the early stages of the trial, however, when measured, only P increased shoot dry matter (DM) compared to the control, 1.3 t/ha compared with 0.52 t/ha, respectively (Figure 1). In terms of late dry matter, only Agritone 750 sprayed late reduced DM, by 40% and the effect was clearly visible in the trial. Medic nodulation scores (measured approximately 8 weeks after sowing) were lower for the Agritone 750, Ecopar + Agritone 750 and urea treatments compared to the control. No treatments increased nodulation score compared to the control (Figure 1).

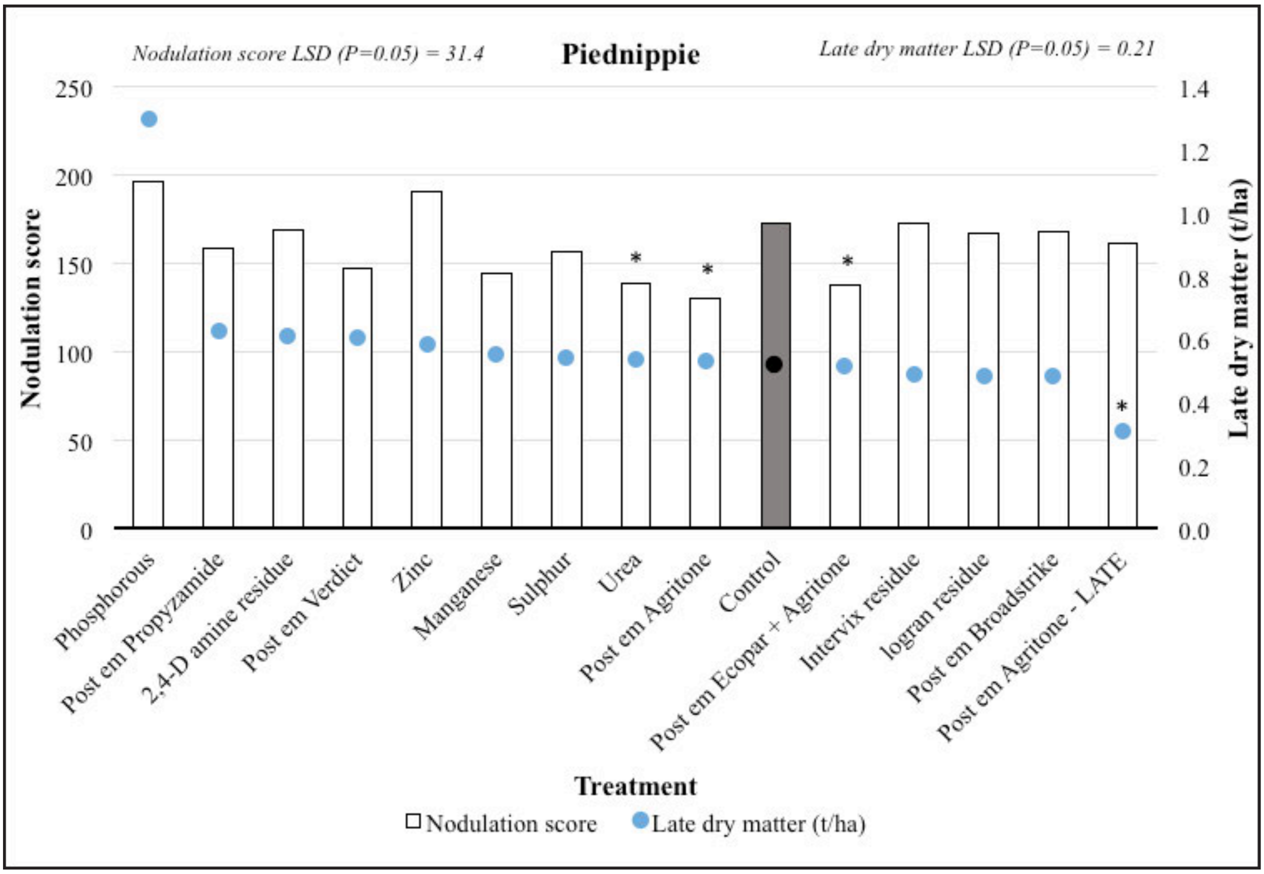


Figure 1 Nodulation scores and late dry matter (t/ha) for Piednippie 2015. *Nodulation score is a calculated value that takes account of the number, location and appearance of nodules on the root system. Higher values indicate better nodulation.*

**Significantly lower than the control (P<0.05)*

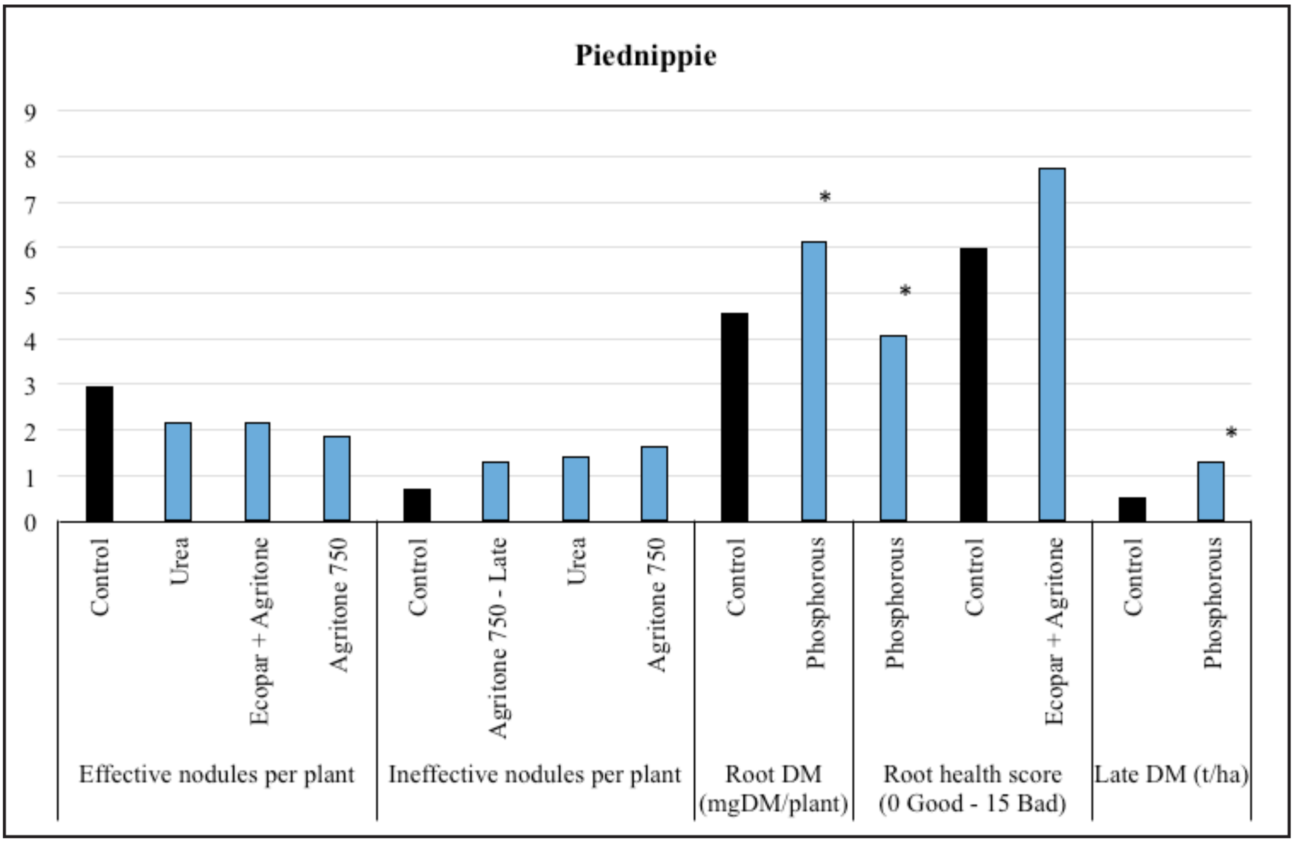


Figure 2 Treatment effects that are significantly different from the control at the Piednippie site in 2015.

