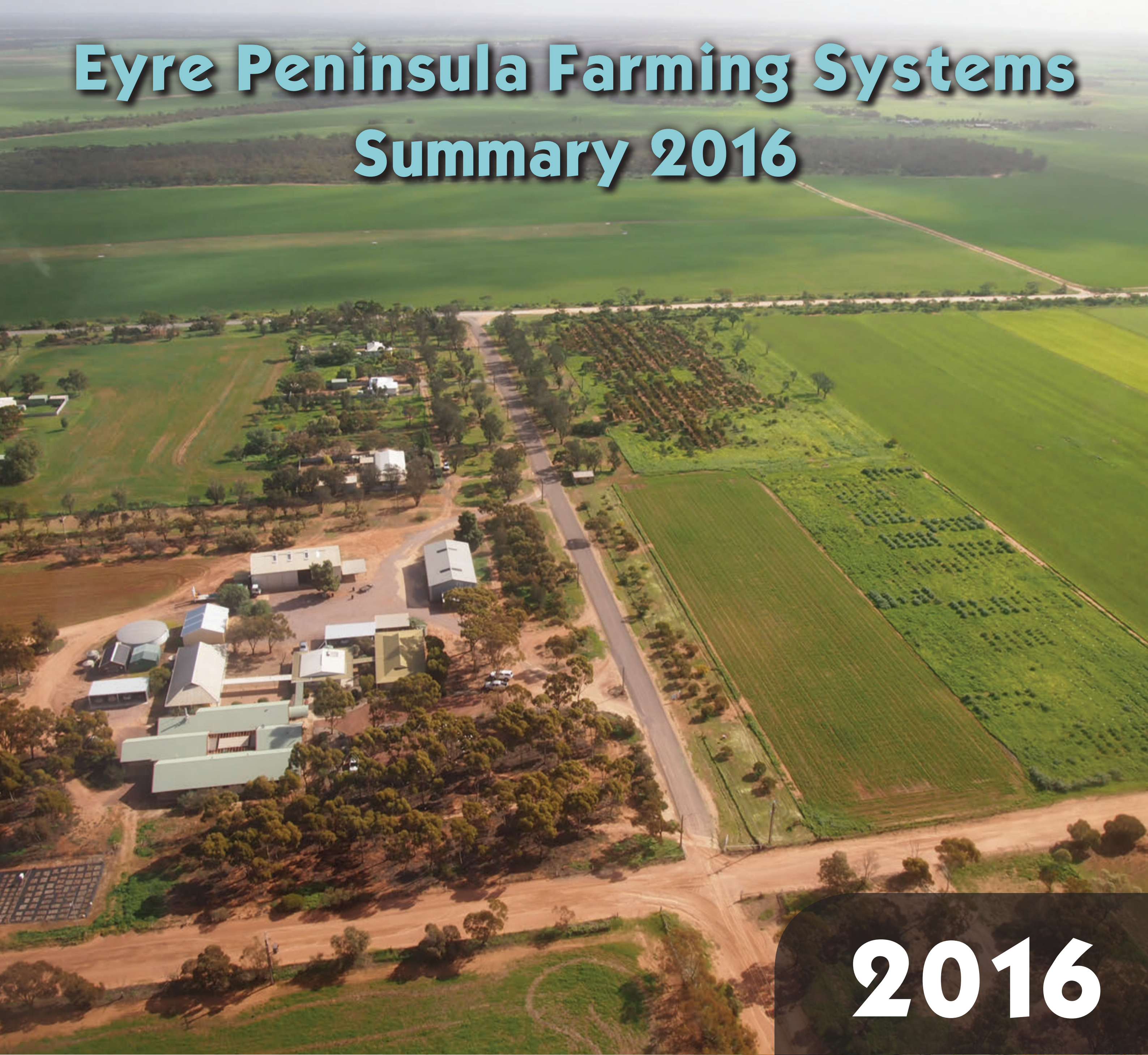
# Eyre Peninsula Farming Systems Summary 2016



2016

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# GRDC Foreword

After another productive season on the Eyre Peninsula (EP) last year, I am pleased to present to you the 2016 Eyre Peninsula Farming Systems Summary. This booklet summarises a significant array of agricultural research, development and extension activities conducted on the EP during 2016, and many of the projects producing these results were funded by the Grains Research and Development Corporation (GRDC) in collaboration with our research partners.

The Primary Industries Research and Development Act, which involves the GRDC investing grain grower levies and Australian Government funding in research and development, has benefited the grains industry since 1992, and is the envy of many other countries. Over the past two decades we've seen significant changes in the grain industry and the research, development and extension landscape. Most notably the industry has grown, and hence, the investments made by GRDC on behalf of growers has increased. Also, the balance in activities between state-based agencies, grower groups, private advisors, retail agronomists, input providers and breeding companies has shifted considerably. In 2015/16 GRDC invested more than $192.8 million in 898 projects delivered by over 2,500 researchers from 283 partner organisations across the country, and in some cases, internationally.

Grain producers on EP 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 EP Development Association, EP Natural Resources Management Board and local farm advisers and agribusinesses who work together to ensure farms remain sustainably profitable. As demonstrated in this booklet, these organisations in partnership with GRDC are producing results and knowledge that enhance the enduring profitability of grain growers through improved varieties, crop protection and soil management practices, new technologies for farming systems and enhanced capabilities.

As mentioned in the foreword to last year's summary, GRDC has opened regional offices, including an office in Adelaide. The new regional staff are working in close collaboration with our Regional Panel and the Regional Cropping Solutions Network (RCSN), to increase our engagement with industry and ensure the relevance and effectiveness of our investments, particularly in the areas of farming systems, agronomy, soils, and nutrition, and local validation, extension and communication. The GRDC team in the Adelaide office currently consists of:

Dr Stephen Loss - General Manager – Systems, Agronomy & Soils,
Dr Ron Osmond - General Manager – Business Development,
Mr Craig Ruchs - Regional Grower Services Manager,
Mr Andrew Etherton - Manager – Systems, Agronomy & Soils,
Ms Denni Greenslade - Contracts Administrator,
Ms Rosie Schocroft - Team Assistant.

Many growers are great innovators. To remain economically and biologically sustainable, growers have had to modify their farming systems and strategies to manage long to medium-term changes in the agricultural industry, while remaining agile in their tactical crop management to exploit variable seasonal conditions that unfold each year. The EP has been blessed with a run of favourable seasons in recent years, but we know that the coming season could be quite different. Most growers are constantly reviewing the main constraints to their businesses and devising and testing ways to do things more efficiently, especially in context of seasonal and economic risks. If you have identified a constraint that is not being addressed by current research and development, or have an idea for an opportunity to improve the profitability of your grains business, then I encourage you to discuss this idea with our regional staff or members of the Regional Panels and RCSNs. Your idea could lead to a GRDC project and an important innovation for the industry.

I want to thank all the contributors to this summary, particularly the SARDI staff who have collated the booklet. I am sure you will use the results presented here to make better informed decisions that benefit your business and further drive the innovation cycle.

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

# Eyre Peninsula Farming Systems Summary 2016

## 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 |
| Mariano Cossani | SARDI, MAC/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 2017


**Front Cover:** Main: Minnipa Agricultural Centre from the air.

Left to right: Speakers from the EPARF Member Day 2016; trials from above; speakers from the EPARF Member Day 2016.

**Back Cover:** (From top to bottom) Minnipa Agricultural Centre sheep flock; visiting a soil moisture probe site on a Sticky Beak Day; lambs being recorded for genetic information; Dot Brace and Jake Hull cooking the BBQ after the EPARF Day; the inside of an automatic weather station; John Kelsh mowing trial plots for simulated grazing.


**Cover design**: The Printing Press

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# Contents

# Minnipa Agricultural Centre Update

Welcome to the eighteenth Eyre Peninsula Farming Systems Summary. This summary of research results from 2016 is proudly supported by the South Australian Grains Industry Trust (SAGIT) and the Grains Research & Development Corporation (GRDC) through the Eyre Peninsula Farming Systems projects.

We would like to thank SAGIT and GRDC for their contribution to Eyre Peninsula for research, development and extension and for enabling us to extend our results to all farm businesses on EP and beyond in other low rainfall areas. All articles since 2010 are also available on the EPARF website www.eparf.com.au.

The year 2016 seemed to fly past faster than any before, with a plethora of staff changes, old projects finishing up and new projects starting, and a large range of excellent agricultural events to attend. While the 2017 calendar is filling up quickly, it's good to take a moment and reflect on what happened in 2016.

## Staff

In 2016, we welcomed new staff members Mariano Cossani (Senior Research Agronomist), Jake Hull (Farm Manager to replace vacancy left by Mark Klante) and Brett Hay (to replace the vacancy left by Ian Richter, who replaced Wade Shepperd when he changed roles from the research team to the farm team, replacing Brett McEvoy). We farewelled Leigh "Meggsy" Davis, and thank him for 22 years of service and wish him all the best in his new role in the private sector. Brian Dzoma is also moving from MAC to the Waite Institute, but staying with SARDI, to take up a research agronomist role for the SA Mallee, as part of the Bilateral program with GRDC. Brian has been a productive and dedicated addition to the research team at MAC for the past 3 years and adapted quickly to local issues and farming systems.

We hosted first year University of Adelaide Agricultural student Stacey Lee and school students Sophie Nuske (Elliston Area School) and Bradley Hutchings (Karcultaby Area School) for work experience in 2016. Cleve Area School agricultural students also visited MAC, learning about current research, trials and equipment used. We are always keen to encourage school and university students to visit MAC and welcome any chance to highlight the wide range of opportunities in agriculture, and the great working environment at MAC in particular.

Staff at MAC received the 'Service to the Community' award from the 2016 SARDI Achievement Awards, for the work on celebrating 100 years of Minnipa Agricultural Centre, and were highly commended in the PIRSA Achievement Awards 2016 for Excellence in Cultivating Regional Growth.

Jessica Crettenden participated in a South Australian Group Study Exchange, Rotary District to the United States and Canada, gaining insights to a wide range of industries and people – an exhausting but rewarding trip from all accounts. Naomi Scholz participated in a study tour to England with advisors from South Australia, Victoria and Tasmania. UK farmers certainly have many issues to deal with – many the same as those farmers have to deal with here, just the scale and quantities differ. I strongly recommend taking the opportunity to visit farmers elsewhere whenever possible – it's a great way to learn!

In keeping with tradition, we were able to attract high calibre speakers to events at MAC, including Dr Stephen Davis (WA), Cam Nicholson (Vic), Dr Rick Llewellyn, Jeanette Long, Ed Hunt, Michael Moodie, Dr Michael Nash and Dr Chris McDonough (SA).

Aside from our own field days and events on Eyre Peninsula (see MAC events article), MAC staff have also been busy presenting their results nationally at conferences. Brian Dzoma presented a poster titled: Reducing sheep methane emissions through improved forage quality in low rainfall farming systems, at the Greenhouse Gas and Animal Agriculture Conference in Melbourne; and a poster paper titled: Improving sheep liveweight gains through alternative forages in low rainfall mixed farming systems, at the Australian Grassland Association Inc Symposium in Armidale. Jessica Crettenden attended the Australian Society of Animal Production (ASAP) International Conference in Adelaide where she presented the paper titled: 'Ewes classified as good mothers have greater cortisol responses when separated from their lambs than ewes classified as poor mothers'.

Amanda Cook (Herbicide efficacy in retained stubble systems) and Brian Dzoma (Identifying the causes of unreliable N fixation by medic based pastures) presented at the GRDC Updates for Farmers in Wudinna.

Amanda Cook and Naomi Scholz presented agronomic sessions at a series of workshops “Cereal Production from the Beginning for Women” held on Central and Lower Eyre Peninsula in 2016. Nigel Wilhelm presented sessions on identification and management of trace element deficiencies in crops at two speaking tours organised by GRDC, the first in northern NSW in July and the second in southern NSW in August.

Nigel Wilhelm and Naomi Scholz completed their contracts with GRDC to facilitate the low rainfall group of GRDC’s Regional Cropping Solutions Network (the program to identify issues and priorities at the coalface of the cropping industry). Nigel now has a position in the low rainfall group as a committee member for the next two years.

Congratulations to Ed Hunt, for being awarded the GRDC Southern Region Seed of Light award which acknowledges outstanding effort in the extension of GRDC-supported grains research outcomes. Well done Ed!! And ex-local Dr Therese McBeath, a CSIRO research scientist based at the Waite Campus in Adelaide, has been presented with the GRDC Southern Region 2017 Emerging Leader Award, congratulations Therese!!

| Project name | Funder | Summary |
|---|---|---|
| **EPARF Sponsored Projects** | | |
| Maintaining profitable farming systems with retained stubble - upper EP | GRDC EPF00001 | 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. Increased knowledge and skills allowing farmers and advisers to improve farm profitability while retaining stubble in farming systems on upper EP. |
| Using soil water information to make better decisions on Eyre Peninsula | SAGIT EP216 | To use an existing network of soil moisture probes across Eyre Peninsula to provide growers across the region with information on how data the soil moisture probes collect can be converted into easily utilized decision support tools that will assist them in targeting yield potential and tailoring inputs to match. |
| Eyre Peninsula Farming Systems Summary 2016-2018 | SAGIT EP116 | This project will support the cost of printing Eyre Peninsula Farming Systems Summaries 2016, 2017 and 2018, enabling the free distribution to all growers on Eyre Peninsula. |
| Reducing methane emissions from improved forage quality on mixed farms | DAFF Action on the Ground AOTGR2-0039 | Aims to compare a range of alternative pastures and forage crops to existing forages to assess their potential to increase sheep production and reduce methane production from sheep. |
| **SARDI Projects** | | |
| Burning of weed seeds in low rainfall farming systems | SAGIT S416 | Determine temperature thresholds for killing the seeds of common weeds for low rainfall farming systems in South Australia, allowing farmers to assess the value of narrow windrow and other burning strategies as integrated management tools for these weeds and ultimately to manage weeds more effectively. |
| Identifying the causes of unreliable N fixation by medic based pastures | SAGIT SARDI1515 | Assess the impacts of current weed control chemicals, adjuvants and rhizobial inoculants on N fixation by medics under field conditions typical of the upper EP and other low rainfall mallee systems. Also assess the impact of nutrition (esp N and P) on N fixation by medics under field conditions and investigate their effects on tolerance to current weed control chemicals. |
| Extension of the Improved management of soil organic matter for profitable and sustainable cropping | GRDC CRF 00002 | The network of trial sites to be continued by BCG, FarmLink, EPARF and Hart farm groups to:<br>• improve scientific understanding of practical strategies used to manage soil carbon and the techniques required for carbon sequestration and the functions of healthy soils on commercial farms<br>• provide baseline soil carbon stocks and how these stocks may be increased across a range of regions, climatic zones, soils, land uses and farming practices. This will be a valuable data source with which to assess opportunities for soil carbon sequestration in the southern sheep/wheat zone. |
| Application of CTF in the low rainfall zone - MAC Research Site | GRDC via ACTFA ACT00004 | 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. |

| Project name | Funder | Summary |
|---|---|---|
| Eyre Peninsula Grain & Graze 3 | GRDC via SFS SFS00028 | Growers and advisors using processes (or tools/packages) to design and manage flexible farming systems equipping them with the ability to adopt and respond to changing environment and market conditions to manage risk and generate profits. By<br>• Improved understanding of risk<br>• Increased business profit by managing risk across seasons, between enterprises and major crops<br>• Optimise profit from the major crops by managing risks within season. |
| Overdependence on agrochemicals | GRDC via CWFS CWF00020 | 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. The reduced dependence will be demonstrated by a minimum of 200 examples of growers changing their practices to reduce their dependence on agrochemicals. |
| Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems | SAGIT S614 | To provide guidelines to farmers on the best options for fluid delivery systems at seeding for increases in crop yields and decrease impacts of crop diseases in current farming systems across southern cropping regions. |
| Maintaining profitable farming systems with retained stubble -Component 1 Coordination Support | GRDC DAS00145 | Coordination Support provided by Naomi Scholz, SARDI. The role includes organisation of national meetings, facilitate sharing of resources and communication between Component 2 grower groups and Component 1 research, and ensuring guidelines and other project products are accessible to growers across Australia now and in the future. |
| MPCN II – Managing micronutrient deficiencies in cropping systems of eastern Australia | GRDC DAS00146 | Several trials have been conducted by MAC staff investigating trace element deficiencies in cereal crops on upper EP. |
| Delivering enhanced agronomic strategies for improved crop performance on water repellent soils of Western Australia | GRDC DAW00244 | MAC staff have supported a trial at Wharminda investigating management of severe water repellency. This is the eastern node of a large project based in WA and led by CSIRO. |
| National Variety Trials | GRDC | Variety yield performance of cereals & break crops at various locations across upper EP. |
| Crop Improvement Trials | Various | Various trials including district variety trials, product trials, species trials. |
| The response of lactating and non-lactating ewes to human presence and lamb handling. | Sheep CRC | Measuring the levels of oxytocin in the blood in ewes exposed to different levels of stress. |
| Managing metabolic disorders in pregnant ewes to improve lamb production and survival | AWI | To determine how variable changes in the mineral status of the ewes are before lambing across a range of common forage types, and whether the mineral status of ewes in late pregnancy is associated with lamb survival. |

Thanks for your continued 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 2017, and wish you all the best for a productive season!

**Naomi Scholz**

SARDI, Minnipa Agricultural Centre

# MAC Staff and Roles 2016

| | |
|---|---|
| Nigel Wilhelm | Science Program Leader Farming Systems |
| Dot Brace | Senior Administration Officer |
| Leala Hoffmann | Administration Officer |
| Naomi Scholz | Project Manager |
| Jake Hull | Farm Manager |
| Andrew Ware | Senior Research Officer, Port Lincoln |
| Mariano Cossani | Senior Research Agronomist |
| Amanda Cook | Senior Research Officer (Stubble and Weed Management, Fluid systems) |
| Jessica Crettenden | Research Officer (EP Grain & Graze) |
| Brian Dzoma | Research Officer (Greenhouse gases, Pastures) |
| Leigh Davis | Agricultural Officer (NVT, Contract Research) |
| Brenton Spriggs | Agricultural Officer (NVT, Contract Research) |
| Ian Richter | Agricultural Officer (EP Farming Systems) |
| Brett Hay | Agricultural Officer (EP Farming Systems) |
| Wade Shepperd | Agricultural Officer (MAC Farm) |
| John Kelsh | Agricultural Officer (MAC Farm) |
| Sue Budarick | Casual Field Assistant |
| Tegan Watts | Casual Field Assistant |
| Lauren Cook | Casual Field Assistant |
| Katrina Brands | Casual Field Assistant |

## DATES TO REMEMBER

**EPARF Member's Day: Wednesday 28 June 2017**

**MAC Annual Field day: Wednesday 6 September 2017**

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

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# Eyre Peninsula Agricultural Research Foundation Annual Report 2016

EPARF
Eyre Peninsula
Agricultural Research Foundation Inc.

*"An independent advisory organisation providing strategic support for the enhancement of agriculture research on Eyre Peninsula"*


**Simon Guerin**

Chairperson, EPARF


## Board of Management

Simon Guerin, Bryan Smith, Craig James (retired September 2016), Dion Trezona, Greg Scholz, Shannon Mayfield, Wes Matthews (elected September 2016), Andy Bates, Mark Stanley, Prof Alan Tilbrook (SARDI), Dr Glenn McDonald (University of Adelaide), John Richardson (LEADA), Mary Crawford (EPNRM), Andrew Ware (EP Science leader), Dot Brace (Executive Officer)

## Welcome to the Eyre Peninsula Farming Systems Summary 2016 with the results of the trials and projects.

Season 2016 has produced a record grain crop for South Australia with reports of 8.55 m tonnes delivered and a lot more stored on farm (3.2 m tonnes Western region). This demonstrates the productivity growth of the grains industry with more output from fewer farmers. Unfortunately the poor grain prices may not give us the opportunity to reinvest into industry what may have been. The laws of supply and demand still seem to apply to agriculture. Even after a successful season there are always lessons to learn and things to keep building on. In some areas frost, root diseases, leaf diseases, weeds and being a wet spring a shortage of nitrogen limited yields. The need for more and more spraying and the ability to look forward to potential risks to our businesses still gives us plenty of research work to investigate.

## 2017 EPARF member day

This year the planned topic for our members day on 28 June 2017 is "Legume Management Packages". The agenda is still in progress so stay tuned to the EPARF website and we hope to see a good crowd attend.

## 2016 EPARF Sponsors

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Thank you to all sponsors for their generous support. 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.

## Appreciation and thanks

Craig James needs to be thanked for his eight years of service to the EPARF board and his valuable input in our discussions. He has been replaced by Wes Matthews so I would like to welcome him on board.

Thank you to the SARDI team at MAC and we hope the farm will retain the support of Government so future farmers can benefit from the work carried out here.

## REMINDERS

**ANNUAL EPARF MEMBERSHIP**

Membership is $132 for the first member in the farm business or entity and $66 for additional members (GST incl)

**Contact Dot Brace 8680 6202 or eparf31@gmail.com**

## EPARF MEMBER DAY 28 JUNE 2017

**'Legume Management Practices'**

Program to include new and/or better adapted alternatives in your farming systems

Expert information on pastures, livestock and the use of legumes in the cropping rotation


***2016 'Sandy Soils' member day guest speakers (left to right):***
***Dr Chris McDonough (Farming Systems Consultant, Insight Extension for Ag), Ben Pope (Farmer, Warramboo), Hayden Whitwell (Farmer, Kimba), David Davenport (Land Management Consultant, PIRSA), Dr Rick Llewellyn (Research Group Leader Agricultural Systems, CSIRO), Brett Masters (Soil and Land Management Consultant, PIRSA), Dr Stephen Davies (Research Officer Soil Productivity, Dept Agriculture and Food, WA)***

# Eyre Peninsula Agricultural Research Foundation Members 2016

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| Linden | Masters | ARNO BAY SA |
| John | Matthews | KYANCUTTA SA |
| Lindsay | Matthews | KYANCUTTA SA |
| Todd | Matthews | KYANCUTTA SA |
| Wes | Matthews | KYANCUTTA SA |
| Ashley | May | KYANCUTTA SA |
| Nigel | May | ELLISTON SA |
| Paul | May | KYANCUTTA SA |
| Shannon | Mayfield | KIMBA SA |
| Clint | McEvoy | STREAKY BAY SA |
| Ashley | Michael | WUDINNA SA |
| John | Michael | WUDINNA SA |
| Darren | Millard | VERRAN SA |
| Leone | Mills | COWELL SA |
| Ian | Montgomerie | STREAKY BAY SA |
| John | Montgomerie | STREAKY BAY SA |
| Carolyn | Mudge | MILTABURRA SA |
| Darren | Mudge | MILTABURRA SA |
| Damien | Mullan | WUDINNA SA |
| Blake | Murray | PENONG SA |
| Lynton | Murray | PENONG SA |
| Len | Newton | ELLISTON SA |
| Anthony | Nicholls | CEDUNA SA |
| Ian | Noble | WHARMINDA SA |
| Daryl | Norris | RUDALL SA |
| Dwayne | North | WUDINNA SA |
| Craig | O'Brien | KYANCUTTA SA |
| Darren | O'Brien | KYANCUTTA SA |
| Clinton | Olsen | WIRRULLA SA |
| Clint | Oswald | YANINEE SA |
| John | Oswald | YANINEE SA |
| Nigel | Oswald | WUDINNA SA |

| | | |
|---|---|---|
| Tim | Ottens | WHARMINDA SA |
| Joe | Pedler | WINGFIELD SA |
| David | Peters | STREAKY BAY SA |
| Ashley | Phillips | MINNIPA SA |
| Darcy | Phillips | MINNIPA SA |
| Jamie | Phillis | UNGARRA SA |
| Andrew | Polkinghorne | LOCK SA |
| Tim | Polkinghorne | LOCK SA |
| Ben | Pope | WARRAMBOO SA |
| Lindsay | Pope | WARRAMBOO SA |
| John | Post | MINNIPA SA |
| Clint | Powell | KIMBA SA |
| Kevin | Preiss | ARNO BAY SA |
| Rowan | Ramsey | KIMBA SA |
| Ben | Ranford | CLEVE SA |
| Dale | Rayson | KIMBA SA |
| Peter | Rayson | KIMBA SA |
| Gavin | Rehn | ARNO BAY SA |
| Marty | Rodda | KIMBA SA |
| Bradley | Rowe | COWELL SA |
| Martin | Ryan | KIMBA SA |
| Allen | Sampson | KAPUNDA SA |
| Kane | Sampson | WARRAMBOO SA |
| John | Schaefer | KIMBA SA |
| Michael | Schaefer | BALHANNAH SA |
| Paul | Schaefer | KIMBA SA |
| Wes | Schmidt | KIMBA SA |
| Thomas | Schmucker | KYANCUTTA SA |
| Gareth | Scholz | MINNIPA SA |
| Greg | Scholz | WUDINNA SA |
| Leigh | Scholz | MINNIPA SA |
| Lyle | Scholz | YANINEE SA |
| Mick | Scholz | YANINEE SA |
| Neville | Scholz | WUDINNA SA |
| Nigel | Scholz | WUDINNA SA |
| Stuart | Scholz | WUDINNA SA |
| Yvonne | Scholz | WUDINNA SA |
| Brook | Seal | KIMBA SA |
| Bill | Shipard | PENONG SA |
| John | Simpson | WUDINNA SA |
| Josh | Siviour | COWELL SA |
| Bryan | Smith | COORABIE SA |
| Reid | Smith | MAITLAND SA |
| Dustin | Sparrow | WUDINNA SA |
| Mark | Stanley | PORT LINCOLN SA |
| Geoffrey | Starr | COWELL SA |
| John | Stillwell | CEDUNA SA |

| | | |
|---|---|---|
| Rodger | Story | COWELL SA |
| Suzanne | Story | COWELL SA |
| Lubin | Stringer | KYANCUTTA SA |
| Anton | Taylor | CUMMINS SA |
| Hugh | Teate | WUDINNA SA |
| Zac | Tiller | LOCK SA |
| Clint | Tomney | STREAKY BAY SA |
| Jarad | Tomney | CHANDADA SA |
| Myles | Tomney | CUNGENA SA |
| Rhys | Tomney | CHANDADA SA |
| Sarah | Traeger | CLEVE SA |
| Dion | Trezona | PETINA SA |
| Craig | Trowbridge | CEDUNA SA |
| Shane | Trowbridge | CEDUNA SA |
| John | Turnbull | CLEVE SA |
| Mark | Turnbull | CLEVE SA |
| Nigel | Turnbull | CLEVE SA |
| Quentin | Turner | ARNO BAY SA |
| Tim | van Loon | PORT ELLIOT SA |
| Daniel | Vater | GLEN OSMOND SA |
| Leon | Veitch | WARRAMBOO SA |
| Sally | Veitch | WUDINNA SA |
| Simon | Veitch | WUDINNA SA |
| Daniel | Vorstenbosch | WARRAMBOO SA |
| Dallas | Waters | WUDINNA SA |
| Dean | Waters | WUDINNA SA |
| Graham | Waters | WUDINNA SA |
| Tristan | Waters | WUDINNA SA |
| Peter | Watson | WIRRULLA SA |
| Ryan | Watson | WIRRULLA SA |
| Paul | Webb | COWELL SA |
| Ken | Webber | PORT LINCOLN SA |
| David | Wendland | MINNIPA SA |
| Craig | Wheare | LOCK SA |
| Philip | Wheaton | STREAKY BAY SA |
| Evan | Whillas | WIRRULLA SA |
| Brian | Wibberley | PORT LINCOLN SA |
| Gregor | Wilkins | YANINEE SA |
| Stefan | Wilkins | YANINEE SA |
| David | Williams | PORT NEILL SA |
| Dion | Williams | STREAKY BAY SA |
| Gwenda | Williams | KIMBA SA |
| Jack | Williams | PORT NEILL SA |
| Josie | Williams | WUDINNA SA |
| Peter | Williams | WUDINNA SA |
| Scott | Williams | WUDINNA SA |
| Dean | Willmott | KIMBA SA |
| Lyall | Wiseman | LOCK SA |
| Craig | Wissell | ARDROSSAN SA |
| Brad | Woolford | KIMBA SA |
| David | Woolford | KIMBA SA |
| Dion | Woolford | KIMBA SA |
| Graham | Woolford | KIMBA SA |
| James | Woolford | KIMBA SA |
| Peter | Woolford | KIMBA SA |
| Simon | Woolford | KIMBA SA |
| Amy | Wright | KIMBA SA |
| Michael | Zacher | LOCK SA |
| Michael | Zerk | LOCK SA |
| Lisa | Zibell | KIMBA SA |

# Minnipa Agricultural Centre Events in 2016

**Naomi Scholz**
SARDI, Minnipa Agricultural Centre

| Event | Topics | Attendance |
|---|---|---|
| **EP Farmer Meetings** x 8<br>Minnipa, Piednippie, Charra, Port Kenny, Buckleboo, Cowell, Cleve and Lock<br>8 - 17 March | Presentation of research results from 2015, discussion of emerging issues for 2016.<br>• Cereal and break crop varieties<br>• Livestock<br>• Soil diseases<br>• Stubble management<br>• Methane emissions<br>• Grass weeds<br>• Other research | 127 people made up of 116 farmers, 10 agribusiness representatives, and 1 NRM staff member attended. |
| **Sheep Group workshops**<br>Lock, Streaky Bay<br>22 - 23 June | Jessica Crettenden (SARDI) and Mary Crawford (EPNRM, SheepConnect) assisted San Jolly, Productive Nutrition, to discuss with farmers about livestock management practices over a series of two workshops, including the following topics:<br>• Key profit drivers<br>• Livestock measurements<br>• Genetics<br>• Nutrition<br>• Reproduction<br>• Meat and wool markets<br>The workshops were supported by the GRDC Grain and Graze project. | 42 people made up of 3 presenters, 35 farmers, 3 agribusiness representatives and 1 NRM staff member attended. |
| **Sheep Group workshops**<br>Cleve, Yallunda Flat<br>28 - 29 June | Jessica Crettenden (SARDI) and Mary Crawford (EPNRM, SheepConnect) assisted Colin Trengrove (Pro Ag Consulting) in running two hands-on lamb survival workshops, discussing livestock management practices including the following topics:<br>• Demonstration of how to conduct lamb autopsies<br>• Reproduction issues and ewe fertility<br>• Ewe nutrition and treatment throughout pregnancy<br>• Lamb survival issues and techniques to overcome them<br>• Pest and predator issues and solutions<br>The workshops were supported by the GRDC Grain and Graze project. | 37 people made up of 3 presenters, 29 farmers, 4 agribusiness representatives and 1 NRM staff member attended. |
| **EPARF Member Day** 'Sandy Soils – getting the most out of your sands'<br>Minnipa Ag Centre<br>27 July | • Overview of sandy soils on EP (Brett Masters)<br>• Practices used on sandy soils in Western Australia to overcome constraints and dealing with non-wetting sands (Dr Stephen Davies)<br>• Seven lessons learnt from seven years of research on mallee sands (Dr Rick Llewellyn)<br>• New Horizons trial results (David Davenport)<br>• Results of broad acre spading trials with the addition of chicken manure done in the Mallee (Dr Chris McDonough)<br>• Local farmer experiences with soil modification (Ben Pope, Hayden Whitwell) | 139 people attended; 98 members, 11 speakers/guests, 15 sponsors and 15 staff. |

| Event | Topics | Attendance |
|---|---|---|
| Peter Kuhlmann's **Grower Field Day Mudamuckla** 15 August | Instigated by Peter Kuhlmann, this grower field day showcased vetch, lentils and harvest weed seed capture. MAC staff (Leigh Davis and Brian Dzoma) presented information on<br>• Wheat varieties<br>• Results from the Grain & Graze 3 medic nodulation trial | 48 farmers and 15 researchers and advisors. |
| **GRDC Update for Farmers** Wudinna 18 August | • Amanda Cook presented "The effect of high stubble loads on herbicide efficacy"<br>• Brian Dzoma presented "The impact of herbicide application on medic nodulation" | 85 growers and advisors. |
| **MAC Annual Field Day** Minnipa Ag Centre 7 September | • MAC farm update<br>• Stubble management<br>• Herbicide efficacy<br>• Fluid fertilisers<br>• Crop competition with weeds<br>• Barley grass management<br>• Wheat and barley grazing trial<br>• Sheep research<br>• Improving medics<br>• Pulse varieties<br>• Controlled traffic<br>• Nutrition<br>• National variety trials<br>• Canola risk management<br>• GRDC/SARDI bilateral project<br>• Nitrogen/water co-limitation trial<br>• Insect pests for 2016 | 170 growers, advisors, and agribusiness representatives. Field day booklet distributed. |
| **Sticky Beak Days** x 15 Upper EP 31 August - 6 October | Common topics included:<br>• Rotations<br>• Chemical usage<br>• Cereal cultivars<br>• Windrow burning and chaff carts<br>• Rhizobia for legumes<br>• Russian wheat aphid<br>• Sheep production, infrastructure, medic pastures<br>• Moisture probes<br>• Sandy soils | 737 farmers, advisors and researchers attended. |
| **Risk Management and Communication with Farmers workshop** for advisors Port Lincoln 14 December | Presenters were Cam Nicholson (Nicon Consulting), Jeanette Long (Ag Consulting Co), Ed Hunt (Ed Hunt Consulting) and Jessica Crettenden (SARDI Livestock & Farming Systems Minnipa Agricultural Centre). The workshop focussed on increasing understanding in risk in farming, assisting clients with decision making, using temperament type to know how information should be pitched and increasing understanding of sheep potential and opportunities for EP farmers. Part of the GRDC funded EP Grain & Graze project. | 21 attendees (NRM: 3, Advisor: 12, Researcher: 4, Other: 2). |

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

EPARF Eyre Peninsula Agricultural Research Foundation Inc.

# Eyre Peninsula seasonal summary 2016

**Brett Masters**
Rural Solutions SA, Pt Lincoln

## OVERVIEW

The 2016 season was one of huge potential with most crops yielding well above average and many growers reporting their best yields ever. The season was however tempered by the impact of severe weather events including wind, hail and frost in some districts and generally poor grain prices. 2015/16 summer rainfall resulted in some stored subsoil moisture at seeding and regular growing season rainfall, which extended well into spring, provided ideal conditions for crop growth and grain fill. In most districts grain yields were well above average with better grain quality than was expected given the high yields. This is perhaps attributed to both late applications of nitrogen and late mineralisation of nitrogen due to damp, warm conditions in spring.