Pastures

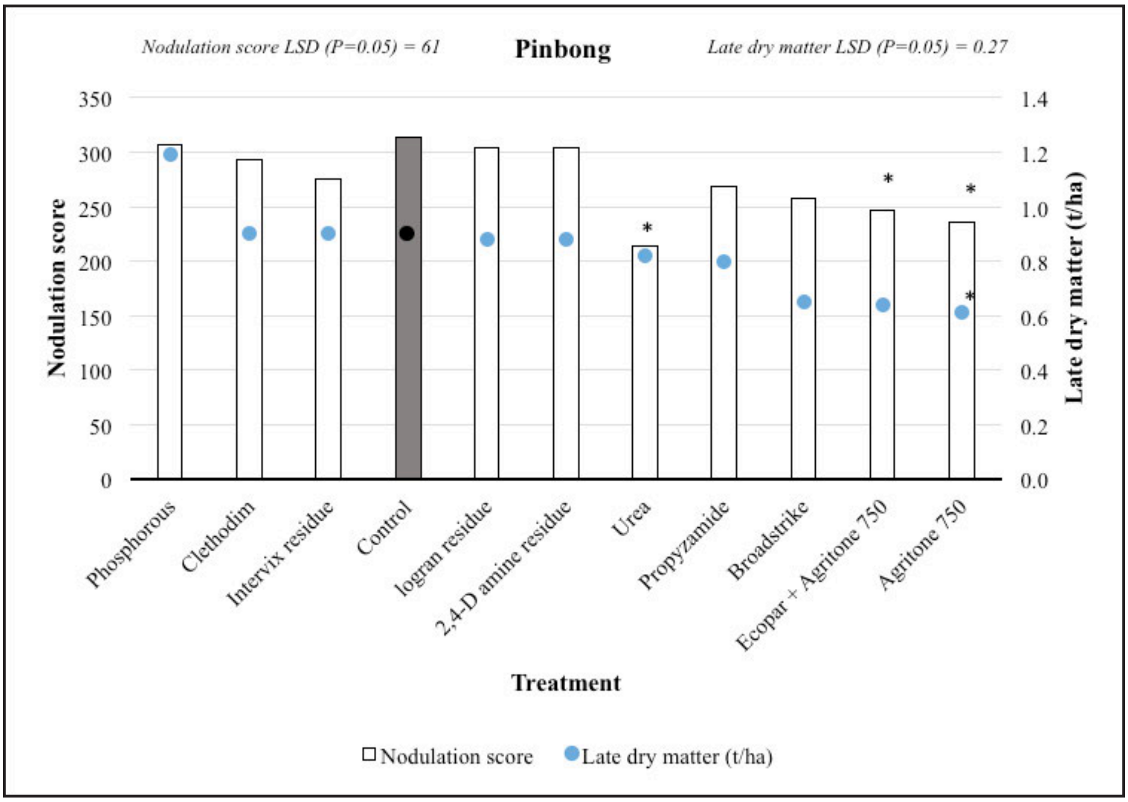


Figure 3 Nodulation scores and late dry matter (t/ha) for Pinbong 2015.
**Significantly lower than the control (P<0.05)*

Urea, Agritone 750 and Ecopar + Agritone 750 proved to be detrimental to nodulation, with lower numbers of effective nodules and higher numbers of ineffective nodules per plant (Figure 2). Phosphorous also proved to be the stand out treatment with the highest nodulation score, late DM, effective nodules per plant, root DM; and the best root health score (4.1). The Ecopar + Agritone mix had the worst root health score (7.8), which was substantially more than the control (6.0).

Pinbong

Plant populations (plants/m2) for both sites were almost the same, Pinbong (136) and Piednippie (135), however the Pinbong site germinated and established earlier than the Piednippie site because of differences in soil type. These differences ultimately affected the performance of the medics and the Pinbong site produced more herbage (0.83 t DM/ha) than Piednippie (0.58 t DM/ha). The effect of nutrition treatments on the medic was not as visually pronounced as it was at Piednippie, nonetheless, in terms of dry matter the P treatment was the only treatment substantially better than the control with 1.2 t DM/ha (Figure 3). Agritone 750 reduced late DM by 32% from the control. Nodulation scores for Agritone 750, Ecopar + Agritone 750 and urea treatments were lower than the control, however no other treatments performed consistently better than the control (Figure 3).

The number of effective nodules per plant was reduced by Broadstrike, Agritone 750, urea and Ecopar + Agritone 750 (Figure 4). These treatments, apart from Broadstrike resulted in a corresponding increase in the number of ineffective nodules, with Ecopar + Agritone 750 causing the medic to have the most number of ineffective nodules. Root DM (mg DM/plant) was decreased by urea, Broadstrike and Propyzamide, with all 3 reducing root DM/plant by about 22% compared to the control. Note that the latter two chemicals did not affect late DM on the grey calcareous sand at Piednippie.

What does this mean?

The value of legume pastures in farming systems is strongly influenced by how well they grow and fix N. High shoot DM yields mean high carrying capacity, better economic returns and potentially more N added to the system via N-rich legume residues from N fixation. On average, 20 kg N/ha is fixed for every tonne of legume shoot dry matter produced (GRDC Nitrogen fixation factsheet, 2014), therefore, a medic pasture producing 3 t/ha of DM might be expected to produce up to 60 kg N/ha in one year, which is equivalent to 140 kg/ha of urea. Variations around these average values are commonly measured. Treatments or conditions affecting nodulation, N-fixation or dry matter production can have positive or negative effects on the amount of N that is actually fixed.

P reserves (Colwell P, 0-10 cm) at Piednippie prior to sowing were 16 mg/kg and 21 mg/kg at Pinbong. Phosphorous (P) had a large and positive effect on shoot dry matter at both sites. There was a 33% and 150% increase in shoot DM at Pinbong and Piednippie respectively, resulting from the application of 10 units of fluid P/ha.