Significant storm activity brought widespread rain to the region in January and February. These rains resulted in some stored subsoil moisture and rapid germination of summer weeds and volunteer cereals. Multiple herbicide applications were required to control this “green bridge” and conserve moisture ahead of the 2016 cropping season. Some growers in the Streaky Bay, Central Eyre and Franklin Harbour districts also cultivated to control weeds. Snail numbers were also high following these rains and growers baited cropping paddocks prior to seeding.

Below average April rainfall temporarily dried out topsoils. Although this halted seeding in some areas, further rain and confidence that there were good subsoil moisture levels enabled growers to restart seeding quickly, with most finishing seeding by the middle of June.

Early sown crops grew rapidly and had moderate biomass levels before cold and wet conditions in July slowed growth. Whilst there was some temporary waterlogging in heavier low lying areas of paddocks south of Cummins, most paddocks remained trafficable with growers able to apply herbicides, nitrogen and foliar trace elements in crop to correct nutrient deficiencies.

Insect pest numbers were high prior to sowing, perhaps as a result of the increased levels of volunteer crops and the mild conditions which favoured reproduction. Most growers applied a broad spectrum insecticide at sowing and pest numbers were below control thresholds as temperatures cooled in early winter. Russian Wheat Aphids were detected in crops at Franklin Harbour in June, however they did not spread rapidly to other areas and damage was minimal. Fungal diseases including blackleg, sclerotinia, powdery mildew, net blotch, grey mould and leaf rust were observed during the season, however growers were able to control these with routine fungicide applications.

A number of heavy frosts from August to October had significant impact on crop yield in the Central and Eastern Eyre Districts of Kyancutta, Lock, Rudall, Darke Peak and Mangalo. Growers reported large yield variations between frosted and unfrosted areas of paddocks. Frost also affected grain quality with low test weights in both wheat and barley. Strong winds in September caused some head loss on early sown barley paddocks in the Streaky Bay, Elliston, Wharminda and Arno Bay districts and accompanying hailstorms caused significant crop damage at a few properties around Kimba and Cleve.

Pastures and fodder crops contained high amounts of biomass by early October. Although some hay was cut, continued wet conditions to the end of October decreased the straw quality of cut paddocks and limited the opportunities to cut hay. Many growers opted to reap feed grain from paddocks sown for hay instead.

In those paddocks unaffected by extreme weather, yields were generally well above average with many growers achieving cereal yields above 3.0 t/ha and canola and pulses yields above 1.8 t/ha. Grain test weights were good and protein levels higher than expected considering the high yields. Although snail numbers in crops were high and there was some concern about how this may affect grain quality, the mild conditions at harvest meant that most of the snails stayed on the ground rather than crawling up into the crop canopy to be picked up by the harvester.

Having poor returns from canola in recent seasons a few landholders in central and Eastern Eyre districts trialed small areas of high value grain legumes such as lentils and chickpeas for the first time. Ideal seasonal conditions resulted in good growth and high yields on many of these crops.

## DISTRICT REPORTS

### Western Eyre

After a generally dry January, widespread rainfall in February and March resulted in rapid germination and growth of summer weeds, with many paddocks requiring multiple herbicide applications or cultivation to control them. Some paddocks were sown for early feed following March rains, however dry conditions in April halted most seeding until early May.

Dry soils at seeding resulted in patchy emergence on sandy soils around Kyancutta and Warramboo and strong winds in late May caused some sand blasting of newly emerged crops forcing farmers to re-sow the tops of dunes in early June. Time of sowing was reflected in differences in crop maturity at the start of July. A number of insect pests, including mites and aphids were reported on pastures and early sown crops, however pest numbers reduced as conditions cooled in June with few reports of significant crop damage.

Regular cold fronts brought above average winter rainfall to the district with most growers applying additional nitrogen to correct deficiency symptoms in crops. Manganese deficiency and rhizoctonia were also common on susceptible soil types.

Cold conditions in July slowed crop and pasture growth. There were isolated reports of light frost and hail in August in inland districts around Minnipa, Wudinna and Kyancutta. Warmer conditions in late August promoted rapid crop and pasture growth with most paddocks containing high levels of biomass by the end of August. Low levels of leaf rust were present in cereal crops coming into spring. There was also some powdery mildew and net blotch present in susceptible crops.

Mild conditions and slightly above average rainfall to the end of October resulted in an extended ripening period for all crops. Heavy frost impacted on crop yields in some areas of Central Eyre Peninsula with large yield variations between the swales and rising ground within paddocks. Strong northerly winds in late October also resulted in some head-loss in barley crops. Whilst this was significant on isolated paddocks the overall area affected was low.

Harvest began in most districts by the end of October. In areas unaffected by frost yields were well above average with good grain quality. Wheat yields over 2.0 t/ha and barley yields more than 2.5 t/ha were common in the Far West and yields of more than 2.5 t/ha for wheat and 3.0 t/ha for barley were common around Streaky Bay, Poochera and Wudinna. Protein levels were better than expected given the exceptional yield, perhaps resulting from late mineralisation of nitrogen due to warm, damp conditions in spring.

Canola yields were also well above average with good oil content (>43%). Yields above 1.5 t/ha were reported in most districts and up to 2.5 t/ha on the better soils around Mt Cooper. Yields of 1.8 t/ha to 2.5 t/ha were reported for all pulse species across the district. High numbers of snails did present some issues with many growers needing to clean grain before delivery.

### Eastern Eyre

Heavy thunderstorms in January and March brought well above average rainfall to Eastern Eyre districts. This rainfall combined with warm conditions led to rapid germination and growth of summer weeds and volunteer crops with most growers applying multiple herbicide applications to control them. Runoff from these rainfall events also caused some erosion on isolated paddocks in the Cleve Hills.

Some early feed and canola was sown in March after these rains but although there was some moisture stored in subsoils, very dry conditions throughout April dried out topsoils and slowed seeding. Good rainfall in May allowed most growers to finish seeding by mid-June. Generally mild conditions during this period resulted in rapid germination and early growth of crops and pastures. There were large differences in crop vigour between early and later sown crops.

High snail numbers and various insect pests were observed at crop emergence, perhaps due to the “green bridge” provided by volunteer crops during summer. Most growers sprayed insecticide and spread snail bait at seeding to protect emerging crops and pest numbers reduced as conditions cooled. Symptoms of Wheat Streak Mosaic Virus were common in crops near paddocks that had volunteer cereals over summer. Aphids and mites were common in emerging crops, however numbers generally reduced with cold conditions in July. Russian Wheat Aphids were also reported on Eyre Peninsula for the first time in the Franklin Harbour district in June but crop damage was limited. Although low levels of disease were common in many crops, routine fungicide applications were effective in controlling them.

Good winter rainfall increased soil moisture levels. Although nitrogen and trace element deficiencies were common, most growers were able to apply adequate nutrition in-crop to overcome these. Heavy frosts were experienced in inland districts near Lock, Darke Peak, Rudall and Mangalo during August. This set back crop growth in these districts whilst further frosts in September and October significantly reduced yields on some paddocks. Crops on the heavier soils around Kimba and Cowell were stressed by hot, drying winds in August and October and strong winds from an intense storm front in September caused head loss in barley crops near Kyancutta, Darke Peak, Wharminda and Arno Bay. During this storm hail also damaged crops on isolated properties near Kimba and Cleve. Whilst the damage was significant in some paddocks it was restricted to isolated paddocks and did not affected a major proportion of the total crop area.

In areas unaffected by these extreme weather events most crops contained high levels of biomass with well above average yield potential at the end of winter. Although there was an increased area sown for hay production this season, damp conditions in early spring restricted the opportunities for hay to be cut and reduced straw quality in those paddocks cut for hay.

Mild conditions at grainfill resulted in extended ripening in most districts. Many growers windrowed barley and canola crops to achieve more even ripening and minimise the danger of pods shattering or head loss. Although snail numbers were high in crops, cool damp conditions at harvest meant that most remained close to the ground rather than moving up into the crop canopy to be picked up by the harvester.

Although wet weather and hot north winds caused some delays most growers finished harvest by the end of December. In areas unaffected by frost, yields were well above average. Wheat yields above 3 t/ha and barley yields more than 3.5 t/ha were commonly reported in the Cleve, Cowell, Arno Bay and Wharminda districts. Grain quality from unfrosted paddocks was good with generally good test weights and higher protein than expected given the high yields. Pulse yields were above average with 1.5 to 2.0 t/ha reported across all species. Canola produced similar yields with very high (above 45%) oil content.

**Lower Eyre**

A number of rainfall events during February brought above average February rainfall to most Lower Eyre districts. Summer weeds and volunteer cereals germinated quickly in the warm, damp conditions with many volunteer crops in head prior to seeding. Snail and insect pest numbers were higher than usual, perhaps due to the damp conditions and the “green bridge” afforded by the early pasture and volunteer cereals. Most growers spread snail bait on paddocks that they intended to crop in 2016 and applied insecticide at seeding. Farmers began sowing early crops following further rain in March and April.

Regular rainfall and above average May temperatures resulted in rapid germination of pastures and newly sown crops and provided ideal conditions for seeding with growers finishing in early June. Aphids and mites caused some damage to emerging crops. However, with cooler winter weather pest numbers reduced below control thresholds. Very cold conditions slowed crop growth in July and mild waterlogging caused issues with paddock trafficability in low lying areas of paddocks south of Cummins. Hail and light frosts were reported around Cummins, Cockaleechie and Karkoo, however these had very little impact on crop growth.

Nitrogen and manganese deficiencies were common, and most growers applied two or more applications of nitrogen and at least one foliar trace element application to crops. Although there were low levels of disease in most crops including blackleg, sclerotinia and Beet Western Yellow virus in canola, leaf rust and powdery mildew in wheat, grey mould on pulses and net blotch in barley these were mostly controlled by routine fungicide applications.

Good spring rainfall and generally mild temperatures provided ideal conditions for grainfill. An extended ripening period led many growers to spraytop canola and some barley crops with glyphosate to control grass weed seed set and improve evenness of ripening. Variable weather conditions during November and December including cool damp mornings, isolated scattered showers and hot north winds caused some interruption to harvest, however most growers finished by the end of December.

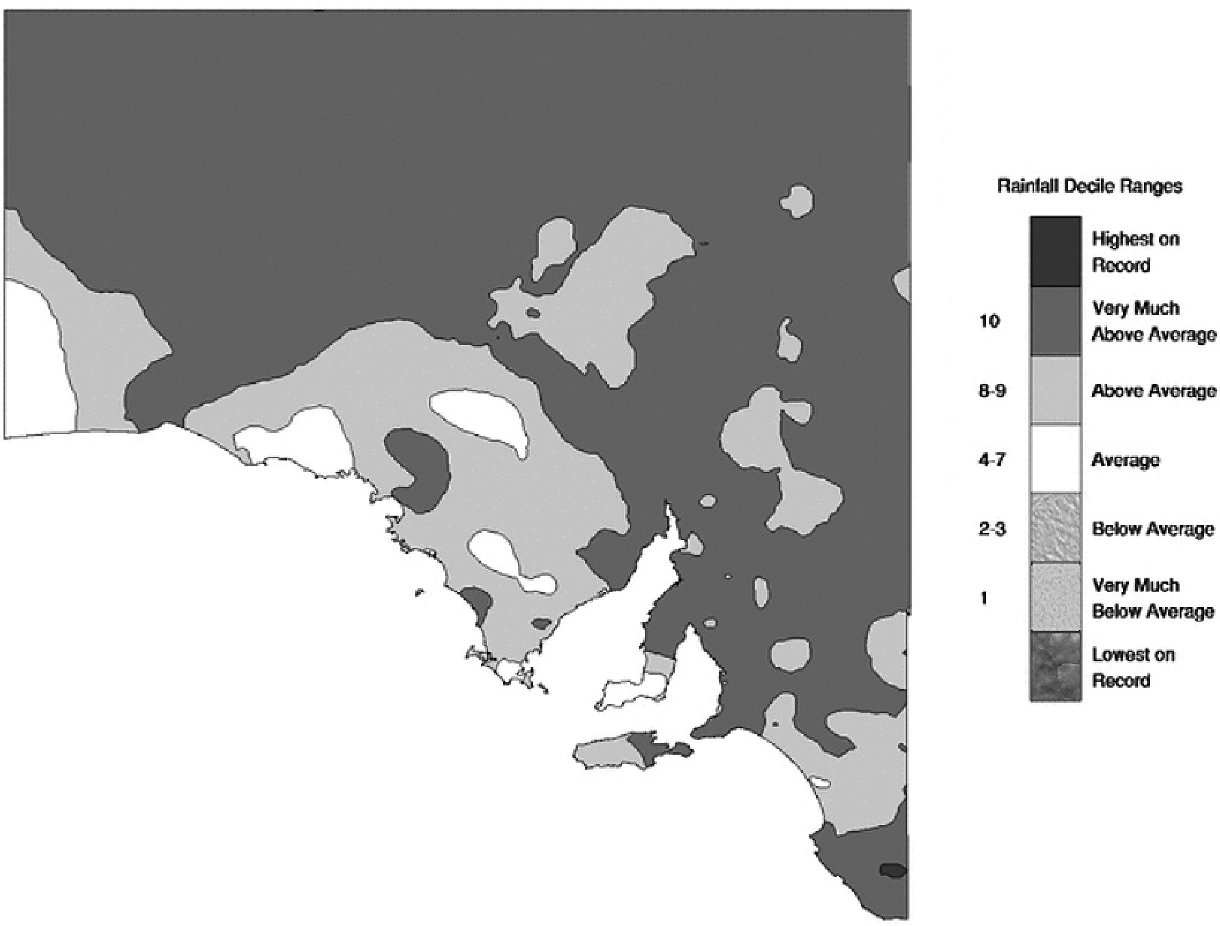
Although there was considerable yield variation according to soil types across paddocks, total paddock yields were generally well above average. Cereal yields in excess of 4.0 t/ha for wheat and 4.5 t/ha were common and some exceptional yields (more than 5.5 t/ha) came from better soil types around Ungarra and Cummins. Grain test weights were high and protein was higher than expected given the high yields. Above average canola yields of more than 1.8 t/ha and more than 43% oil content were common. Pulse yields were exceptional with most species yields 2.0 to 3.0 t/ha.


## Acknowledgements

The author wishes to acknowledge that much of the information contained within this summary has been compiled from PIRSA's 2016 Crop and Pasture Reports.


**South Australian Rainfall Deciles 1 April to 31 December 2016**

**Distribution Based on Gridded Data**
**Australian Bureau of Meteorology**




http://www.bom.gov.au

Government of South Australia
Primary Industries and Regions SA

# MAC Farm Report 2016

INFORMATION

**Jake Hull**
SARDI, Minnipa Agricultural Centre

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**Location:**
Minnipa Ag Centre
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm

## Key outcomes

- **On average MAC wheat yielded 2.9 t/ha, barley 3.4 t/ha, canola 0.55 t/ha.**
- **60% of the total farm area was cropped.**
- **420 breeding ewes produced 120% lambs at marking.**
- **110 tonnes of certified Scepter seed was made available for sale to growers off the header.**

## Background

The performance of the SARDI 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 farm.

MAC had white peg trials in ten paddocks and whole paddock demonstrations in N1 (sowing times), N6W (Compass and Hindmarsh), N3 (Scope and Spartacus) and Airport Town (lentils).

## What happened?

### *Weather*

The year of 2016 started with 3 mm of rainfall in January, 28 mm in February, 37 mm in March and then 8 mm on 6/7 April. Follow up rain was minimal during most of April and early May, MAC received only 8 mm until 8-10 May. During this time 24 mm fell over three days and the season was officially open! May finished with 44 mm. Following May, MAC experienced two wet but cold months with 65 mm in June and 53 mm in July. August was quite a dry month in comparison with recent seasons, with only 27 mm and some warm weather. Moisture stress began to be evident during the latter part of August. September was a month of small but helpful rain events which kept things cool enough for crops to push on and start to fill quite well. October was very similar to September with milder weather and small rain events. The crops held on really well and made this year's harvest one of the latest in recent times. With only 6 days over 30 degrees, which included a maximum of 35.5 and an average daily maximum of 23.9 degrees, October was very kind indeed. In total we received 268 mm of growing season rainfall (GSR), falling on 103 days, compared to 258 mm of GSR in 2015.

### *Seeding*

We started by sowing Stingray canola on 7 April. After a wait we put some Volga vetch in on 29 April, followed by Scope barley on 4, 5 and 6 of May, which was sown just before the break of the season. Following good opening rains on the 7-8 of May we began sowing wheat with Trojan and Scepter on 11 May, followed by Mace wheat on 12 May, continuing until 17 May. With a change of sowing depth made to 5 cm, Jumbo2, Bolt and Hurricane lentils were sown on 18 May. The change to Compass barley was made on 19 May, finishing on 24 May. Cummins vetch (South 10) and Winteroo oats (Barn/House) completed the program on 27 May.

Over the entire operation MAC total areas sown were, wheat 390 ha (35%), barley 265 ha (24%), oats and vetch 34 ha (3%), canola 15 ha (1%), with 37% pasture, out of 1,121 ha including Minnipa Progress Association land.

### *Certified seed*

Scepter wheat was grown as certified seed, with 110 tonnes sold off the header.

### *Harvest*

Harvest commenced on 28 October (canola) and finished on 1 December (vetch) and the program was completed with not too many interruptions. The average farm yields were: wheat 2.9 t/ha, barley 3.4 t/ha, canola 0.55 t/ha, lentils 0.97 t/ha, oats 1.8 t/ha and vetch approximately 0.7 t/ha.