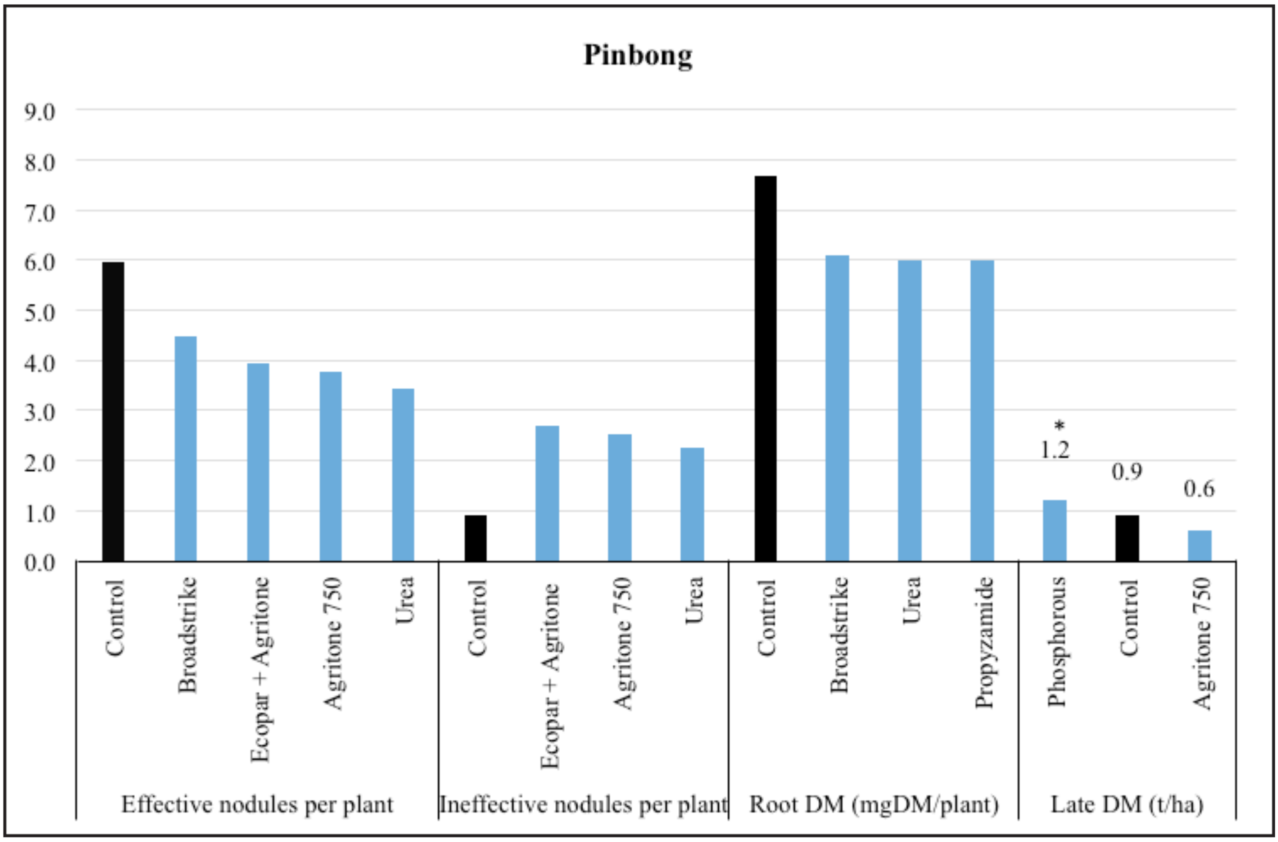


Figure 4 Treatment effects that are significantly different from the control at the Pinbong site in 2015.

If similar increases were achieved in a regenerating paddock with 3 t/ha of shoot DM, they would translate to between 20 and 90 kg/ha of extra fixed N. These amounts of fixed N are equivalent to 43 and 196 kg/ha of urea, capturing an extra $14 to $65/ha value from the pasture phase (assuming the cost of urea is $330/tonne), (Indexmundi, 2015). These gains are greater if the comparison is made to some of the herbicide affected treatments.

Our trials indicated that there can be a shoot DM penalty if certain herbicides are used as part of the weed control program during the pasture phase. There was a 32% and 40% shoot DM penalty from using Agritone 750 at Pinbong and applying it late at Piednippie. Using the same methodology applied in the previous paragraph, these production penalties translate to 19 kg and 24 kg/ha less fixed N (equivalent to 42 kg and 52 kg/ha of urea). This penalty alone could substantially reduce the value of the weed control achieved by Agritone. Measures of reduced nodulation suggest that these loss estimates will likely increase when the N-fixation data is included.

These preliminary results show that there is an advantage to be realised in terms of pasture DM through the use of phosphorous when establishing new medic pastures, even on paddocks of moderate P reserves. Chemical weed control remains a vital component of integrated weed management in cropping systems, however some chemicals may have a negative effect on pasture DM and more specifically on nodulation and N-fixation when applied during the medic pasture phase. These effects must be balanced against the value of weed control they provide. The timing of application can also have negative consequences especially when chemicals are applied late in the season. We still await the N fixation results (from the ^{15}N technique) and soil mineral N from the 2016 autumn soil sampling. These results will allow us to calculate the precise effect of each treatment on the amount of N fixed and better understand its relationship to pasture DM and nodulation under upper EP conditions.

Acknowledgements

Thanks to Greg Scholz and Brent Cronin for allowing us to have the trials at their properties, and Andy Bates for his input in this project. This project is funded from SAGIT (SARDI 1515: Identifying the causes of unreliable N fixation by medic based pastures).
Registered products: see chemical trademark list.

References

GRDC (2014) *Nitrogen fixation factsheet. Southern and Western Regions. Nitrogen fixation of crop legumes: Basic principles and practical management.*

Indexmundi (2015) http://www.indexmundi.com/commodities/?commodity=urea&currency=aud. Accessed on 2/02/2016.

Pastures

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE
SAGIT

Improving medic pastures in low rainfall mixed farming systems - how to get the most ‘free’ N

Jessica Crettenden
SARDI, Minnipa Agricultural Centre

RESEARCH

Almost ready

Location:
Minnipa Agricultural Centre
Paddock S7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 8.46 t DM/ha
Actual: 5.37 t DM/ha
Paddock History
2014: Wheat
2013: Wheat
2012: Medic pasture
Soil Type
Red sandy loam
Soil Test
Organic C%: 0.6
Phosphorous: 2-22 mg/kg
Plot Size
22 m x 24 m x 3 reps
Yield Limiting Factors
Broadleaved weeds, aphids (late Sept.)
Livestock
Stimulated grazing

Key messages

- **The paddock utilised for the trial had a significant number of effective naturalised medic rhizobia. There was no rhizobial inoculation response.**
- **Total annual biomass was higher in the regenerating medic plots versus sown treatments due to earlier germination and growth of naturalised medic.**
- **Grazing increased overall medic production.**

Why do the trial?

Medics are a common and attractive break ‘crop’ option in low rainfall mixed farming systems due to their natural regeneration, good quality feed value, low cost maintenance and valuable nitrogen (N) fixation qualities. To capture these advantages, medic pastures need to be kept in a productive state to ensure that the seed bank is adequate and that the plant is fixing the N that is needed for the following crop.

In recent years, some medic pastures have been of poor quality due to a range of factors including chemical usage, incorrect grazing methods, mechanical damage and other modern farming practices, resulting in reduced production and subsequent N_2-fixation. Best practice medic production guidelines have already been established, however some of these techniques are not adopted due to the time and expense involved. For these reasons, many farmers are looking for simple practices to establish medic pastures and boost their production using cost and time efficient methods.

The aim of this trial was to look at current techniques used by farmers, or recommended by consultants, to improve medic pastures and determine the most effective method to optimise N_2-fixation. Biomass, nodulation and N_2-fixation differences between management practices, including inoculation treatments on both sown and regenerating medic stands were measured. The trial also investigated if grazing medic pastures in the break phase of the rotation benefits or impedes nodulation and subsequent N_2-fixation.

How was it done?

The trial was designed to mimic current options used by farmers to manage their regenerating and sown medic pastures, with a focus on treatments adding fertilizer and/or rhizobial inoculant in some form (Table 1). Simulated grazing (mowing) was imposed on half of each plot at opportune periods throughout the season, to imitate the grazing management of medic pastures in a mixed farming system. A site was located in a paddock that had grown wheat for the past two years.

The trial site was burnt on 15 April to remove stubble residue. Soil was sampled for pre-sowing soil water content, soil chemical analysis, deep soil N and rhizobia number and effectiveness on 4 May. Seed rhizobia counts were also measured prior to sowing. The site was prickle-chained on 9 May prior to sowing over two days on 18 and 19 May. Fertilizer broadcasting for treatment 5 occurred on 12 June prior to a substantial rainfall event. Plant counts were taken prior to prickle-chaining to determine early germination and at establishment stage on 15 June after sowing. Grass weeds were sprayed out of all treatments using 200 ml/ha of Elantra Xtreme and Hasten spray adjuvant @ 500 ml/100 L water on 16 July. Plant samples were taken for nodulation assessment on 4 August. Biomass was measured and simulated grazing on half of each plot was imposed on the regenerated medic only (treatments 1-5) on 17 August due to their advanced growth compared to the sown treatments.

Table 1 Number, sowing method, seed type and rate of trial treatments.

No.	Sowing method*	Seed type**	Treatment
1	R	Nil	Control
2	R	Nil	Inoculum liquid mix*** sprayed on regenerated medic
3	R	Nil	None (in-season opportune treatment)
4	R	Nil	In-furrow inoculum liquid mix*** applied to regenerated medic
5	R	Nil	Fertiliser broadcast @ 50 kg/ha MAP
6	S	B	Sown
7	S	C	Sown (commercial seed coat)
8	S	B	Sown, pre-coated with peat slurry inoculant
9	S	B	Sown with in-furrow inoculum liquid mix***
10	S	C	Sown (commercial seed coat) with fertiliser @ 50 kg/ha MAP
11	B	C	Seed broadcast (commercial seed coat) and prickle-chained
12	S	B	Powdery Mildew tolerant medic seed (new variety), pre-coated with peat slurry inoculant

**Sowing method: R=regenerated, S=sown (10 kg/ha), B=broadcast (10 kg/ha)*
***Seed type: B=bare, C=commercial pre-coated treatment (Jaguar variety)*
****Inoculum liquid mix created through peat inoculant hung by tea-bag (stockings) in spray/liquid fertiliser tank and dissolved in water (in-furrow or sprayed @ 10 kg/ha peat inoculant with 100 L/ha water)*

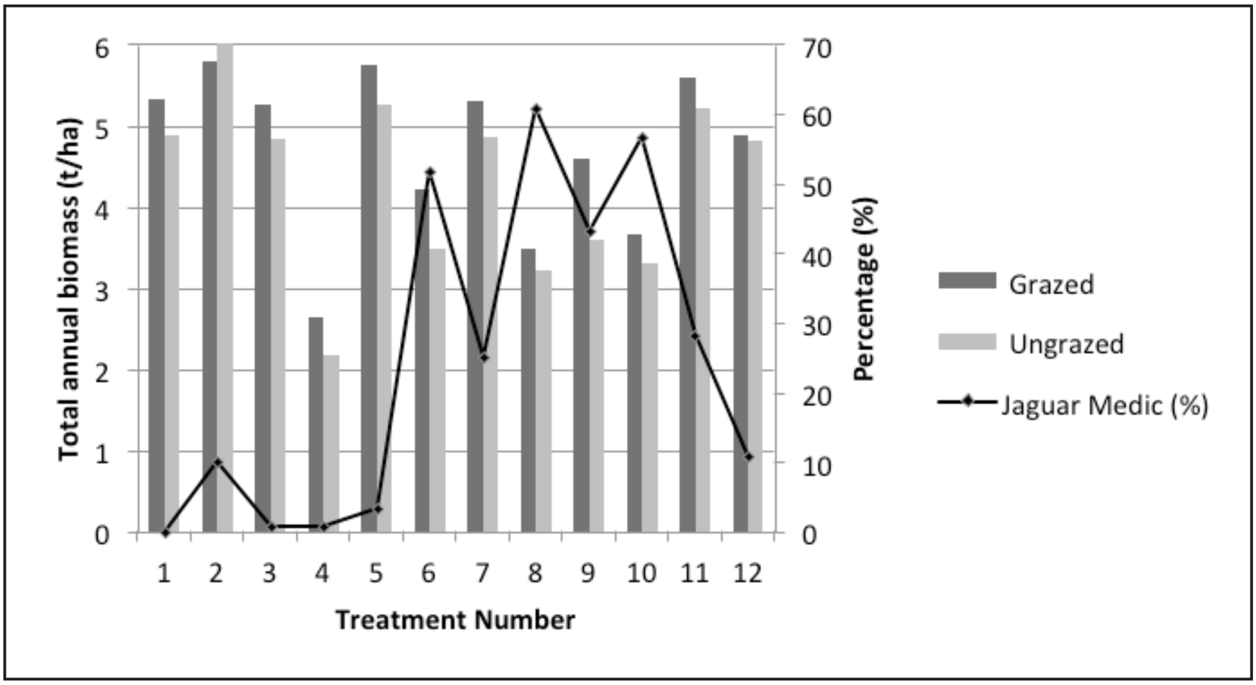


Figure 1 Total annual biomass figures treatment and grazed versus ungrazed differences LSD (P=0.05) is 2.2 and the percentage of Jaguar medic LSD (P=0.05) is 26.

Biomass cuts were taken and the percentage of grass and broad-leaved weeds, in addition to sown versus regenerated medic plants (visual through marked leaves) were recorded in all treatments prior to the second grazing simulation on 16 September. Anthesis biomass was measured on 2 November. Sampling for post-anthesis soil water content occurred on 21 December, and soil N will be measured prior to sowing in 2016.

What happened?

Plant growth and type

Establishment plant counts ranged from 217-426 plants/m^2 for all treatments other than treatments 4 and 5, which recorded lower plant counts of 74 and 171 plants/m^2 respectively. Treatment differences were measured in the percentage of sown medic (Jaguar medic with prominent leaf marker) compared to the naturalised medic (which has no leaf marker) in-season, with sown treatments containing 40% more Jaguar plants (Figure 1).

Biomass after the first graze was higher in the ungrazed plots with 3.1 t/ha versus 2.0 t/ha measured in the grazed plots a month after the first simulated grazing event. There were also treatment differences measured at this time with treatment 12 recording the highest biomass of 3.2 t/ha and treatments 8 and 4 measuring the lowest at 1.9 and 1.7 t/ha respectively. All other treatments ranged from 2.2 to 2.9 t/ha.

Dry matter (DM) measured approximately six weeks after the second graze (at anthesis) showed differences between all treatments, ranging from 2.1 to 4.3 t/ha in treatment 8 and the control respectively. The ungrazed plots had higher biomass than the grazed treatments at anthesis, averaging 4.3 t/ha versus 2.3 t/ha. Total annual biomass differed between treatments with an average of 0.4 t/ha more biomass measured in the grazed versus the ungrazed plots, which is summarised in Figure 1.

Soil water and nutrition

The measured available soil N content in the root zone at seeding averaged 25.3 kg/ha plus an estimated 24.5 kg/ha N had mineralized, which resulted in an average of almost 50 kg/ha N likely to be available to the plant throughout the growing season. Pre-seeding soil nutrition tests also showed the site had low Colwell phosphorous (P) levels, averaging 19 mg/kg with a moderate phosphorous buffering index (PBI), averaging 92.1 in the top 10 cm, meaning P levels and tie-up may have been a limiting factor to plant growth across the entire trial area.

Rhizobia and nodulation

The number of medic rhizobia pre-sowing averaged 9220/g soil (top 10 cm) and the effectiveness of these 'natural' rhizobia averaged 97% (relative to the commercial strain RRI128). There were no differences in nodule number or appearance between treatments. The average number of effective nodules on the tap roots and lateral roots was 4.1 and 1.7 nodules per plant respectively. The mean number of all nodules per plant was 7.3 which is reasonable for strand medic which is sometimes referred to as a 'shy' nodulator. A moderate level of root damage was observed. Root health score averaged 7.4 (0=good, 15=bad).

What does this mean?

Medic growth across the site was substantial in 2015. The timing of medic emergence and growth stages varied between treatments due to differences in treatment management around this period, which mostly correlated to biomass growth later in the season. Sown treatments 4 (cultivated at the time of liquid in-furrow inoculation), 6-10, and 12 had slower growth than the regenerated treatments due to late sowing, which resulted in these plots only being grazed once. Total annual biomass results showed that regenerated treatments produced more biomass per hectare, regardless of whether they were grazed or not, which is most likely due to earlier germination of naturalised medic and consequent greater production levels. It is important to note that how the pasture performs over the longer term following the introduction of the new cultivars is crucial to pasture improvement; therefore these results may not reflect the success of each treatment. In particular, comparing sown to regenerated medic should be determined by plant growth in the following season. For this reason, regeneration will be measured on the trial site in 2016.