***Issues encountered and questions asked in 2016:***

- Poor establishment of canola due to sowing depth and SU residues.
- Poor establishment of Spartacus barley due to sowing depth (outside three laps).
- Is the current set up of air-seeder correct or are changes needed? (changes to be made).
- Can lentils be a consistent break option in our area?
- Is sulphur and phosphorus deficiency becoming a problem at MAC?
- Barley grass continues to be a headache.

***Table 1 Harvest results, 2016 grain yields and protein aligned with paddock rotational histories***

| Paddock | Paddock History 2011-2015 | Crop 2016 | Sowing date 2016 | Yield (t/ha) | Protein (%) | Screenings (%) |
|---|---|---|---|---|---|---|
| North 1 | W P W W P | Mace (W) | 12 May | 2.9 | 11.0 | 1.0 |
| North 2 | W W B P C | Scepter (W) | 11 May | 3.11 | 10.9 | 0.8 |
| North 3 | P W W V W | Scope/ Spartacus (B) | 4 May | 2.8/2.6 | 12.3/11.4 | 1.2/2.0 |
| North 4 | W B P W W | Medic (P) | | | | |
| North 5 N | P P W W B | Medic (P) | | | | |
| North 5 S | P W W W P | Mace (W) | 14 May | 3.6 | 12.0 | 1.1 |
| North 6 E | W B Pe W W | Compass (B) | 21 May | 3.5 | 13.2 | 2.8 |
| North 6 W | Pe W W C W | Compass/ Hindmarsh (B) | 22 May | 3.3/3.3 | 12.8/11.8 | 2.0/2.2 |
| North 7/8 | B P W P W | Medic (P) | | | | |
| North 9 | W W B V W | Scope/Hatchet (B/W) | 10 May | 3.0/2.1 | 12.5/11.7 | 2.9/2.3 |
| North 10 | W P W W P | Mace (W) | 15 May | 3.8 | 12.0 | 0.8 |
| North 11 | P W P W W | Stingray (C) | 7 April | 0.6 | | |
| North 12 | C W W S S | Mace (W) | 15 May | 3.1 | 11.8 | 0.8 |
| South 1 | W B C W Pe | Mace (W) | 17 May | 3.0 | 9.9 | 1.1 |
| South 2/8 | W W Pe W W | Medic (P) | | | | |
| South 3 S | W W P P W | Compass (B) | 19 May | 3.3 | 12.5 | 2.6 |
| South 3 N | C W B P W | Scope (B) | 6 May | 2.9 | 11.3 | 1.0 |
| South 4 | B P W P O/V | Trojan (W) | 11 May | 2.6 | 12.1 | 0.6 |
| South 5 | W C B W P | Mace (W) | 17 April | 3.0 | 10.6 | 0.8 |
| South 6 E | P M W W B | Medic (P) | | | | |
| South 6 W | Pe W Pe B O | Medic (P) | | | | |
| South 7 | W P W W P | Mace (W) | 17 May | 3.1 | 11.3 | 0.9 |
| South 9 | P W W B P | Medic (P) | | | | |
| South 10 | P W V B B | Cummins (V) | 27 May | 0.6 | | |
| Competition 1 | | Lucerne | 27 May 15 | | | |
| Competition 2 | | Lucerne | 27 May 15 | | | |
| Competition 3 | | Oats | 14 May 15 | Self-sown | | |
| Competition 4 | | Volga (V) | 29 April | 0.8 (2 ha grazed) | | |
| Barn | X X P P W | Winteroo (O) | 27 May | 1.8 | | |

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

***Farm improvements and equipment***

- New diesel forklift purchased.

## Livestock

In the last week of January 2016 we put the rams in with 420 ewes in single sire mating groups of approximately 50 ewes per ram. Unfortunately one ram was a failure and only mated 30% ewes, leaving us with a scanned percentage of 128%. A very high percentage of twins and triplets surviving made up for the dry ewes. Some of the ewes suffered from pregnancy toxaemia. The majority of lamb deaths were attributed to dystocia and starvation/hypothermia especially in the lower birth weight twin and triplet lambs. A total of 600 lambs were born to 346 pregnant ewes (154%), with 502 (120%) surviving to marking.

The 78 dry ewes were put in with White Suffolk rams after pregnancy scanning and all but 11 of these had lambs, with 79 lambs weaned.

Ewe av. fleece weight 6.8 kg.

Lamb av. fleece weight 3.3 kg

Lamb av. fleece diameter 18.1 $\mu$m

Lamb av. eye muscle 30.7 mm, av. fat (CF) 2.6 mm

Lamb av. weight at 3 months (weaning) 32 kg, 10 months (yearling) 43 kg, at 12 months (hogget) 53 kg

Four rams were purchased from studs presenting ASBVs on EP.

Two research trials were carried out on the Minnipa sheep in 2016, with the results yet to be analysed:

- ‘Managing metabolic disorders in pregnant ewes to improve lamb production and survival’ with the aim to determine how variable changes in the mineral status of the ewes are before lambing across a range of common forage types, and whether the mineral status of ewes in late pregnancy is associated with lamb survival, and;
- ‘Ewes categorised as good mothers had a greater cortisol response to lamb removal than ewes classified as poor mothers’, investigating the greater cortisol response in good mothers may contribute to behavioural and physiological mechanisms to protect lambs in threatening environments.

## Acknowledgements

MAC farm staff Wade Shepperd and John Kelsh. MAC research staff Jessica Crettenden and Brian Dzoma and MAC administration staff Leala Hoffmann and Dot Brace.

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

### *LEADA's 2016 achievements and 2017 focus*

LEADA continued to deliver the GRDC stubble management project along with other smaller projects funded by a range of partners. Through this project a successful Nitrogen Workshop was held in July 2016 covering areas of nitrogen supply and losses in leaky soils, knowing your yield potential, nitrogen use efficiency of key lower EP soils and profit-risk of nitrogen management of lower EP soils. Trials are continuing and results from the project will be extended through LEADA's Expo and Field Days in the following years.

Funding gained through the National Landcare Program to develop two case studies summarising farmer's management of acid soils has been published and provides 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 are available from LEADA.

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 soil characteristics as well as production. The guidelines have been finalised and a booklet produced.

LEADA engaged SARDI to perform lupin variety and lupin plant density time of sowing experiments in 2016. A site at Wanilla was selected and soil moisture and nutrition tests were conducted. The results from these trials will be extended through LEADA's Expo and Field Days.

LEADA gained funding support through the EPNRM Sustainable Farming Systems Project Grant to run a series of 5 workshops titled 'Understanding Crop Production for Women'. The workshops cover areas about growing cereals and legumes; disease, weed and pest identification and management; opportunities and risks; business management and marketing. The final workshop in Series I will be held in February 2017 and LEADA will be running a second series of these workshops in 2017/2018 with the assistance of funding through the EPNRM Board and sponsorship.

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:**
Bruce Morgan, Chair 0427 872 038
Megan Low, Executive Officer 0427 393 065

**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, Sam Ness, 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 $m^2$ (square 100 m by 100m)

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

1 ha = 2.471 acres

### Mass

1 t (metric tonne) = 1,000 kg

1 imperial tonne = 1,016 kg

1 kg = 2.205 lb

1 lb = 0.454 kg

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

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

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

1 bu (wheat) = 60 lb = 27.2 kg

1 bag = 3 bu = 81.6 kg (wheat)

### Volume

1 L (litre) = 0.22 gallons

1 gallon = 4.55 L

1 L = 1,000 mL (millilitres)

### Speed

1 km/hr = 0.62 miles/hr

10 km/hr = 6.2 miles/hr

15 km/hr = 9.3 miles/hr

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

### Pressure

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

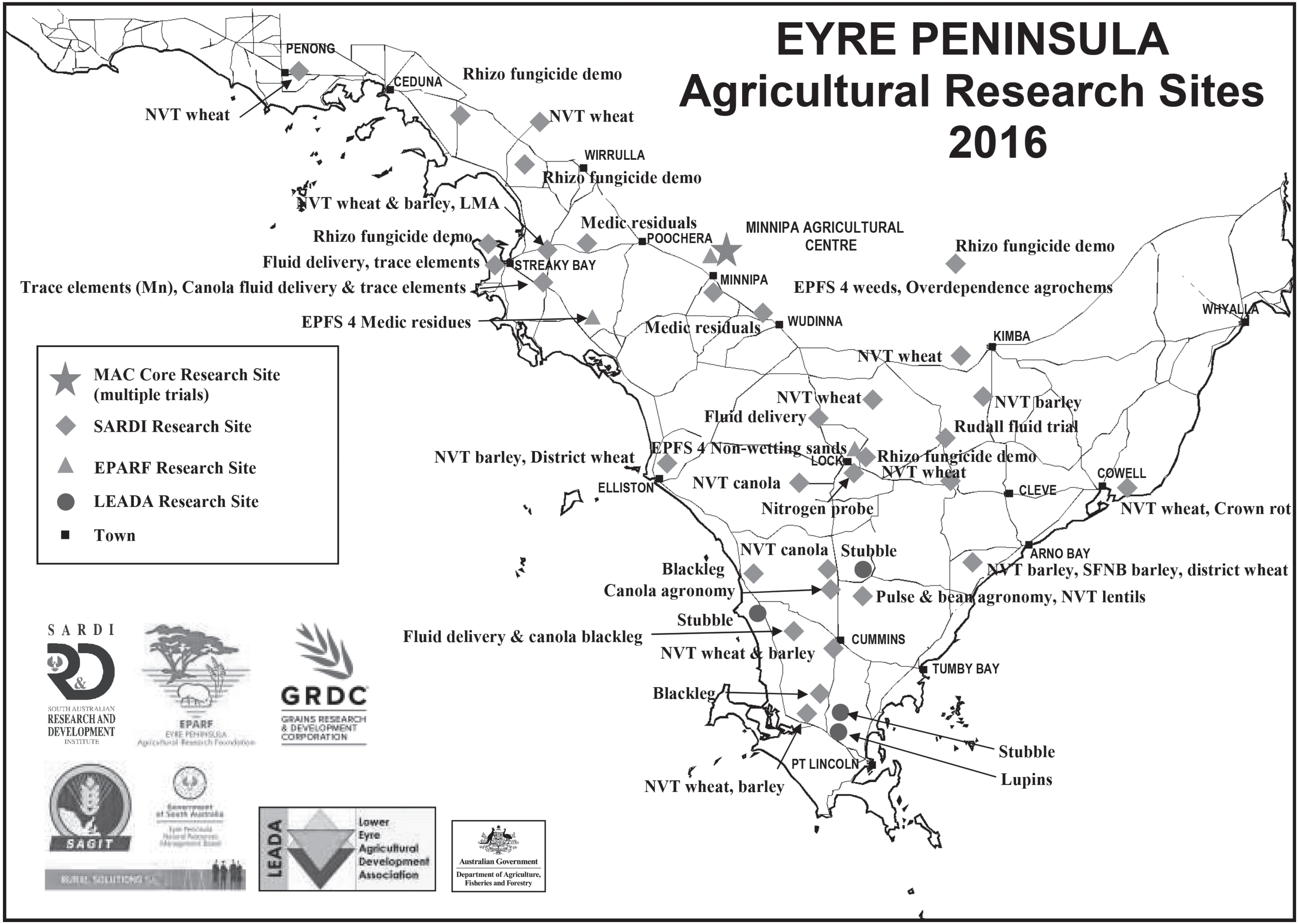
25 psi = 1.7 bar = 172 kPa

### Yield

1 t/ha = 1000 kg/ha

### Yield Approximations

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


EYRE PENINSULA
Agricultural Research Sites
2016
PENONG
CEDUNA
NVT wheat
Rhizo fungicide demo
NVT wheat
WIRRULLA
Rhizo fungicide demo
NVT wheat & barley, LMA
Medic residuals
POOCHERA
MINNIPA AGRICULTURAL
CENTRE
Rhizo fungicide demo
Rhizo fungicide demo
Fluid delivery, trace elements
STREAKY BAY
Trace elements (Mn), Canola fluid delivery & trace elements
MINNIPA
EPFS 4 weeds, Overdependence agrochems
EPFS 4 Medic residues
Medic residuals
WUDINNA
WHYALLA
KIMBA
NVT wheat
NVT wheat
NVT barley
Fluid delivery
Rudall fluid trial
EPFS 4 Non-wetting sands
LOCK
Rhizo fungicide demo
NVT wheat
NVT barley, District wheat
ELLISTON
NVT canola
COWELL
CLEVE
Nitrogen probe
NVT wheat, Crown rot
NVT canola
Stubble
ARNO BAY
Blackleg
NVT barley, SFNB barley, district wheat
Canola agronomy
Pulse & bean agronomy, NVT lentils
Stubble
Fluid delivery & canola blackleg
CUMMINS
NVT wheat & barley
TUMBY BAY
Blackleg
Stubble
PT LINCOLN
Lupins
NVT wheat, barley
MAC Core Research Site
(multiple trials)
SARDI Research Site
EPARF Research Site
LEADA Research Site
Town
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EPARF
EYRE PENINSULA
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SAGIT
LEADA
Lower
Eyre
Agricultural
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Association
Australian Government
Department of Agriculture,
Fisheries and Forestry

# Section 1

# Cereals

**Section Editor:**
**Brian Dzoma**
SARDI
Minnipa Agricultural Centre

# Elliston and Wharminda district wheat variety trials in 2016

RESEARCH

**Jacob Giles, Andrew Ware and Ashley Flint**
SARDI, Port Lincoln

**Try this yourself now**

**Location:** Elliston
Nigel & Debbie May
**Rainfall**
Av. Annual: 427 mm
Av. GSR: 353 mm
2016 Total: 546 mm
2016 GSR: 421 mm
**Yield**
Potential: 6.68 t/ha (W)
Actual: Trial Av. 5.23 t/ha (W)
**Paddock History**
2015: Grass free pasture
2014: Grass free pasture
2013: Wheat
**Soil Type**
Grey light sandy clay loam
**Plot Size**
1.5 m x 10 m x 3 reps
**Yield Limiting Factors**
Disease - possibly eye spot

**Location:** Wharminda - Tim Ottens
Wharminda Ag Bureau
**Rainfall**
Av. Annual: 338 mm
Av. GSR: 253 mm
2016 Total: 460 mm
2016 GSR: 339 mm
**Yield**
Potential: 5.05 t/ha (W)
Actual: Trial Av. 2.94 t/ha (W)
**Paddock History**
2015: Legume pasture
2014: Barley
2013: Wheat
**Soil Type**
Sand
**Plot Size**
1.5 m x 10 m x 3 reps
**Yield Limiting Factors**
Frost

## Key messages

- **Elliston wheat varieties performed well above average in an exceptional year with a long, cool finish. A wide range of varieties yielded well. These included; Corack, Wyalkatchem, Cosmick, Shield, Yitpi, Mace, Emu Rock and Cutlass.**
- **At Elliston, Scepter did not perform as well as expected. A late developmental issue may be the cause.**
- **Later maturing Cutlass, Yitpi and Trojan as well as mid-maturing Scepter were the top yielding varieties at Wharminda in 2016.**
- **The Wharminda trial experienced a number of consecutive days of frost from mid-late September which may have affected grain yield and quality of earlier flowering varieties.**

## Why do these trials?

These variety trials were undertaken to fill the gaps in regions where National Variety Trials were not undertaken. They continue to be highlighted as a subject of relative importance as they allow local growers to identify, evaluate and ground proof any issues or successes of variety performance at a local level.

***Elliston district wheat trial***

## How was it done?

Sown on 12 May 2016, the trial contained fifteen wheat varieties, replicated three times. Prior to sowing, 2.5 L/ha Boxer Gold, 1.6 L/ha Avadex and 2 L/ha Roundup were applied. The trial was sown with DAP fertiliser (18:20:0:0) @ 100 kg/ha treated with flutriafol 250 fungicide @ 400 ml/ha.

1.4 L/ha of Bromicide MA and 0.15 L/ha Lontrel was applied for broadleaved weed control and 3 L/ha of a chelated blend of zinc, copper and manganese (Smart Trace Triple) to remedy potential trace element deficiencies. These were done on 28 June when soil available water was known to be high and the plants were in no way under stress. Fastac was sprayed @ 200 ml/ha to combat red-legged earth mite, with another round of Smart Trace Triple @ 3 L/ha on 19 July and later Prosaro @ 300 ml/ha on 22 September for foliar disease.