Although not significant, grazed treatments showed a trend towards higher total biomass, which is most likely due to the initial medic establishment and ensuing substantial growth throughout the season. Grazing allowed the medic to boost production levels with timely rainfall events throughout the growing season.

Legume pastures typically fix around 20 kg/ha of N per tonne of dry matter (GRDC Nitrogen fixation factsheet, 2014). However, a poorly nodulated legume plant will contribute less fixed nitrogen to soil reserves, which can occur due to a number of agronomic factors affecting rhizobial persistence or the processes of nodulation (e.g. low soil pH, herbicide residues). The number of medic rhizobia measured at the site indicated that there were liberal numbers of 'natural' rhizobia and they were good at N_2-fixation. At these levels (and effectiveness), an inoculation response is unlikely because inoculating usually adds 100 rhizobia/g of soil (top 10 cm) and so the inoculant strain is outnumbered by more than 10:1.

The amount of N contributed from each treatment will be determined when soil nitrogen levels are measured prior to sowing the site in 2016. Medic regeneration on each treatment will also be measured in-season. The trial will be repeated in 2016 on a site that has a history of poor pasture establishment and production.

Acknowledgements

I gratefully acknowledge Jake Howie and Ross Ballard for their guidance throughout the trial and Leigh Davis, Brenton Spriggs, Brett McEvoy and John Kelsh for site establishment and management. The Eyre Peninsula Grain and Graze 3 project is funded by GRDC (SFS00028).

Registered products: see chemical trademark list.

Section 9

Section Editor:
Naomi Scholz
SARDI, Minnipa Agricultural Centre

Sharing Info

Water security – make every drop count

Mary Crawford
Sustainable Farming, Natural Resources Eyre Peninsula

Key messages

- **Start with reliable information about your property's water supply. Any assumptions need to be clarified. Know where the water is, how much is available and if it is fit for purpose.**
- **Carefully consider your current and future water needs. A little extra investment (planning and/or financial) to establish the most efficient and cost-effective design for your property will reduce operating costs and maximise performance in future.**
- **Don't skim on monitoring. Establish a robust water quality monitoring regime that reduces risks from leakage or low flow rates, pollution and contaminates.**

Water security on Eyre Peninsula is an essential requirement for running a farm business and can have a significant impact upon the livestock and cropping enterprise in relation to stock welfare, farm productivity and business profitability.

What is the issue?

Farmers have identified a number of key issues they consider either a threat to their water security or their business enterprise including:

- Price of mains water limiting sustainability or expansion of their livestock enterprise
- Unreliable flow rates, particularly for farmers at the end of supply lines
- High calcium levels causing scale in pipes
- Aging infrastructure (in the wrong place, subject to leakages and low flow rates)
- Limited options for new or expansion of dams, springs and bores due to lack of suitable surface or underground catchments, poor water quality and quantity and high evaporation rates.

Why is it an issue?

In periods of low rainfall or in low rainfall areas, water shortages can be a significant limitation to productivity. Poorly managed and monitored point source water supplies from springs and dams can result in silting, salinity and poor water quality.

A lack of water for livestock can mean having to cart water in or destock. Poor water quality can restrict the type of stock run or inhibit their productivity. Leakages or blockages in a system can also lead to livestock fatalities especially in extreme heat situations, if systems cannot be maintained and monitored effectively.

The quality of water used to mix with agricultural chemicals can reduce the effectiveness of the chemical applications. Poor quality water can:

- Reduce activity of agricultural chemicals
- Block spray lines or nozzles, reducing chemical application uniformity
- Increase wear of nozzles can also causing reduced chemical application uniformity
- Increase wear on spray rigs.

[Source: *NSW Dept of Primary Industries. Water quality for chemical spraying, Sandra McDougall*]

Water budgets – knowing how much you use and where it goes

The starting point in developing a sustainable farm water plan is undertaking an audit of the current water usage.

A water audit should:

- Identify water requirements (uses of water) on-farm
- Consider available water supplies on-farm including reliable off-farm water sources or other alternatives
- Check that the water quality meets livestock and/or cropping requirements
- Determine if water supply/ storage will meet maximum requirements, with enough storage and correct flow rates into troughs
- Consider current and future storage requirements
- Calculate current and potential losses through evaporation, leakages and wastage
- Include current and future costs, such as your time to monitor and repair or replace the water systems.

Information provided by the water budget along with an understanding of water distribution, quality and seasonal weather patterns can help guide decision-making on farm.

Current water infrastructure – knowing what you have and its condition

It is essential before developing a new water plan for the property to have an understanding of your current system:

- What does your current system look like?
- Are the pipes and water points in the right location?
- What is the current condition of the pipelines and water points? (e.g. corrosion, leaks, age of pipes, erosion etc.)
- Identifying the strengths, weaknesses, opportunities and threats to your infrastructure.

Planning for the future - ensure that the final design meets current and future needs

Don't let the familiarity of your current system cloud your thinking when looking at improving your farm water system. It is an ideal opportunity when evaluating your water system to revisit your farm plan and business model looking forward for the next 10-20 years.

The farm plan should intergrate:

- The economic, family and environmental goals of a farming business
- Physical capacity of the land and water resources
- Management, equipment and infrastucure requirements.

There are many advances in technologies and equipment that allow systems to be built which would have been impossible 30 years ago. Farmers are installing sheeted catchments, leak detection devices, tank monitoring telemetry, installing larger pipes and fittings for better flow rates.

The three steps in developing a new water system plan are:

1. Map your existing property layout and add all existing pipelines, dams, tanks and troughs,
2. Identify infrastructure which is a high priority to replace and
3. Draw in future water system infrastructure.

Checklist – have you thought of all the options?

- Ensure the final design of the system meets all the current and future requirements while being the most cost efficient and cost effective alternative.
- Cost comparisons should firstly consider sustainability followed by reliability, performance and operating costs.
- Potential interest on the capital outlay, depreciation, maintenance, labour and alternative energy sources (e.g. wind, solar or diesel) only become evident under sound investigations, planning and design.
- A little extra spent on set-up costs is far outweighed by benefits in performance and reduced operational costs.
- Sound planning also allows for the water system to be implemented in stages to suit annual budgeting and development programs.
- Never be afraid to ask for advice.

Further information

EP NRM Website naturalresources.sa.gov.au/eyrepeninsula/land-and-water/sustainable-agriculture/farm-water

SheepConnect SA website www.sheepconnectsa.com.au

GWM Water - On-Farm Water Reticulation Guide http://www.gwmwater.org.au/services/wimmera-mallee-pipeline

AWI – Stock Water – a limited resource https://www.wool.com/globalassets/start/on-farm-research-and-development/sheep-health-welfare-and-productivity/sheep-nutrition/awi-drought-resources/gd0387_stock_water_rnd_final_low-res.pdf

Acknowledgements

Water Use On Farm workshops are supported and funded by the Australian National Landcare Program and the Eyre Peninsula Natural Resources Management Board. Thank you to Linden Masters, Geraldine Turner, Corey Yeates, and Luke Nettle for their support for this project. Thank you to all the presenters who supported the day, sharing their knowledge and expertise.