***Table 1 Elliston district wheat trial results in 2016***

| Variety | Yield (t/ha) | Protein (%) | Test weight (kg/hL) | Screenings (%) |
|---|---|---|---|---|
| Corack | 5.87 | 10.6 | 81.7 | 3.0 |
| Wyalkatchem | 5.80 | 10.7 | 83.2 | 1.5 |
| Cosmick | 5.71 | 10.6 | 83.2 | 6.0 |
| Shield | 5.53 | 10.9 | 82.0 | 3.7 |
| Yitpi | 5.49 | 11.6 | 80.2 | 4.6 |
| Mace | 5.45 | 10.6 | 81.6 | 2.5 |
| Emu Rock | 5.43 | 11.5 | 82.2 | 5.9 |
| Cutlass | 5.42 | 11.2 | 80.6 | 2.7 |
| Scout | 5.40 | 10.8 | 84.3 | 2.6 |
| Trojan | 5.22 | 10.6 | 83.3 | 2.3 |
| Grenade CL Plus | 4.95 | 11.2 | 82.0 | 2.4 |
| Scepter | 4.87 | 10.0 | 82.8 | 3.6 |
| Kord CL Plus | 4.68 | 12.1 | 81.8 | 3.2 |
| Axe | 4.37 | 12.2 | 80.7 | 1.3 |
| Hatchet CL Plus | 4.32 | 12.7 | 82.2 | 1.9 |
| **Site mean** | **5.23** | **11.2** | **82.1** | **3.2** |
| *LSD (P=0.05)* | *0.46* | | | |
| CV (%) | 5.3 | | | |

***Table 2 Elliston district wheat yields as a percentage of Yitpi (2012-2016)***

| Variety | 2016 | 2015 | 2014 | 2013 | 2012 |
|---|---|---|---|---|---|
| Axe | 80 | 109 | 95 | 87 | 92 |
| Corack | 107 | 82 | 108 | 93 | 94 |
| Justica | NA | NA | 108 | 89 | 87 |
| Cobra | NA | 111 | 109 | NA | NA |
| Trojan | 95 | 81 | 108 | NA | NA |
| Grenade CL Plus | 90 | 111 | 106 | NA | NA |
| Emu Rock | 99 | 99 | 98 | NA | NA |
| Scepter | 89 | NA | NA | NA | NA |
| Cutlass | 99 | NA | NA | NA | NA |
| Shield | 101 | 115 | 107 | NA | NA |
| Hatchet CL Plus | 79 | 91 | NA | NA | NA |
| Phantom | NA | 113 | 117 | NA | NA |
| Cosmick | 104 | 109 | NA | NA | NA |
| Kord CL Plus | 85 | 132 | 102 | 104 | 75 |
| Mace | 99 | 197 | 117 | 121 | 99 |
| Scout | 98 | 101 | 104 | 92 | 106 |
| Wyalkatchem | 106 | 111 | 112 | 113 | 97 |
| Yitpi | 100 | 100 | 100 | 100 | 100 |
| **Yitpi (t/ha)** | **5.49** | **0.47** | **2.87** | **1.41** | **3.08** |

Cereals

## What happened?

Overall, the site saw well above average yields (Table 1) with Corack, Wyalkatchem, Cosmick, Shield, Yitpi, Mace, Emu Rock and Cutlass all yielding well. Clearfield varieties (Hatchet, Kord and Grenade) yielded poorly compared to other varieties trialed. The yield of Scepter was 10% (0.58 t/ha) lower than Mace. Straw samples indicated the presence of eye spot on the Scepter stubble, but further investigation is required to identify the cause of the poor yield of Scepter at this site. Axe was the lowest yielding variety (4.37 t/ha).

Protein levels across the site were reasonable with all varieties except Scepter reaching the APW requirement of 10.5% while some varieties achieved over 11.5% (H2). Those that yielded higher generally achieved lower protein content, whilst lower yields resulted in higher protein levels. Test weights were all well above the minimum requirement of 76 kg/hL.

Table 2 shows grain yield as a percentage average of Yitpi for the years 2012 to 2016. The standout varieties, (Phantom, Cobra, Wyalkatchem, Mace, Cosmick, Shield and Grenade CL), all yielded higher than Yitpi on average for this period. However not all varieties have data available over the full period. Data for Cosmick has been derived from the past two years only.

Of the more commonly grown varieties, Wyalkatchem and Mace have both shown to perform well. Differences can be seen in average to lower yielding years where Mace yielded higher, and adversely in 2016 where Wyalkatchem proved to have higher yield potential.

Grenade CL Plus has shown to be a relatively consistent performer and only showed a significant yield limit during 2016, an exceptional year. Kord CL Plus yielded marginally lower.

***Wharminda district wheat trial***

## How was it done?

Sown on 10 May 2016, fifteen wheat varieties were replicated three times in a randomised plot design. Pre-sowing, 2.5 L/ha Boxer-Gold, 1.6 L/ha Avadex, 3 L/ha Roundup and 0.1 L/ha oxyflourfen @ 240 g/L were applied to the trial. Upon sowing, 80 kg/ha of DAP was applied, having been treated with flutriafol @ 400 ml/ha.

On 11 June, around GS 30, urea was applied @ 50 kg/ha. On 28 June the trial received a broadleaf spray in the form of 1.4 L/ha Bromicide MA as well as 0.15 L/ha Lontrel alongside 3 L/ha of Smart Trace Triple. Alpha-cypermethrin at 0.15 ml/ha was applied to control cutworm.

***Table 3 Wharminda district wheat trial results in 2016***

| Variety | Yield (t/ha) | *Maturity | Protein (%) | Test weight (kg/hL) | Screenings (%) |
|---|---|---|---|---|---|
| Cutlass | 3.77 | ML | 11.3 | 80.9 | 4.0 |
| Yitpi | 3.72 | ML | 11.5 | 81.1 | 5.4 |
| Trojan | 3.64 | ML | 11.3 | 81.6 | 4.7 |
| Scepter | 3.40 | EM | 11.5 | 79.6 | 2.8 |
| Mace | 3.14 | EM | 12.1 | 79.3 | 2.7 |
| Shield | 3.11 | EM | 12.5 | 76.0 | 4.6 |
| Corack | 3.03 | EM | 11.5 | 77.3 | 3.5 |
| Scout | 3.02 | M | 12.4 | 80.1 | 3.7 |
| Wyalkatchem | 3.02 | EM | .3 | 77.9 | 3.1 |
| Cosmick | 2.85 | EM | 12.7 | 79.1 | 7.9 |
| Kord CL Plus | 2.80 | EM | 12.3 | 78.0 | 4.0 |
| Grenade CL Plus | 2.78 | EM | 12.4 | 79.3 | 3.2 |
| Emu Rock | 2.26 | E | 12.5 | 71.2 | 8.3 |
| Axe | 1.99 | E | 12.7 | 71.6 | 5.3 |
| Hatchet CL Plus | 1.57 | VE | 13.4 | 72.4 | 9.5 |
| **Site mean** | **2.94** | | **12.16** | **77.7** | **4.8** |
| *LSD (P=0.05)* | *0.52* | | | | |
| CV (%) | 10.7 | | | | |

**VE = Very Early, E= Early, EM = Early to Mid, M = Mid, ML= Mid to Late*

*Table 4 Wharminda district wheat yields as a percentage of Yitpi (2014-2016)*

| Variety | 2016 | 2015 | 2014 |
|---|---|---|---|
| Corack | 81 | 107 | 136 |
| Mace | 84 | 108 | 129 |
| Shield | 83 | 96 | 123 |
| Wyalkatchem | 81 | 109 | 122 |
| Cobra | NA | 107 | 120 |
| Trojan | 98 | 101 | 118 |
| Justica CL Plus | NA | NA | 115 |
| Scout | 81 | 100 | 115 |
| Cutlass | 101 | NA | NA |
| Scepter | 91 | NA | NA |
| Cobra | NA | 107 | 120 |
| Cosmick | 77 | 105 | NA |
| Hatchet CL Plus | 42 | 84 | NA |
| Axe | 53 | 87 | 114 |
| Emu Rock | 61 | 98 | 114 |
| Grenade CL Plus | 75 | 91 | 113 |
| Phantom | NA | 97 | 113 |
| Kord CL Plus | 75 | 85 | 109 |
| Yitpi | 100 | 100 | 100 |
| **Yitpi yield (t/ha)** | **3.72** | **3.56** | **2.87** |

## What happened?

Later maturing Cutlass, Yitpi and Trojan were the top yielding varieties (Table 3), with mid maturing Scepter also performing well. Hatchet CL Plus, Axe and Emu Rock yielded the lowest. Test weights were well below the required 76 kg/hL for these varieties, and screenings were above 5%. Yitpi and Cosmick also exceeded the 5% limit for screenings. As a point of interest, Scepter yielded 8% higher than Mace.

This trial experienced a number of frost events from mid-late September. This included six days between 6-16 September and eight consecutive days between 21-28 September. This may have lined up with the flowering window of earlier maturing varieties and possibly limited yield in these varieties.

Table 4 displays the yield performances of commonly grown wheat varieties relative to Yitpi over the past 3 years. Shown are 3 highly variable years with no consistency between seasons or varieties year to year. Of the varieties with all three years of data, Corack, Mace, Shield, Wyalkatchem and Trojan appear to yield consistently well across the seasons. Grenade CL Plus and Kord CL Plus appear to yield 10-15% lower than conventional varieties over the period. The season of 2016 saw dramatic yield penalties for early maturing 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 2016 NVT Cereal Yield Performance Tables and the Cereal Variety Disease Guide.

## Acknowledgements

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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Co-limitation in wheat crops of Eyre Peninsula as a way to better understand N and water economy

**C. Mariano Cossani[1, 2], Andrew Ware[1] and Victor O. Sadras[3]**
[1]SARDI, Port Lincoln; [2]SARDI, Minnipa Agricultural Centre; [3]SARDI, Waite

RESEARCH

**Try this yourself now**

**Location:** Minnipa Agricultural Centre, paddock N5S
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 3.60 t/ha (W)
Actual: 4.93 t/ha
**Paddock History**
2015: Legume pasture
2014: Barley
2013: Wheat
**Soil Type**
Red sandy clay loam
**Plot Size**
10 m x 1.6 m x 3 reps
**Yield Limiting Factors**
Water availability, hot temperatures

## Key messages

- **Wheat yields increased with the level of water and N co-limitation explored.**
- **Higher yield in modern cultivars was partially associated with higher co-limitation.**
- **The higher yield of modern cultivars was related to use efficiency rather than to capture of water and N.**
- **Grain yield increased with increasing N uptake per unit of water used.**

## Why do the trial?

Within Eyre Peninsula, as in other Mediterranean environments, grain yields of cereal crops are variable, and in many cases, this is due to under-fertilisation. Previous modelling and field experiments showed the need for higher rates of fertilisation in south-eastern Australia. Research into interactions between water and N, with simulation models and empirical data, has proved that yield, as well as water-use efficiency, is positively related to the degree of co-limitation between water and N [1, 2]. In other words, yield and water use efficiency increase when the stress produced by water has similar intensity to the stress produced by N. The understanding of how resources co-limit and its genotypic variability in wheat crops of Eyre Peninsula is a key step for improving the water use efficiency and to reduce yield gaps.

This trial is part of a new project which addresses research and development gaps on the interactions between water and nitrogen in Australian cropping systems identified in GRDC scoping study DAS00157. The novelty of this project is a new tool to estimate the actual water and nitrogen stress and co-limitation in the season. The new tool will complement existing tools and provide opportunities to adjust N availability in the season, thereby reducing farmers' risk and increasing chances of capturing the benefits of wetter seasons. Results are expected to be applicable to the medium to low rainfall areas of south-eastern and western Australia. The current project is focused on management of nitrogen fertiliser under uncertain conditions as related to variable rainfall and changing agronomic practices.

The aim of the current trial was to evaluate the impact of water and N co-limitation on grain yield of wheat under different N and water availability and to assess the genotypic variability in the main parameters.

## How was it done?

A field experiment combining four wheat genotypes released in different decades, two N rates, and two water availabilities was set up at Minnipa Agricultural Centre. The genotypes were chosen to represent at least the last 50 years of agriculture and were Halberd (1969), Spear (1984), Mace (2007) and Scepter (2015). Nitrogen rates were control (12 kg N/ha applied at sowing) and 120 kg N/ha split in two applications before Zadocks growth stage 31. The two water treatments consisted of a rainfed crop and a 25 mm irrigation at the beginning of stem elongation; we used 13 cm spaced drip irrigation lines parallel to the crop rows. The sowing density was targeted at 180 plants/m$^2$, and rows spaced at 27 cm. Prior to sowing we applied MAP at a rate of 120 kg/ha. Weeds, pests and diseases were controlled following the practices used for National Variety Trials (NVT).

Soil water content was measured gravimetrically at sowing and maturity to 1 m depth, and water use calculated as the difference in soil water plus in-season rainfall. Water use efficiency ($WUE_{Biomass\ or\ yield}$) was calculated as the ratio between total biomass (kg/ha) or grain yield (kg/ha) and water use (mm).

Nitrogen uptake was measured for each experimental unit and N use efficiency was calculated. The levels of water and N stress were calculated using the method of Cossani *et al* (2010) with locally derived parameters. The stress indices range from 0 (no stress) to 1 (maximum stress) for both water and N. Nitrogen stress index and water stress index were used to calculate total stress index ($T_{WN}$), maximum stress index ($M_{WN}$) and co-limitation.

A co-limitation index ($C_{WN}$) tending to 1 when the magnitude of the limitation by water and nitrogen were similar. Therefore, values closer to 1 indicate better balance between N and water stress, while closer to 0 indicate either water or N stress was dominant. Yield potential was estimated at 6.35 t/ha.

## Results

Environmental conditions (soil, rainfall, and temperatures) were outstanding for crops in Minnipa. There was 27% more rainfall from April to October than the average. An additional benefit of temperatures from August to November was also observed with a lower minimum (20%), and lower maximum temperatures (5%) than the average of Minnipa.

***Grain yield***

Grain yield of wheat increased with the year of release of the cultivar at a rate of approximately 24 kg/ha per year (Figure 1). The addition of 25 mm of water increased grain yield by approximately 0.3 t/ha. However, there was a genotype x water availability interaction showing a higher response to extra water supply for the modern cultivars in comparison with the older lines. On the other side, N did not produce any significant response in grain yield. The highest yield was observed for Scepter (4.8 t/ha) with the extra-supply of water, while the lowest yield was obtained by Halberd (3.3 t/ha) (Figure 1). Grain yield was mainly related to grain number per square meter ($R^2$=0.80 $P<0.001$), but also to the thousand kernel weight ($R^2$=0.54 $P<0.01$).

Cereals

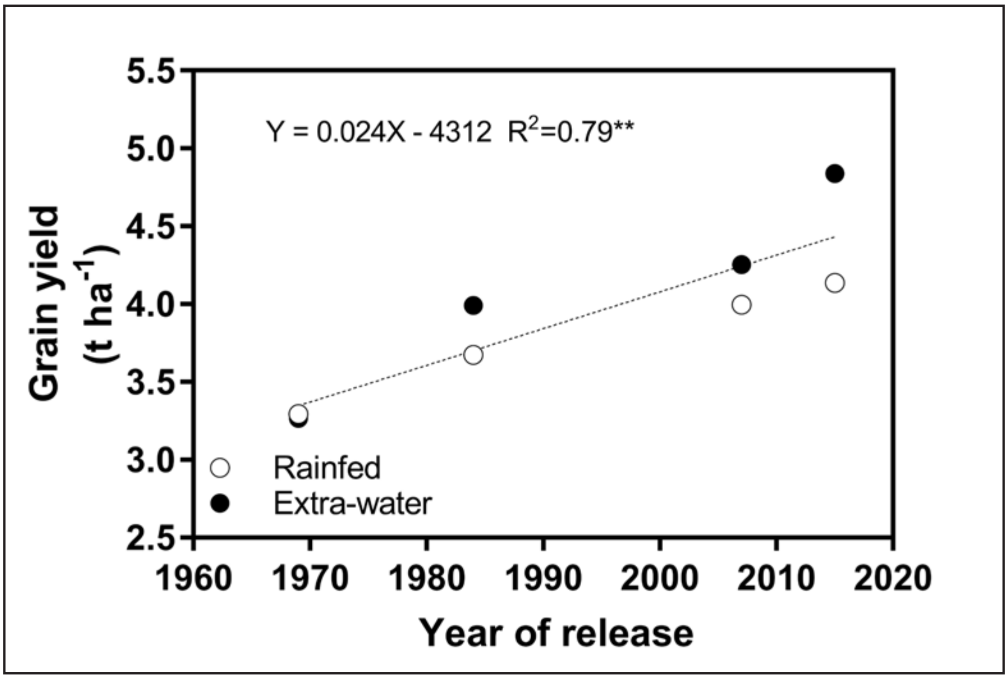


***Figure 1 Grain yield as a function of the year of release for all 4 cultivars evaluated. Closed dots represent treatment with 25 mm of extra water, while clear dots represent rainfed conditions***
*** Indicates a level of statistical significance of P <0.01*

***Efficiency in the use of water and nitrogen***

Water use efficiency (kg$_{grain}$/ha/mm) ranged between 10.8 and 17.5 kg$_{grain}$/ha/mm for all cultivars and conditions, and was affected by water availability x cultivar interaction. Scepter was the most responsive cultivar to the extra-water supply. Similar to grain yield, water use efficiency increased with the year of release of the cultivars at a rate of 0.11 kg$_{grain}$/ha/mm/year. The highest water use efficiency was observed for Scepter with extra water supply (17.2 kg$_{grain}$/ha/mm) which was approximately 50% more efficient in using water than Halberd. Intermediate water use efficiency values were found for Spear (13.2 kg$_{grain}$/ha/mm) and Mace (15.4 kg$_{grain}$/ha/mm).

Nitrogen use efficiency (NUE) ranged from 12.5 to 21.4 kg$_{grain}$/kg N$_{available}$ with the N, and differed between cultivars. Similarly to grain yield and WUE, NUE increased with the year of release (Figure 2) at a rate of 0.087 kg$_{grain}$/ha/kg N$_{available}$/ha/year. In this case, there was a general increase in NUE as a consequence of higher water availability (16.7 kg$_{grain}$/kg N$_{available}$ vs 15.0 kg$_{grain}$/kg N$_{available}$ for extra water and rainfed treatments, respectively). As expected, N treatment affected NUE by decreasing it when more N was applied (14.2 kg$_{grain}$/kg N$_{available}$ vs 17.6 kg$_{grain}$/kg N$_{available}$ for fertilised and unfertilised treatments, respectively).