Government of South Australia
Eyre Peninsula Natural Resources Management Board

Australian Government | National Landcare Programme

Farmers leading the way with emissions reduction

EXTENSION

Mark Stanley
Regional Connections Pty Ltd, Port Lincoln

Key messages

- **Farmer involvement is critical to reducing global greenhouse gas emissions.**
- **Whilst opportunities are currently limited for broad acre farm involvement, new methods for entering the Emissions Reduction Fund are being developed.**
- **Consider closely the costs and benefits of entering into a carbon trading scheme and use professional advice.**
- **The Carbon Farming Knowledge project provides local expertise to understand the opportunities in carbon farming.**

Background

The farming sector is critical to the achievement of emission reduction targets being set by nations across the world. This presents farmers with a range of opportunities to become involved in emissions reduction and carbon sequestration. Whilst these opportunities may currently be small for most broad acre farming businesses, this will increase as research unveils more opportunities for farmers to increase their operational efficiencies and to store carbon on their properties. The Carbon Farming Knowledge project, which involves five private farm advisers on the Eyre Peninsula, continues to drive the understanding and practical responses to reducing greenhouse gas emissions through improved crop and livestock management and carbon sequestration.

Carbon trading in practice

Carbon trading is designed to direct investment to the most cost-effective emissions reduction activity. New activities that reduce the levels of greenhouse gases being emitted into the atmosphere may create Australian Carbon Credit Units (ACCUs).

An ACCU is issued based on a farmer's ability to prove a reduction in greenhouse gas emissions or carbon sequestration over time associated with a parcel of land. It comes down to 'what would emissions have been like if the current on-farm practice continued' versus 'how have emissions been reduced as a result of making a change to on-farm practices'.

There are many sources of possible reductions, such as fertiliser and manure management, reduction of enteric (intestinal) fermentation, avoided deforestation, crop residue management, rice emissions management, legacy landfill emissions, waste management and savannah burning management.

Farmers are storing carbon in the landscape in a number of ways, such as native vegetation plantings, agroforestry, improving forest management and soil carbon sequestration through plant residue management and changing crop land to perennial pastures. For any farmer to earn carbon credits they must undertake their activity using an approved Emissions Reduction Fund method.

Factors to consider

Farmers deciding whether to pursue opportunities in the carbon trading market should consider the following:

Get professional advice

Independent legal advice is recommended or the use of a recognized expert in the carbon trading market. A professional adviser will assess how difficult and costly the project is to implement, do some preliminary calculations to assess viability and consider the project timeframe. Farmers must consider how difficult the project will be to implement, and the risks and returns.

Consider the benefits

Setting up a carbon farming project to trade credits is not cheap. For example, estimates are that undertaking a reforestation project can cost $200,000 because of the monitoring, reporting, verification and onsite visits. The 30% of gross income is the industry rule for what carbon managers are paid with on average 70% of the sale price going to landholders. However, farmers who have taken up projects believe the value in participation is not only in the sale of ACCUs but also in improving farm efficiency, profitability and productivity.

References

The National Greenhouse Gas Inventory – http://ageis.climatechange.gov.au/

The Carbon Farming Initiative – www.mycarbonfarming.com.au

Ben Keogh, Australian Carbon Traders.

Moving from the Carbon Farming Initiative to the Emissions Reduction Fund

At the end of 2014, the Carbon Farming Initiative (CFI) was incorporated into the Emissions Reduction Fund (ERF), expanding the scope of the program beyond the land sector. The Australian Government purchases ACCUs from eligible projects through reverse auctions. To be eligible to participate in a reverse auction, projects must use an approved method to reduce greenhouse gas emissions or store carbon. Methods explain the way in which projects that aim to product carbon credits are to run to ensure these projects are scientifically valid.

Emissions Reduction Fund Methods

There are twenty two approved ERF methods, covering agriculture, vegetation management, energy efficiency, mining, transport, waste and wastewater.

Approved methods are limited to initiatives that can be proven to reduce emissions or store a known amount of carbon e.g. research by the Cotton Research and Development Corporation has enabled a method to be approved for improving nitrogen fertiliser efficiency in cotton. However, in the grains industry, the effects of fertiliser efficiency are more difficult to quantify and so no method is currently approved.

Methods are under development for soil carbon using default values and beef cattle herd management. In the future it is expected that methods will be developed for nitrogen fertiliser use efficiency in other industries and for sheep flock management.

References:

The National Greenhouse Gas Inventory – http://ageis.climatechange.gov.au/

Greenhouse in Agriculture - www.greenhouse.unimelb.edu.au

Primary Industries Climate Challenge Centre – www.piccc.org.au

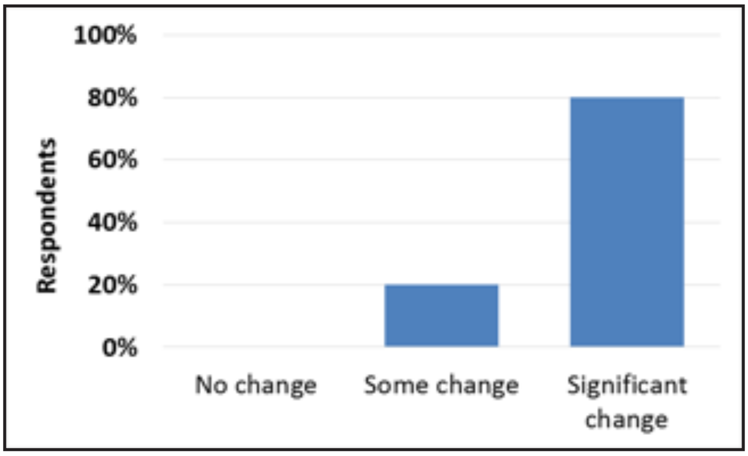


Figure 2 Advisor rating of the change in knowledge (from October 2013 to August 2015) of the Emissions Reduction Fund (formerly the Carbon Farming Initiative) and the various emissions reduction techniques available.

Emissions Reduction Fund Auctions

In the first round of auctions held in April 2015, 258 projects were registered, with 144 successful in selling ACCUs (Figure 1). The successful bids ranged from 12,000 tonnes to 3.5 million tonnes of CO_2-e (carbon dioxide equivalents), with 73 percent relating to the CFI categories of agriculture, landfill and vegetation management.

The second auction was held on November 4-5, 2015. $557 million was spent for 45 million tonnes of carbon abatement at an average of $12.25 per tonne with land use projects again dominating, contracting 80% of the funding.

Reference

Emissions Reduction Fund - www.environment.gov.au/climate-change/emissions-reduction-fund

Attitudes to Carbon Farming

The Carbon Farming Knowledge project continues to drive the understanding and practical responses to reducing carbon emissions through improved crop and livestock management and engaging in carbon reduction markets. The ‘model’ used to build adviser knowledge and confidence has been highly successful.

Advisors now have greater confidence in identifying and discussing possible greenhouse gas reducing practices with their farmer clients. A lack of benefits to a client’s business is now the primary barrier identified by advisers to adoption of greenhouse reducing practices, not financial implications or resources (that were identified at the start of the project).

Carbon Farming Knowledge project contacts

The Eyre Peninsula has five advisers involved in the project. If you want to learn more about carbon farming give one of them a call:

- Ed Hunt, Wharminda
- Brian Ashton, Port Lincoln
- Andy Bates, Streaky Bay
- Josh Hollitt, Port Lincoln
- Mark Stanley, Port Lincoln

For up to date technical and policy information on carbon farming and the opportunities it presents follow the Carbon farming Knowledge project web site on www.carbonfarmingknowledge.com.au and subscribe to news blogs and newsletters on the site.

Acknowledgements

This project is supported by funding from the Australian Government.