Furthermore, there was an increase ($R^2$ = 0.88) in N utilization efficiency (kg$_{grain}$ /kg N$_{uptaken}$) with the year of release at a rate of approximately 0.13 kg$_{grain}$/kg N$_{uptaken}$/year. These results indicate that once N is uptaken, modern lines are more efficient in producing yield than old lines.

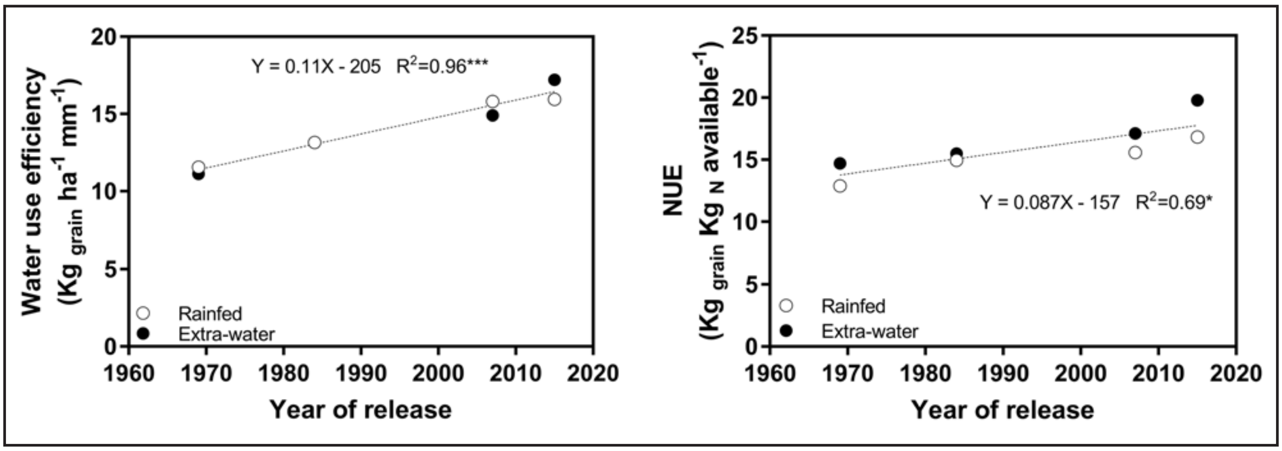


***Figure 2 Water use efficiency and nitrogen use efficiency as a function of the year of release for all 4 cultivars evaluated. Closed dots represent treatment with 25 mm of extra water, while clear dots represent rainfed conditions***

**, **, or *** Indicate a level of statistical significance of P <0.05; P<0.01; P<0.001, respectively*

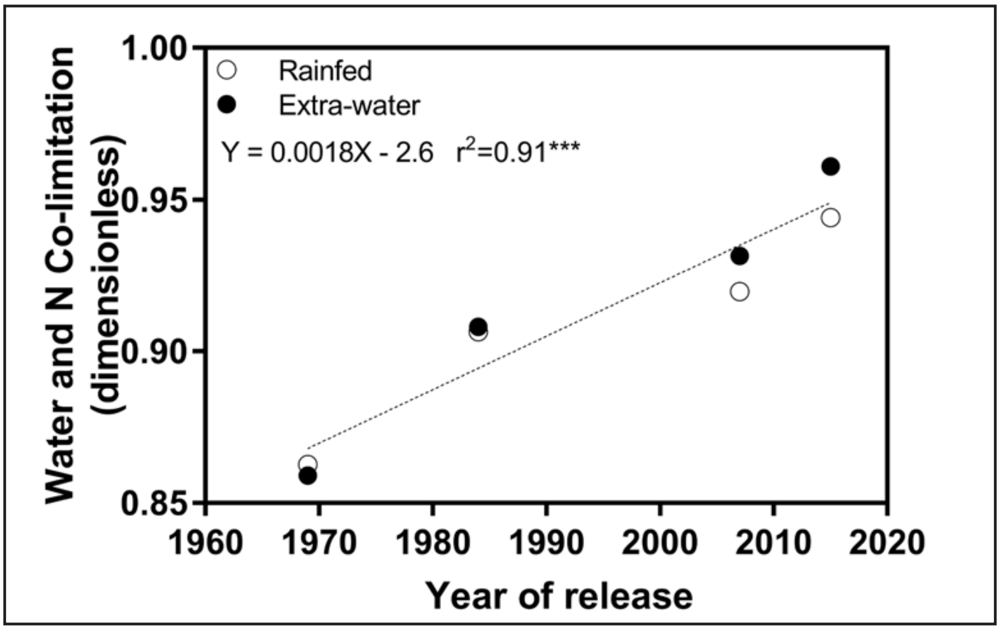


***Figure 3 Water and N co-limitation as a function of the year of release for all 4 cultivars. Closed dots represent treatment with 25 mm of extra water, while clear dots represent rainfed conditions***

**** Indicates a level of statistical significance of P<0.001*

Given the high N in the soil and high rainfall during the growing season, co-limitation range was narrow, between 0.79 and 0.96, indicating balanced stress of water and N. Following the same pattern observed for grain yield, the best balance between N and water stress was obtained by Scepter (0.95) while the poorest balance was observed for Halberd (0.86).

Interestingly, and in line with the resource use efficiency, the water and N co-limitation was higher in the modern cultivars than in the old cultivars (Figure 3). There was a positive correlation between grain yield and water and N co-limitation ($R^2$=0.95 $P<0.001$). N and water co-limitation was also positive related to water use efficiency (Figure 4, upper panel). These results are in line with previous research for South Australia and for Spain.

Similarly to the results observed with water use efficiency, N use efficiency ($kg_{grain}/kg\ N_{available}$) and N utilization efficiency ($kg_{grain}/kg\ N_{uptaken}$) were positively related to water and N co-limitation (Figure 4 middle and bottom panel). Results agree with previous work carried out by SARDI researchers that demonstrated that breeding for yield has improved the nutrition economy of wheat.

In general, modern cultivars tended to uptake more N per each mm of water used (Figure 5). There were no significant differences between both modern cultivars (Mace, Scepter), while differences between old cultivars indicated a higher capacity to uptake N per each mm of water used for Spear than for Halberd. The higher capacity to uptake N per each mm of water used was also positively related to the grain yield ($R^2$=0.82 $P<0.05$) and to harvest index ($R^2$=0.76, $P<0.05$). Results are in line with recently published results for Australia which demonstrates that modern cultivars have higher N uptake per unit root biomass in comparison with old cultivars [3].

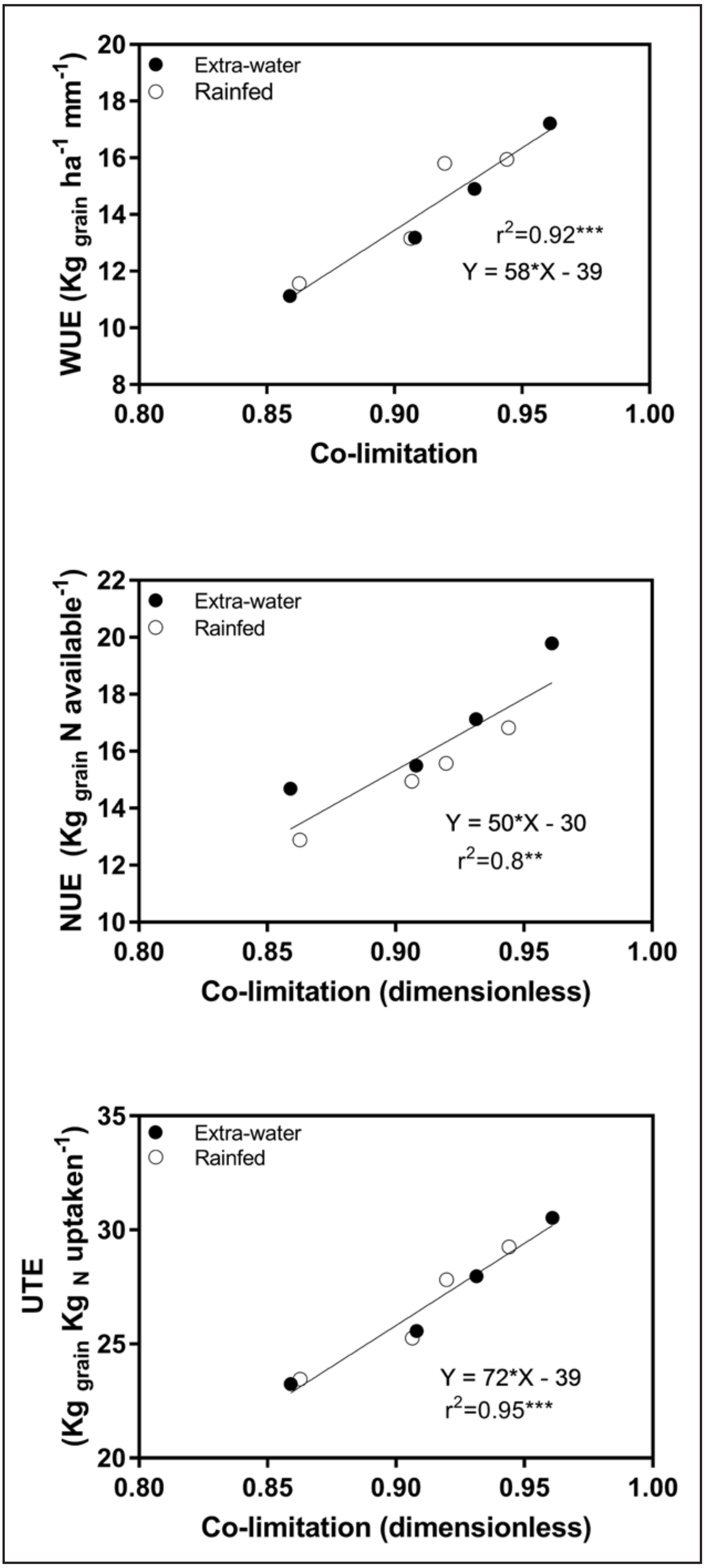


***Figure 4 Water use efficiency (WUE), nitrogen use efficiency (NUE), and nitrogen utilization efficiency (UTE) as a function of water and N co-limitation for all 4 cultivars. Closed dots represent treatment with 25mm of extra water, while clear dots represent rainfed conditions***

**, **, or *** Indicate a level of statistical significance of $P<0.05$; $P<0.01$; $P<0.001$, respectively*

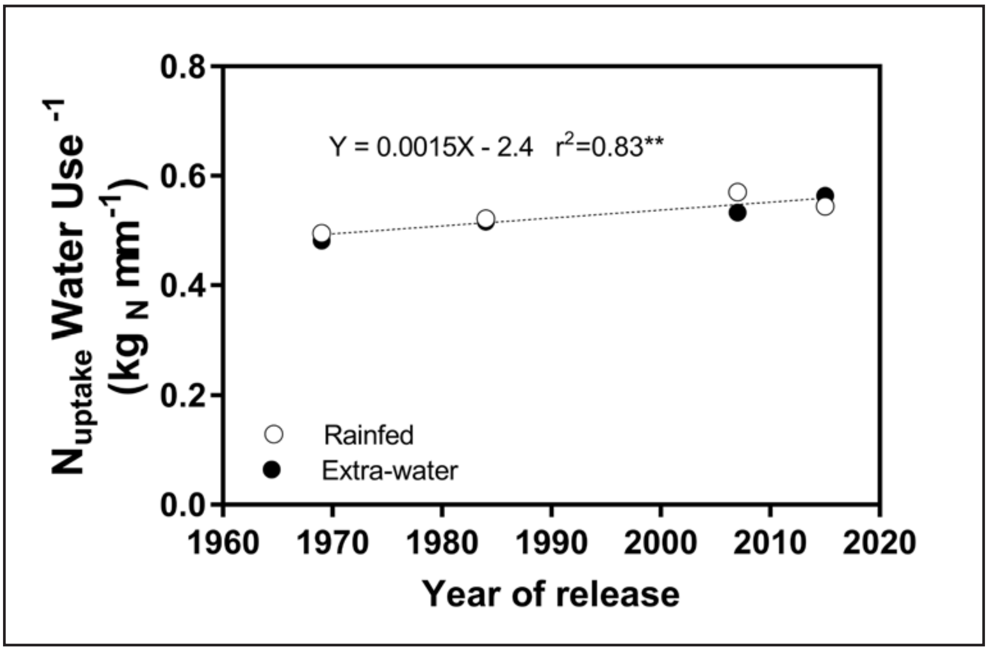


***Figure 5 N uptake per mm of water used as a function of the year of release for all 4 cultivars. Closed dots represent treatment with 25 mm of extra water, while clear dots represent rainfed conditions***
*** Indicate a level of statistical significance of P<0.01*

## What does this mean?

Results of the first experimental year, 2016 agreed with previous results in Spain and Australia underlining the importance of properly matching N to water availability. The grain yields, WUE, NUE and UTE were higher where a balance between stress of N and water was achieved. Additionally, the experiments indicate a genetic progress through breeding in terms of the capacity of plants to balance their stress, by improving the efficiency in N uptake for each mm of water used. These results reinforce the concept and importance of developing tools to estimate the co-limitation of resources. These tools could help farmers to improve the yields by better matching N to actual water stress levels. Such kinds of tools should be based on plant status, soil conditions (water and N) and probability of rainfall.

This preliminary analysis, together with previous literature, suggests an improvement in the root system by eliminating a redundancy in deeper soil layers. That reduction was associated to a higher water use efficiency of modern cultivars in comparison to the old cultivars.

Further research is needed to investigate to what extent roots can be further trimmed to improve the water use efficiency by reducing yield gaps.

## Acknowledgements

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## References


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SARDI

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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Effect of time of sowing and variety on grain yield: MAC demonstration

**Jake Hull, Wade Shepperd and John Kelsh**
SARDI Minnipa Agricultural Centre

DEMO

**Try this yourself now**

**Location:** Minnipa Agricultural Centre, paddock North 1
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 3.60 t/ha (W)
Actual: 2.90 t/ha
**Paddock History**
2016: Mace wheat
2015: Medic pasture
2014: Mace wheat
2013: Mace wheat
**Soil Type**
Red loam
**Plot Size**
8.6 m x 1.6 m x 3 reps

## Key messages

- **There was no difference in grain yield (t/ha) between the early season variety (Trojan) and the later varieties (Mace and Scepter) sown 13 days later.**
- **In 2016 sowing Mace and Scepter earlier on 13 May reduced grain protein by 0.3% compared to sowing it thirteen days later.**
- **For the later sowing on 26 May, Mace and Scepter had similar grain yield, however, protein was higher for Scepter.**
- **When sown early, Trojan had higher protein than Mace and Scepter.**

## Why do the trial?

The aim of this paddock demonstration was to compare grain yield and grain quality of a mid-late maturing variety (Trojan) and two early-mid season maturing varieties (Mace and Scepter).

## How it was done?

On 13 May Trojan was sown using a 30 ft (9 m) air seeder along the full length of the paddock using three repetitions at 70 kg/ha seeding rate with 60 kg/ha DAP (18:20:0:0). Knockdown chemicals used were 1.5 L/ha of glyphosate, 500 ml/ha ester 680 and 118 g/ha Sakura + SOA and Li 700. Sakura was used to help control grass weeds as there was little germination of weeds at sowing. Mace and Scepter were also sown at 70 kg/ha seeding rate with 60 kg/ha DAP (18:20:0:0) on this date for comparison between these two varieties (Table 1).

The late time of sowing was on 26 May with Mace and Scepter, using the same rates of seed and fertiliser as the Trojan. These varieties were sown on strips left between the early sowing, so no extra chemicals were used. As Trojan is a longer growing season wheat variety, it was not included in the later time of sowing.

The paddock strips were harvested using a plot header with four 8.6 m strips per variety with three repetitions done across the demonstration area. Only averages can be compared between varieties with different times of sowing.

## What happened?

Sowing Trojan earlier on 13 May had similar grain yield (t/ha) as Mace and Scepter sown thirteen days later on 26 May. However Trojan had better grain quality with higher test weight and protein than Mace and Scepter (Table 2).

Mace grain yield was 3% higher when sown early. However, for 26 May sowing it yielded the same as Scepter, but had lower protein (11.2%) than Scepter (11.4%).

*Table 1 Grain yield and quality for Mace and Scepter sown on 13 May (time of sowing 1)*

| Variety | Yield (t/ha) | Test weight (hL) | Protein (%) | Screenings (%) | Moisture (%) |
|---|---|---|---|---|---|
| Mace | 3.4 | 81.3 | 10.9 | 2.2 | 10.1 |
| Scepter | 3.3 | 82.3 | 10.6 | 1.1 | 10.1 |
| Site mean | 3.4 | 81.8 | 10.8 | 1.7 | 10.1 |

*Table 2 Grain yield and quality for Trojan, Mace and Scepter sown at ideal sowing times*

| Sowing Date | Variety | Yield (t/ha) | Test weight (hL) | Protein (%) | Screenings (%) | Moisture (%) |
|---|---|---|---|---|---|---|
| 13 May | Trojan | 3.4 | 82.4 | 11.6 | 2.5 | 10.3 |
| 26 May | Mace | 3.3 | 81.0 | 11.2 | 2.2 | 10.1 |
| 26 May | Scepter | 3.3 | 81.8 | 11.4 | 2.4 | 10.1 |
| | Site mean | 3.4 | 81.7 | 11.4 | 2.4 | 10.2 |

## What does this mean?

Results from this one year broad acre demonstration at Minnipa Agricultural Centre show that there was no yield advantage in sowing Mace and Scepter earlier in this season. There was however a gain in grain protein by sowing these two varieties at the earlier sowing date. Results also indicate that Mace and Scepter can achieve similar grain yield as Trojan when sown early in the season, but Trojan in this instance achieved higher grain protein. As the 2016 season ended with mild moist conditions, the longer season varieties performed well across the region. The protein and yield data would presumably be quite different for each variety if the season had finished with warm dry weather.