Building Farmer & Advisor Knowledge in **Carbon Farming**

Chemical product trademark list

Knock Down + Spikes

Alliance – registered trademark of Crop Care Australasia Pty Ltd
Boxer Gold – registered trademark of Syngenta Australia Pty Ltd
BroadSword - registered trademark of Nufarm Australia Limited
Brodal Options - registered trademark of Bayer
Bromicide 200 - registered trademark of Nufarm Australia Limited
Buttress- registered trademark of Nufarm Australia Limited
Goal – registered trademark of Dow Agrowsciences
Gramoxone - registered trademark of Syngenta Group Company
Hammer - registered Trademark of FMC Corporation
Kyte 700 WG - registered trademark of Nufarm Australia Limited
Nail 240EC – registered trademark of Crop Care Australasia Pty Ltd
Nuquat - registered trademark of Nufarm Australia Limited
Revolver- registered trademark of Nufarm Australia Limited
Roundup Attack - registered trademark of Monsanto Australia Limited.
Roundup PowerMax – registered trademark of Monsanto Technology LLC used under licence by Nufarm Australia
Spray Seed - registered trademark of Syngenta Group Company
Striker - registered trademark of Nufarm Technologies USA Pty Ltd
TriflurX – registered trademark of Nufarm Australia Limited
Weedmaster DST – registered trademark of Nufarm Australia Ltd

Cereal Broad Leaf

2,4-D amine – registered trademark of Dow AroSciences
Agritone 750 – registered trademark of Nufarm Australia Limited
Ally - registered trademark of Du Pont (Australia) Ltd or its affiliates
Amicicde625 - registered trademark of Nufarm Australia Limited
Archer - registered trademark of Nufarm Australia Limited
Broadside – registered trademark of Nufarm Australia Limited
Broadstrike – registered trademark of the Dow Chemical Company or an affiliated company of DOW
BromicideMA – registered trademark of Nufarm
Dual Gold - registered trademark of a Syngenta Group Company
Ecopar – registered trademark of Sipcam Pacific Australia Pty Ltd
Logran 750WG - registered trademark of Syngenta Group Company
Lontrel – registered trademark of Dow AroSciences
LV Ester 680 - registered trademark of Crop Care Australasia. Pty Ltd
LVE MCPA - registered trademark of Dow AroSciences
Tigrex - registered trademark of Bayer
Velocity - registered trademark of Bayer

Clearfield Chemical

Intervix - registered trademark of BASF

Triazine Tolerant (TT)

Gesaprim 600Sc - registered trademark of Syngenta Group Company
Lexone - registered trademark of Du Pont (Australia) Ltd or its affiliates
Supercharge - registered trademark of Syngenta Group Company

Adjuvants

Bonza - registered trademark of Nufarm Australia Limited
Chemwet 1000 – registered trademark of Nufarm
Hasten – registered trademark of Victorian Chemical Company Pty. Limited
Kwicken - registered Trademarks of Third Party SST Australia Pty Ltd
LI 700 - registered trademark of United Agri Products.
Spreadwet – registered trademark of SST Australian Pty Ltd

Grass Selective

Avadex Xtra - registered trademark of Nufarm
Clethodim – registered trademark of Syngenta Group Company
Elantra Xtreme – registered trademark of Sipcam Pacific Australia Pty Ltd
Factor – registered trademark of Crop Care Australasia Pty Ltd
Hoegrass - registered trademark of Bayer
Monza - registered trademarks of Monsanto Technology LLC used under license by Nufarm Australia Limited
Propyzamide - 4 Farmers Australia Pty Ltd
Raptor - registered trademark of BASF
Rustler – registered trademark of Cheminova Aust. Pty Ltd.
Sakura - registered trademark of Kumiai Chemical Industry Co. Ltd
Select – registered trademark of Arysta Life Sciences and Sumitomo Chemical Co. Japan
Targa - registered trademark of Nissan Chemical Industries, Co Japan
Verdict - registered trademark of the Dow Chemical Company or an affiliated company of DOW

Insecticide

Alpha Duo – registered trademark of registered trademark of Syngenta Group Company
Astound Duo - registered trademark of Nufarm Australia Limited
Dimethoate - registered trademark of Nufarm Australia Limited
Dominex Duo - registered trademark of Crop Care Australasia Pty Ltd
Karate Zeon - registered trademark of Syngenta Group Company
Lemat - registered trademark of Bayer
Lorsban – registered trademark of Dow Agrowsciences

Fungicide

Cruiser Maxx – registered trademark of a Syngenta Group Company
EverGol - registered trademark of the Bayer
Jockey - registered trademark of the Bayer
Stayer - registered trademark of the Bayer
Baytan - registered trademark of the Bayer
Raxil - registered trademark of the Bayer
Gaucho - registered trademark of the Bayer
Helix – registered trademark of a Syngenta Group Company
Impact – registered trademark of Cheminova A/S Denmark
Prosaro - registered trademark of Bayer
Uniform – registered trademark of a Syngenta Group Company
Vibrance - registered trademark of a Syngenta Group Company

Contact list for authors

Name	Position	Location	Address	Phone Number	E-mail
Bates, Andy	Principal Consultant	Bates Agricultural Consulting	PO Box 137 Streaky Bay SA 5680	Mob 0427 261 709	batesag@bigpond.net.au
Barr, James	PhD candidate	University of South Australia		Mob 0417 823 623	james.barr@unisa.edu.au
Brace, Dot	Executive Officer	EPARF	PO Box 31 MInnipa SA 5654	Ph (08) 8680 6202	dot.brace@sa.gov.au
Cook, Amanda	Research Officer	SARDI Minnipa Agricultural Centre	PO Box 31 Minnipa SA 5654	Ph (08) 8680 6217	amanda.cook@sa.gov.au
Crawford, Mary	Sustainable Farming Officer	DEWNR	PO Box 22 Port Lincoln SA 5606	Ph (08) 8688 3074 Mob 0407 187 878	mary.crawford@sa.gov.au
Crettenden, Jessica	Research Officer	SARDI Minnipa Agricultural Centre	PO Box 31 Minnipa SA 5654	Ph (08) 8680 6227	jessica.crettenden@sa.gov.au
Davies, Stephen	Research Officer - Soil Productivity	Department of Agriculture and Food, Western Australia	PO Box 110 Geraldton WA 6530	Ph (08) 9956 8515 Mob 0408 439 497	stephen.davies@agric.wa.gov.au
Davis, Leigh	NVT Senior Agricultural Officer	SARDI Minnipa Agricultural Centre	PO Box 31 Minnipa SA 5654	Ph (08) 8680 6200 Mob 0428 288 033	leigh.davis@sa.gov.au
Day, Sarah	Research Officer	SARDI Field Crop Improvement Centre	PO Box 822 Clare SA 5453	Ph (08) 8842 6264	sarah.day@sa.gov.au
Dzoma, Brian	Research Officer	SARDI Minnipa Agricultural Centre	PO Box 31 Minnipa SA 5654	Ph (08) 8680 6205	brian.dzoma@sa.gov.au
Egarr, Andrew	Wheat Breeder	Australian Grain Technologies	Perkins Building Roseworthy Campus Roseworthy SA 5371	Ph (08) 8313 1276 Mob 0435 608 182	andrew.egarr@ausgraintech.com
Evans, Margaret	Senior Research Officer	SARDI Plant Research Centre	PO Box 397 Adelaide SA 5001	Ph (08) 8303 9379	marg.evans@sa.gov.au
Frischke, Alison	Grain & Graze Systems Officer	BCG	PO Box 167 Eaglehawk VIC 3556	Ph (03) 5437 5352 Mob 0429 922 787	alison@bcg.org.au
Guerin, Simon	Chair	EPARF	Post Office Port Kenny SA 5671	Ph (08) 8625 5143 Mob 0427 255 144	simonlizguerin@bigpond.com
Hunt, James	Senior Lecturer	LaTrobe University Department of Animal, Plant and Soil Sciences	5 Ring Road, La Trobe University Bundoora VIC 3086	Ph (03) 9032 7425	j.hunt@latrobe.edu.au
Kleemann, Sam	Research Officer	University of Adelaide	PMB 1 Waite Campus Glen Osmond SA 5065	Ph (08) 8303 7908	samuel.kleemann@adelaide.edu.au
Lamont, Helen	Executive Officer	LEADA	PO Box 3569 Port Lincoln SA 5606	Mob 0409 885 606	lamontconections@gmail.com
Linsell, Katherine	Research Officer	SARDI Waite	PO Box 397 Adelaide SA 5001	Ph (08) 8303 9437 Mob 0417 889 253	katherine.linsell@sa.gov.au
Loss, Stephen	General Manager - Farming Systems, Soils & Agronomy (South)	GRDC National Wine Centre	Hackney Rd & Botanic Rd, Adelaide SA	Mob 0408 412 453	stephen.loss@grdc.com.au
Mao, Dili	Research Officer	SARDI Field Crop Improvement Centre	PO Box 822 Port Lincoln SA 5606	Ph (08) 8842 6265	dili.mao@sa.gov.au
Masters, Brett	Soil & Land Management Consultant	Rural Solutions SA	PO Box 1783 Port Lincoln SA 5606	Ph (08) 8688 3460 Mob 0428 105 184	brett.masters@sa.gov.au
Mason, Dr Sean	Research Fellow	University of Adelaide	PMB 1 Glen Osmond SA 5064	Ph (08) 8303 8107 Mob 0422 066 635	sean.mason@adelaide.edu.au
McBeath, Therese	Ecosystem Sciences	CSIRO	PMB 2 Glen Osmond SA 5064	Ph (08) 8303 8455	therese.mcbeath@csiro.au
McDonald, Glenn	Senior Lecturer	University of Adelaide School of Agriculture, Food and Wine	PMB 1 Waite Campus Glen Osmond SA 5065	Ph (08) 8303 7358	glenn.mcdonald@adelaide.edu.au