## Acknowledgements

Amanda Cook, Ian Richter and Brian Dzoma, SARDI Minnipa Agricultural Centre.

***Upper Eyre Peninsula wheat variety yield performance*** *2016 and long term (2012-2016) expressed as t/ha and % of site average yield*

| Variety | Upper Eyre Peninsula | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 (as % site average) | | | | | | | Long term yield brackets (2012-2016) | | | | | | |
| | Kimba | Minnipa | Mitchellville | Nunjikompita | Penong | Poochera | Warramboo | No. Trials | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 |
| AGT Katana | 91 | 97 | 108 | 91 | 92 | 91 | 93 | 32 | 109 | 101 | 102 | 102 | 102 | 101 |
| Axe | 97 | 88 | 98 | 84 | 83 | 84 | 94 | 32 | 112 | 97 | 98 | 94 | 96 | 96 |
| Beckom | 121 | 109 | 108 | 112 | 100 | 98 | 105 | 25 | 108 | 105 | 105 | 111 | 109 | 106 |
| Chief CL Plus | 84 | 102 | 89 | 107 | 110 | 112 | 106 | 12 | 99 | 106 | 109 | 104 | 105 | 104 |
| Cobra | 104 | 105 | 94 | 109 | 109 | 106 | 101 | 32 | 86 | 100 | 101 | 104 | 104 | 105 |
| Corack | 98 | 99 | 88 | 99 | 87 | 95 | 101 | 32 | 112 | 106 | 112 | 104 | 106 | 106 |
| Cosmick | 107 | 100 | 104 | 105 | 97 | 103 | 100 | 25 | 107 | 104 | 104 | 108 | 106 | 105 |
| Cutlass | 109 | 94 | 109 | 95 | 119 | 110 | 81 | 14 | 102 | 102 | 101 | 101 | 99 | 100 |
| DS Darwin | - | - | - | - | - | - | - | 0 | 95 | 97 | 97 | 97 | 98 | 98 |
| DS Pascal | - | - | - | - | - | - | - | 0 | 79 | 91 | 86 | 92 | 91 | 93 |
| Emu Rock | 103 | 102 | 112 | 99 | 89 | 94 | 108 | 32 | 116 | 102 | 103 | 105 | 105 | 103 |
| Estoc | 108 | 98 | 95 | 94 | 102 | 90 | 85 | 32 | 101 | 100 | 100 | 99 | 98 | 99 |
| Gladius | 97 | 100 | 101 | 97 | 108 | 99 | 96 | 32 | 104 | 98 | 98 | 98 | 98 | 98 |
| Grenade CL Plus | 99 | 96 | 93 | 96 | 100 | 92 | 96 | 32 | 109 | 99 | 98 | 97 | 97 | 97 |
| Hatchet CL Plus | 100 | 98 | 103 | 93 | 91 | 99 | 101 | 32 | 111 | 97 | 98 | 97 | 98 | 97 |
| Kord CL Plus | 83 | 92 | 79 | 91 | 98 | 93 | 95 | 25 | 111 | 99 | 99 | 96 | 96 | 96 |
| LRPB Arrow | 101 | 112 | 100 | 107 | 100 | 108 | 106 | 14 | 101 | 106 | 108 | 109 | 109 | 107 |
| Mace | 107 | 103 | 101 | 104 | 99 | 101 | 107 | 32 | 112 | 106 | 110 | 105 | 106 | 106 |
| Scepter | 115 | 110 | 104 | 107 | 106 | 104 | 112 | 14 | 116 | 108 | 111 | 113 | 112 | 109 |
| Scout | 108 | 104 | 113 | 101 | 106 | 87 | 97 | 32 | 98 | 99 | 97 | 104 | 102 | 102 |
| Shield | 112 | 105 | 121 | 94 | 104 | 102 | 105 | 32 | 114 | 101 | 99 | 106 | 103 | 100 |
| Tenfour | 108 | 104 | 110 | 101 | 98 | 99 | 104 | 19 | 107 | 106 | 111 | 109 | 110 | 110 |
| Trojan | 105 | 112 | 92 | 116 | 122 | 105 | 97 | 32 | 95 | 104 | 105 | 104 | 103 | 105 |
| Wyalkatchem | 100 | 100 | 97 | 100 | 92 | 106 | 103 | 32 | 99 | 103 | 105 | 104 | 104 | 103 |
| Yitpi | 105 | 98 | 94 | 103 | 108 | 107 | 81 | 25 | 98 | 98 | 95 | 94 | 94 | 95 |
| **Site av. yield (t/ha)** | **2.81** | **3.44** | **2.08** | **2.01** | **1.51** | **2.16** | **2.56** | | **0.73** | **1.38** | **1.83** | **2.16** | **2.78** | **3.32** |
| *LSD % (P=0.05)* | *8* | *8* | *9* | *9* | *6* | *8* | *6* | No Trials | 5 | 6 | 6 | 6 | 5 | 4 |
| Date sown | 12 May 16 | 16 May 16 | 26 May 16 | 24 May 16 | 24 May 16 | 23 May 16 | 11 May 16 | | | | | | | |
| Soil type | LSL | LSL | LSL | LSL | LSL | LSL | L | | | | | | | |
| Rainfall (mm) J-M/A-O | 97/321 | 63/260 | 102/198 | 27/274 | 90/234 | 124/323 | 57/286 | | | | | | | |
| pH (water) | 7.7 | 8.6 | 8.9 | 8.6 | 8.5 | 8.6 | 8.6 | | | | | | | |
| Previous crop | Oat | gf Pasture | Pasture | gf Pasture | gf Pasture | Pasture | gf Pasture | | | | | | | |
| Site stresses | fr, h | fr, h | fr, h | fr, h | fr, h | fr, h | fr, h | | | | | | | |

**Abbreviations**

Soil type: S=sand, L=loam

gf=grass free

Site stresses: fr=frost, h=heat at flowering

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2012-2016)**

**Data analysis by GRDC funded National Statistics Group**

## *Mid and Lower Eyre Peninsula wheat variety yield performance*

*2016 and long term (2012-2016) expressed as t/ha and % of site average yield*

| Variety | Mid and Lower Eyre Peninsula | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 (as % site average) | | | Long term yield brackets (2012-2016) | | | | | | | | |
| | Cummins | Rudall | Wanilla | No. Trials | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 |
| AGT Katana | 95 | 99 | 99 | 16 | 105 | 100 | 104 | 102 | 101 | 98 | 97 | 99 |
| Axe | 87 | 82 | 79 | 16 | 100 | 83 | 99 | 93 | 94 | 91 | 86 | 90 |
| Beckom | 108 | 113 | 117 | 13 | 109 | 116 | 108 | 112 | 108 | 105 | 108 | 108 |
| Chief CL Plus | 99 | 96 | 104 | 6 | 109 | 120 | 107 | 103 | 102 | 104 | 109 | 98 |
| Cobra | 111 | 107 | 114 | 16 | 102 | 112 | 106 | 107 | 107 | 107 | 111 | 108 |
| Corack | 104 | 94 | 113 | 16 | 113 | 113 | 116 | 104 | 109 | 103 | 106 | 102 |
| Cosmick | 102 | 96 | 115 | 13 | 106 | 111 | 106 | 108 | 107 | 104 | 106 | 107 |
| Cutlass | 102 | 107 | 97 | 7 | 96 | 102 | 97 | 99 | 101 | 104 | 103 | 105 |
| DS Darwin | 95 | 91 | 77 | 12 | 97 | 94 | 98 | 97 | 98 | 98 | 98 | 98 |
| DS Pascal | 99 | 88 | 87 | 3 | 83 | 82 | 85 | 94 | 93 | 98 | 96 | 101 |
| Emu Rock | 95 | 105 | 107 | 16 | 110 | 100 | 108 | 106 | 103 | 96 | 96 | 99 |
| Estoc | 90 | 107 | 93 | 16 | 97 | 99 | 97 | 98 | 99 | 101 | 100 | 100 |
| Gladius | 99 | 94 | 95 | 16 | 99 | 93 | 98 | 98 | 97 | 97 | 94 | 97 |
| Grenade CL Plus | 96 | 93 | 91 | 16 | 99 | 90 | 97 | 96 | 96 | 95 | 92 | 94 |
| Hatchet CL Plus | 95 | 102 | 100 | 16 | 101 | 86 | 100 | 96 | 96 | 92 | 89 | 93 |
| Kord CL Plus | 94 | 95 | 83 | 13 | 99 | 90 | 97 | 94 | 95 | 94 | 91 | 93 |
| LRPB Arrow | 108 | 111 | 115 | 7 | 111 | 122 | 111 | 110 | 109 | 107 | 112 | 106 |
| Mace | 104 | 101 | 105 | 16 | 112 | 113 | 113 | 105 | 107 | 102 | 105 | 102 |
| Scepter | 111 | 112 | 112 | 7 | 116 | 122 | 116 | 114 | 112 | 106 | 110 | 108 |
| Scout | 115 | 109 | 115 | 16 | 99 | 101 | 100 | 106 | 103 | 102 | 102 | 106 |
| Shield | 92 | 110 | 106 | 16 | 105 | 100 | 99 | 105 | 97 | 96 | 94 | 97 |
| Tenfour | - | - | - | 3 | 114 | 118 | 119 | 112 | 115 | 107 | 112 | 110 |
| Trojan | 114 | 106 | 87 | 16 | 100 | 113 | 105 | 105 | 110 | 110 | 113 | 112 |
| Wyalkatchem | 97 | 107 | 106 | 16 | 106 | 112 | 106 | 104 | 103 | 103 | 106 | 101 |
| Yitpi | 99 | 99 | 82 | 12 | 91 | 90 | 90 | 92 | 94 | 98 | 95 | 97 |
| **Site av. yield (t/ha)** | **5.85** | **3.96** | **3.97** | | **2.39** | **2.51** | **3.18** | **3.93** | **4.19** | **4.71** | **5.34** | **5.83** |
| *LSD % (P=0.05)* | *6* | *9* | *7* | No Trials | 2 | 1 | 3 | 3 | 4 | 1 | 1 | 1 |
| Date sown | **19 May 16** | **17 May 16** | **17 May 16** | | | | | | | | | |
| Soil type | L | LSL | LS | | | | | | | | | |
| Rainfall (mm) J-M/A-O | 83/404 | 61/312 | 108/480 | | | | | | | | | |
| pH (water) | 8.6 | 7.4 | 5.4 | | | | | | | | | |
| Previous crop | Canola | gf Pasture | Lupin | | | | | | | | | |
| Site stresses | fr, h | fr, h | h | | | | | | | | | |

**Abbreviations**
Soil type: S=sand, L=loam
gf=grass free
Site stresses: fr=frost, h=heat at flowering

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2012-2016)**
**Data analysis by GRDC funded National Statistics Group**

## ***Upper Eyre Peninsula barley variety yield performance*** *2016 and long term (2012-2016) expressed as t/ha and % of site average yield*

| Variety | UPPER EYRE PENINSULA | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 (as % site average) | | | | Long term yield brackets (2012-2016) | | | | | | | | | |
| | Darke Peak | Elliston | Minnipa | Piednippie | No Trials | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 |
| Alestar | 92 | 92 | 81 | 97 | 20 | 89 | 82 | 97 | 95 | 99 | 95 | 95 | 98 | 102 |
| Bass | 93 | 93 | 97 | 99 | 20 | 96 | 108 | 101 | 100 | 97 | 102 | 97 | 102 | 105 |
| Buloke | 96 | 96 | 97 | 102 | 20 | 102 | 106 | 101 | 99 | 100 | 99 | 100 | 98 | 98 |
| Commander | 104 | 104 | 97 | 104 | 20 | 98 | 109 | 94 | 105 | 94 | 103 | 103 | 105 | 99 |
| Compass | 97 | 97 | 110 | 98 | 20 | 146 | 136 | 115 | 113 | 116 | 112 | 120 | 104 | 89 |
| Fathom | 113 | 113 | 117 | 107 | 20 | 128 | 132 | 111 | 113 | 106 | 115 | 113 | 112 | 103 |
| Fleet | 103 | 103 | 105 | 114 | 20 | 109 | 124 | 98 | 109 | 95 | 108 | 108 | 108 | 98 |
| Flinders | - | - | - | - | 16 | 90 | 94 | 99 | 93 | 99 | 93 | 94 | 92 | 98 |
| Gairdner | - | - | - | - | 0 | 78 | 90 | 89 | 89 | 92 | 85 | 91 | 84 | 89 |
| Granger | - | - | - | - | 16 | 93 | 91 | 98 | 97 | 98 | 97 | 97 | 99 | 101 |
| Hindmarsh | 99 | 99 | 107 | 77 | 20 | 139 | 127 | 119 | 106 | 117 | 108 | 112 | 99 | 94 |
| Keel | 99 | 99 | 109 | 100 | 20 | 124 | 132 | 110 | 107 | 106 | 108 | 109 | 102 | 95 |
| La Trobe | 104 | 104 | 104 | 87 | 20 | 136 | 125 | 117 | 108 | 115 | 110 | 112 | 103 | 97 |
| Maltstar | 105 | 105 | 92 | 105 | 16 | 80 | 81 | 92 | 98 | 92 | 99 | 94 | 105 | 110 |
| Maritime | 87 | 87 | 86 | 91 | 20 | 100 | 109 | 98 | 96 | 100 | 93 | 99 | 89 | 88 |
| Oxford | - | - | - | - | 16 | 66 | 74 | 87 | 95 | 86 | 97 | 88 | 106 | 114 |
| Rosalind | 103 | 103 | 114 | 97 | 12 | 148 | 117 | 122 | 113 | 122 | 116 | 118 | 111 | 102 |
| Scope CL | 95 | 95 | 93 | 99 | 20 | 101 | 105 | 100 | 98 | 100 | 97 | 100 | 95 | 95 |
| Spartacus CL | 104 | 104 | 114 | 92 | 12 | 142 | 131 | 120 | 110 | 117 | 113 | 114 | 104 | 98 |
| Westminster | - | - | - | - | 0 | 62 | 71 | 85 | 88 | 87 | 86 | 85 | 91 | 101 |
| **Site av. yield (t/ha)** | **4.53** | **5.01** | **3.72** | **2.62** | | **1.11** | **1.74** | **2.27** | **2.81** | **3.07** | **3.68** | **4.06** | **4.53** | **5.01** |
| *LSD % (P=0.05)* | *13* | *5* | *8* | *12* | No. Trials | 2 | 1 | 2 | 7 | 1 | 4 | 1 | 1 | 1 |
| Date sown | 11 May 16 | 12 May 16 | 16 May 16 | 23 May 16 | | | | | | | | | | |
| Soil type | LS | SL | LSL | LSL | | | | | | | | | | |
| Rainfall (mm) J-M/A-O | 86/315 | 91/421 | 63/260 | 124/323 | | | | | | | | | | |
| pH (water) | 6.6 | 7.7 | 8.6 | 8.6 | | | | | | | | | | |
| Previous crop | Canola | gf Pasture | gf Pasture | Pasture | | | | | | | | | | |
| Site stress factors | fr, h | h | fr, h | fr, h | | | | | | | | | | |

**Abbreviations**
Soil type: S=sand, L=loam
gf=grass free

Site stresses: fr=frost, h=heat at flowering

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2012-2016)**
**Data analysis by GRDC funded National Statistics Group**