Name	Position	Location	Address	Phone Number	E-mail
McKay, Alan	Senior Research Scientist	SARDI Waite Plant Research Centre	PO Box 397 Adelaide SA 5001	Ph (08) 8303 9375	alan.mckay@sa.gov.au
McMurray, Larn	Senior Research Agronomist	SARDI - Field Crop Improvement Centre	PO Box 822 Clare SA 5453	Ph (08) 8842 6265	larn.mcmurray@sa.gov.au
Moodie, Michael	Principal Consultant	Mallee Sustainable Farming		Mob 0448 612 892	michael.moodie@msfp.org.au
Mudge, Barry	Principal Consultant	Barry Mudge Consultant		Mob 0417 826 790	theoaks5@bigpond.com
Nagel, Stuart	Research Officer	SARDI Crop Improvement	PO Box 397 Adelaide SA 5001	Ph (08) 8303 9377 Mob 0407 720 729	stuart.nagel@sa.gov.au
Reseigh, Jodie	Senior Consultant	Rural Solutions SA	PO Box 31 Minnipa SA 5654	Mob 0428 103 886	jodie.reseigh@sa.gov.au
Scholz, Naomi	Project Manager	SARDI Minnipa Agricultural Centre	PO Box 31 Minnipa SA 5654	Ph (08) 8680 6233 Mob 0428 540 670	naomi.scholz@sa.gov.au
Stanley, Mark	Principal Consultant	Regional Connections Pty Ltd	PO Box 866 Port Lincoln SA 5606	Mob 0427 831 551	mark@regionalconnections.com.au
Telfer, Paul	Research Officer	Australian Grain Technologies	Roseworthy Campus Roseworthy SA 5371	Ph (08) 8303 7806 Mob 0418 805 297	paul.telfer@ausgraintech.com
vanRees, Harm	Consultant	Cropfacts Pty Ltd	69 Rooney Rd, RSD Mandurang South, 3551	Mob 0419 325 252	harm@cropfacts.com.au
Wallwork, Hugh	Principal Cereal Pathologist	SARDI Plant Research Centre	GPO Box 397 Adelaide SA 5001	Ph (08) 8303 9382 Mob 0427 001 568	hugh.wallwork@sa.gov.au
Ware, Andrew	Research Scientist	SARDI, Port Lincoln	PO Box 1783 Port Lincoln SA 5606	Ph (08) 8688 3417	andrew.ware@sa.gov.au
Wilhelm, Nigel	Farming Systems Leader Scientific Consultant	SARDI Minnipa Agricultural Centre Waite	PO Box 31 Minnipa SA 5654 GPO Box 397 Adelaide SA 5001	Mob 0407 185 501 Ph (08) 8303 9353 (Adel) Ph (08) 8680 6200 (Min)	nigel.wilhelm@sa.gov.au

Acronyms and Abbreviations

ABA	Advisory Board of Agriculture
ABARES	Australian Bureau of Agriculture and Resource Economic and Sciences
ABS	Australian Bureau of Statistics
ADWG	Average daily weight gain
AFPIP	Australian Field Pea Improvement Program
AGT	Australian Grain Technologies
AH	Australian Hard (Wheat)
AM fungi	Arbuscular Mycorrhizal Fungi
APSIM	Agricultural Production Simulator
APW	Australian Prime Wheat
AR	Annual Rainfall
ASW	Australian Soft Wheat
ASBV	Australian Sheep Breeding Value
AWI	Australian Wool Innovation
BCG	Birchip Cropping Group
BYDV	Barley Yellow Dwarf Virus
CBWA	Canola Breeders Western Australia
CCN	Cereal Cyst Nematode
CfoC	Caring for our Country
CLL	Crop Lower Limit
DAFF	Department of Agriculture, Forestry and Fisheries
DAP	Di-ammonium Phosphate (18:20:00)
DCC	Department of Climate Change
DEWNR	Department of Environment, Water and Natural Resources
DGT	Diffusive Gradients in Thin Film
DM	Dry Matter
DMD	Dry Matter Digestibility
DOMD	Dry Organic Matter Digestibility
DPI	Department of Primary Industries
DSE	Dry Sheep Equivalent
EP	Eyre Peninsula
EPARF	Eyre Peninsula Agricultural Research Foundation
EPFS	Eyre Peninsula Farming Systems
EPNRM	Eyre Peninsula Natural Resources Management Board
EPR	End Point Royalty
FC	Field Capacity
GM	Gross Margin
GRDC	Grains Research and Development Corporation
GS	Growth Stage (Zadocks)
GSR	Growing Season Rainfall
HLW	Hectolitre Weight
IPM	Integrated Pest Management
LEADA	Lower Eyre Agricultural Development Association
LEP	Lower Eyre Peninsula
LRCP	Low Rainfall Collaboration Project
LSD	Least Significant Difference
LW	Live weight
MAC	Minnipa Agricultural Centre
MAP	Monoammonium Phosphate (10:22:00)
ME	Metabolisable Energy
MLA	Meat and Livestock Australia
MRI	Magnetic Resonance Imaging
NDF	Neutral Detergent Fibre
NDVI	Normalised Difference Vegetation Index
NLP	National Landcare Program
NRM	Natural Resource Management
NVT	National Variety Trials
PAWC	Plant Available Water Capacity
P	Probability
PBI	Phosphorus Buffering Index
PEM	*Pantoea agglomerans, Exiguobacterium acetylicum* and *Microbacteria*
pg	Picogram
PGR	Plant growth regulator
PIRD	Producers Initiated Research Development
PIRSA	Primary Industries and Regions South Australia
RD&E	Research, Development and Extension
RDTS	Root Disease Testing Service
SAFF	South Australian Farmers Federation
SAGIT	South Australian Grains Industry Trust
SANTFA	South Australian No Till Farmers Association
SARDI	South Australian Research and Development Institute
SASAG	South Australian Sheep Advisory Group
SBU	Seed Bed Utilisation
SED	Standard Error Deviation
SGA	Sheep Genetics Australia
SU	Sulfuronyl Urea
TE	Trace Elements
TT	Triazine Tolerant
UNFS	Upper North Farming Systems
WP	Wilting Point
WUE	Water Use Efficiency
YEB	Youngest Emerged Blade
YP	Yield Prophet

NOTES:










MAC
MAC