## *Mid and Lower Eyre Peninsula barley variety yield performance*

*2016 and long term (2012-2016) expressed as t/ha and % of site average yield*

| Variety | MID AND LOWER EYRE PENINSULA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 (% site average) | | | Long term yield brackets (2012-2016) | | | | | | | |
| | Wanilla | Wharminda | Cummins | No. Trials | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6.5 |
| Alestar | 103 | 97 | 103 | 11 | 94 | 95 | 96 | 98 | 101 | 103 | 104 |
| Bass | 100 | 107 | 100 | 13 | 98 | 100 | 106 | 99 | 97 | 93 | 103 |
| Buloke | - | - | 110 | 11 | 101 | 101 | 100 | 99 | 98 | 96 | 98 |
| Commander | 104 | 101 | 97 | 13 | 103 | 99 | 99 | 101 | 100 | 100 | 94 |
| Compass | 105 | 105 | 90 | 13 | 120 | 119 | 108 | 109 | 104 | 105 | 92 |
| Fathom | 108 | 108 | 102 | 13 | 113 | 114 | 115 | 109 | 103 | 100 | 101 |
| Fleet | 109 | 105 | 93 | 13 | 108 | 104 | 103 | 103 | 100 | 98 | 91 |
| Flinders | 104 | 97 | 96 | 13 | 95 | 96 | 96 | 95 | 96 | 95 | 99 |
| Gairdner | 80 | 83 | 85 | 13 | 92 | 89 | 84 | 89 | 92 | 92 | 88 |
| Granger | 94 | 88 | 103 | 13 | 96 | 97 | 98 | 99 | 100 | 100 | 102 |
| Hindmarsh | 98 | 108 | 100 | 13 | 114 | 117 | 111 | 106 | 102 | 99 | 100 |
| Keel | 94 | 100 | 94 | 13 | 111 | 111 | 109 | 103 | 98 | 94 | 95 |
| La Trobe | 96 | 112 | 102 | 13 | 113 | 116 | 112 | 107 | 103 | 101 | 102 |
| Maltstar | 106 | 109 | 109 | 11 | 92 | 92 | 99 | 100 | 102 | 103 | 107 |
| Maritime | - | - | - | 7 | 101 | 99 | 93 | 95 | 94 | 93 | 89 |
| Oxford | 106 | 102 | 104 | 13 | 86 | 87 | 98 | 97 | 100 | 100 | 109 |
| Rosalind | 109 | 102 | 111 | 9 | 117 | 121 | 116 | 114 | 111 | 113 | 109 |
| Scope CL | 91 | 88 | 91 | 13 | 101 | 100 | 97 | 98 | 97 | 96 | 95 |
| Spartacus CL | 101 | 120 | 103 | 9 | 115 | 119 | 115 | 108 | 103 | 100 | 103 |
| Westminster | 91 | 89 | 97 | 13 | 84 | 83 | 87 | 90 | 95 | 96 | 99 |
| **Site av. yield (t/ha)** | **4.41** | **3.95** | **6.50** | | **2.66** | **3.29** | **3.73** | **4.34** | **4.74** | **5.20** | **6.49** |
| *LSD % (P=0.05)* | *7* | *8* | *7* | No. Trials | 1 | 2 | 3 | 3 | 2 | 1 | 1 |
| Date sown | 19 May 16 | 10 May 16 | 19 May 16 | | | | | | | | |
| Soil type | LS | LS | L | | | | | | | | |
| Rainfall (mm) J-M/A-O | 108/480 | 93/338 | 83/404 | | | | | | | | |
| pH (water) | 5.4 | 6 | 8.6 | | | | | | | | |
| Previous crop | Lupin | gf Pasture | Canola | | | | | | | | |
| Site stress factors | h | fr, h | fr, h | | | | | | | | |

**Abbreviations**
Soil type: S=sand, L=loam
gf=grass free
Site stresses: fr=frost, h=heat at flowering

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2012-2016)**
**Data analysis by GRDC funded National Statistics Group**

Break Crops

# Section 2

**Section Editor:**
**Amanda Cook**
SARDI, Minnipa Agricultural Centre

# Break Crops

***Eyre Peninsula field pea variety trial yield performance 2016***
*(as a % of site mean) and long term (2011-2015) average across sites (as % of site mean)*

| | Lower Eyre Peninsula | | | | Upper Eyre Peninsula | | |
|---|---|---|---|---|---|---|---|
| **Variety** | **2016** | | **2011-2015** | | **2016** | **2011-2015** | |
| | **Lock** | **Yeelanna** | **% Site mean** | **Trial #** | **Minnipa** | **% Site Mean** | **Trial #** |
| Kaspa | 73 | 86 | 95 | 10 | 89 | 105 | 7 |
| Parafield | 90 | 96 | 89 | 8 | | 86 | 4 |
| PBA Gunyah | 91 | 91 | 93 | 10 | 95 | 108 | 6 |
| PBA Oura | 119 | 101 | 106 | 10 | 92 | 100 | 7 |
| PBA Pearl | 112 | 97 | 124 | 10 | 88 | 103 | 7 |
| PBA Percy | 110 | 116 | 103 | 10 | 88 | 99 | 5 |
| PBA Twilight | | | 89 | 10 | 94 | 107 | 6 |
| PBA Wharton | 88 | 92 | 101 | 10 | 102 | 102 | 7 |
| Sturt | | | | | 87 | 91 | 5 |
| **Site mean yield (t/ha)** | **2.35** | **2.70** | **1.86** | | **2.87** | **1.59** | |
| *LSD (P=0.05) (t/ha)* | *0.3* | *0.4* | | | *0.2* | | |
| Date sown | 30 May | 31 May | | | 1 May | | |
| Soil type | LC | LC | | | CL | | |
| Previous crop | Barley | Wheat | | | Barley | | |
| Rainfall (mm) J-M/A-O | 42/288 | 71/449 | | | | | |
| pH (water) | 7.7 | 8.2 | | | 8.7 | | |
| Site stress factors | fr, ht | fr, ht | | | | | |

Soil types: S=sand, L=loam, C=clay
Site stress factors: ht = high temperatures during flowering/pod fill, fr = reproductive frost damage

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

## *Lower Eyre Peninsula faba bean variety trial yield performance: 2016 and long term*

*(2012-2016) average (as a % of site mean)*

| | Lower Eyre Peninsula | | | | | |
|---|---|---|---|---|---|---|
| **Variety** | **2016** | **Long term average across sites** | | | | |
| | **Cockaleechie** | **No Trials** | **<2** | **2 - 3** | **3 - 4** | **>4** |
| Farah | 4.14 | 25 | 102 | 95 | 99 | 97 |
| Fiesta VF | 4.31 | 25 | 100 | 95 | 98 | 98 |
| Nura | 3.95 | 25 | 96 | 94 | 97 | 93 |
| PBA Rana | 4.28 | 25 | 84 | 86 | 90 | 93 |
| PBA Samira | 3.99 | 25 | 98 | 102 | 102 | 103 |
| PBA Zahra | 4.51 | 25 | 100 | 102 | 102 | 104 |
| **Site av. yield (t/ha)** | **4.57** | | **1.76** | **2.43** | **3.33** | **4.78** |
| *LSD (P=0.05) (t/ha)* | *0.5* | No Trials | 7 | 9 | 4 | 5 |
| Date sown | 10 May | | | | | |
| Soil Type | CL | | | | | |
| Rainfall (mm) J-M/A-O | 71/449 | | | | | |
| pH (water) | 8.2 | | | | | |
| Previous crop | Wheat | | | | | |
| Site stress factors | | | | | | |

Soil types: L=loam, C=clay

*Varieties have only had limited evaluation at these sites, treat with caution

**Data source: GRDC, NVT and PBA - Australian Faba Bean Breeding Program (long term data based on weighted analysis of sites and courtesty by National Statistics Program)**

## *Lower Eyre Peninsula lupin variety trial yield performance 2016*

*2016 and predicted regional performance (2009 - 2015) expressed as % of site average yield*

| | Lower Eyre Peninsula | | | |
|---|---|---|---|---|
| **Variety** | | **Long term average across sites** | | |
| | **Ungarra** | **Yield (t/ha)** | **% of Site Mean** | **# Trials** |
| Danja | 81 | 1.8 | 79 | 9 |
| Jenabillup | 102 | 2.3 | 101 | 16 |
| Jindalee | 77 | 1.9 | 81 | 16 |
| Mandelup | 90 | 2.2 | 98 | 16 |
| PBA Barlock | 110 | 2.4 | 105 | 13 |
| PBA Gunyidi | 99 | 2.4 | 106 | 14 |
| PBA Jurien | 111 | 2.5 | 108 | 9 |
| Wonga | 93 | 2.1 | 91 | 14 |
| **Site av. yield (t/ha)** | **2.32** | **2.28** | | |
| *LSD (P=0.05) (t/ha)* | *0.22* | | | |
| Date sown | 6 May | | | |
| Soil Type | S | | | |
| Rainfall (mm) J-M/A-O | 5.3 | | | |
| pH (water) | 105/399 | | | |
| Previous crop | Wheat | | | |
| Site stress factors | fr, ht | | | |

Soil types: S = sand

Stress factors: fr = frost damage (reproductive), ht=high temperatures during flowering/pod fill

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

## *Lower Eyre Peninsula lentil variety trial yield performance 2016*

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

| Variety | Lower Eyre Peninsula | | |
|---|---|---|---|
| | 2016 | 2009 - 2015 | |
| | Yeelanna | % site mean | Trial # |
| Boomer | | 80 | 2* |
| Nipper | 101 | 93 | 6 |
| Northfield | | 82 | 2* |
| Nugget | 101 | 94 | 6 |
| PBA Ace | 99 | 99 | 6 |
| PBA Blitz | 93 | 98 | 6 |
| PBA Bolt | 105 | 97 | 6 |
| PBA Bounty | | 101 | 2* |
| PBA Flash | 98 | 103 | 6 |
| PBA Herald XT | | 86 | 6 |
| PBA Hurricane XT | 110 | 102 | 4 |
| PBA Jumbo | | 102 | 6 |
| PBA Jumbo 2 | 115 | 112 | 4 |
| **Site mean yield (t/ha)** | **2.26** | **1.70** | |
| *LSD (P=0.05) (t/ha)* | 0.5 | | |
| Date sown | 31 May | | |
| Soil type | LC | | |
| Rainfall (mm) J-M/A-O | 71/449 | | |
| pH (water) | 8.2 | | |
| Previous crop | Wheat | | |
| Site stress factors | fr, ht | | |

**Varieties have only had limited evaluation at these sites, treat results with caution*

Soil type: L=loam, C=clay

Site stress factors: ht=high temperatures during flowering/pod fill, fr=reproductive frost damage

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

## Eyre Peninsula canola variety trial yield performance 2016

(2016 performance expressed as % of site average yield)

| Variety | Lower Eyre Peninsula | | | | | Upper Eyre Peninsula | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | Long term average across sites | | | | 2016 | | Long term average across sites | | | | |
| | **Yeelanna** | **No Trials** | **2.0** | **2.5** | **3.0** | **Lock** | **Minnipa** | **No Trials** | **1.0** | **1.5** | **2.0** | |
| AV Garnet | 96 | 9 | 99 | 105 | 109 | 94 | No Trial | 10 | 74 | 92 | 98 | Conventional |
| Nuseed Diamond | 101 | 8 | 117 | 104 | 119 | 110 | | 7 | 247 | 152 | 120 | |
| Victory V3002 | 77 | 7 | 102 | 105 | 96 | 85 | | 5 | 149 | 118 | 105 | |
| **Site av yield (t/ha)** | **2.83** | | **1.71** | **2.10** | **2.64** | **1.54** | | | **0.77** | **1.33** | **1.68** | |
| *LSD % (P=0.05)* | *12* | No Trials | 5 | 3 | 1 | 6 | | No Trials | 2 | 2 | 1 | |
| Banker CL | 117 | 3 | 112 | 118 | 134 | 105 | 112 | 4 | 100 | 115 | 118 | Clearfield |
| Hyola 474CL | - | 6 | 100 | 100 | 107 | 93 | 92 | 8 | 103 | 107 | 108 | |
| Hyola 575CL | 81 | 7 | 99 | 99 | 103 | 90 | 89 | 6 | 101 | 105 | 106 | |
| Hyola 577CL | 92 | 5 | 100 | 107 | 120 | - | - | 0 | 91 | 104 | 104 | |
| Pioneer 44Y89 (CL) | 85 | 4 | 107 | 101 | 109 | 96 | 94 | 6 | 117 | 113 | 109 | |
| Pioneer 44Y90 (CL) | 111 | 3 | 117 | 121 | 134 | 101 | 101 | 4 | 127 | 124 | 116 | |
| Pioneer 45Y88 (CL) | 102 | 6 | 104 | 111 | 120 | - | - | 1 | 82 | 96 | 98 | |
| Pioneer 45Y91 (CL) | 105 | 1 | 110 | 118 | 122 | - | - | 0 | 102 | 102 | 101 | |
| **Site av yield (t/ha)** | **2.73** | | **1.71** | **2.10** | **2.64** | **1.76** | **1.11** | | **0.77** | **1.22** | **1.66** | |
| *LSD % (P=0.05)* | *12* | No Trials | 5 | 3 | 1 | 5 | 9 | No Trials | 2 | 3 | 3 | |
| ATR Bonito | 99 | 7 | 97 | 99 | 101 | 96 | Trial Abandoned - poor establishment | 8 | 92 | 94 | 99 | Triazine Tolerant |
| ATR Gem | 95 | 9 | 93 | 98 | 99 | - | | 2 | 87 | 91 | 96 | |
| ATR Mako | 76 | 5 | 98 | 98 | 96 | - | | 0 | 95 | 97 | 99 | |
| ATR Stingray | - | 6 | 95 | 89 | 112 | 103 | | 8 | 92 | 97 | 104 | |
| ATR Wahoo | 99 | 9 | 91 | 102 | 105 | - | | 0 | 77 | 85 | 92 | |
| DG 560TT | 102 | 1 | 103 | 100 | 100 | - | | 0 | 108 | 104 | 101 | |
| Hyola 450TT | - | 6 | 99 | 95 | 95 | 93 | | 7 | 102 | 104 | 99 | |
| Hyola 559TT | 106 | 7 | 105 | 103 | 105 | 102 | | 8 | 106 | 109 | 106 | |
| Hyola 650TT | 99 | 6 | 100 | 103 | 111 | - | | 0 | 97 | 102 | 100 | |
| InVigor T 4510 | - | 0 | 107 | 112 | 127 | 103 | | 2 | 113 | 112 | 109 | |
| Pioneer 44T02 TT | | 2 | 106 | 99 | 104 | - | | 4 | 114 | 112 | 107 | |
| Pioneer 45T01 TT | - | 3 | 100 | 101 | 99 | 103 | | 2 | 103 | 101 | 96 | |
| **Site av yield (t/ha)** | **2.46** | | **1.71** | **2.10** | **2.64** | **1.70** | | | **0.77** | **1.22** | **1.66** | |
| *LSD % (P=0.05)* | *14* | No Trials | 5 | 3 | 1 | 6 | | No Trials | 2 | 3 | 3 | |
| Date sown | 4 May | | | | | 12 May | 10 May | | | | | |
| Soil type | CL | | | | | LSL | LSL | | | | | |
| pH (water) | 8.2 | | | | | 8.3 | 8.7 | | | | | |
| Rain (mm) J-M/A-O | 71/449 | | | | | 42/288 | 63/260 | | | | | |
| Site stress factors | fr, ht | | | | | ht | fr, ht | | | | | |

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

Site stress factors: ht=high temperatures during flowering/pod fill, fr=reproductive frost damage

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

# Evaluating alternative pulse options for low rainfall regions

RESEARCH

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

**Almost ready**

**Location:**
Minnipa Agricultural Centre, paddock S10
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 2.39 t/ha (pulses)
Actual: 1.99 - 2.39 t/ha (peas)
**Paddock History**
2015: Barley
2014: Barley
2013: Vetch
**Soil Type**
Clay loam
**Plot Size**
2 m x 10 m x 3 reps

## Key messages

- **Production of alternative pulse options to field pea in low rainfall regions has potential to be successful under favourable seasonal conditions providing essential production criteria are met.**
- **Some 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.**
- **Field peas have proven to be a reliable option on the upper Eyre Peninsula and are likely to be a lower risk and more profitable option in seasonal conditions that are less favourable for alternative pulse options.**
- **Chickpeas are generally less suited to many cropping regions of South Australia, and with a change in the ascochyta blight pathogen growers need to carefully consider their risk to AB infection and ability to effectively control the disease, including in low rainfall regions.**

## 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, relatively high prices, production success stories and availability of varieties with improved agronomic characteristics has renewed interest in alternative pulse options and driven an increase in lentil production in low rainfall regions. This is the third consecutive year that this pulse comparison trial has been conducted. Pulse performance in 2016 was generally improved over the previous two years and mean crop yields from each year have been included for comparison.

## How was it done?

A pulse field demonstration trial was set up at Minnipa in 2016 to compare newly released faba bean, chickpea, field pea and lentil varieties. Five varieties of chickpea, six varieties of faba bean, and seven varieties of lentil and field pea were selected for comparison. Included in the variety selection were Nura faba bean, Genesis TM 090 chickpea, Kaspa field pea and Nugget lentil as traditional commercial standards. Chickpea, field pea and lentil seed was treated with P-Pickle-T and field pea were treated with Apron seed treatment prior to sowing. All crops were sown on 18 May. 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 and flowering were recorded during the growing season and grain yields were taken at harvest. Field peas and lentils were harvested on 4 November. Faba beans and chickpeas were harvested on 24 November.

***Table 1 Faba bean, chickpea, field pea and lentil variety performance, Minnipa 2016 (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 | 2.13 | 225 | Early/mid | PBA Striker | 1.39 | 239 | Early |
| PBA Samira | 2.10 | 231 | Early/mid | Genesis079 | 1.28 | 240 | Early |
| Nura | 2.08 | 230 | Early/mid | PBA Monarch | 1.23 | 238 | Early |
| AF09169 | 2.00 | 224 | Early | PBA Slasher | 1.10 | 240 | Mid |
| AF09167 | 1.98 | 224 | Early | Genesis090 | 0.91 | 245 | Mid |
| Fiord | 1.97 | 225 | Early | | | | |
| **Crop Mean** | **2.04** | | | **Crop Mean** | **1.18** | | |
| *LSD (P=0.05)* | *0.20* | | | *LSD (P=0.05)* | *0.26* | | |
| **2015 mean** | **1.45** | | | **2015 mean** | **0.67** | | |
| **2014 mean** | **1.89** | | | **2014 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 | 2.39 | 231 | Early | CIPAL1301 | 1.96 | 240 | Early/mid |
| OZP1101 | 2.30 | 239 | Mid/late | PBA Hurricane XT | 1.95 | 242 | Mid |
| PBA Twilight | 2.25 | 227 | Early | PBA Jumbo2 | 1.85 | 239 | Mid |
| PBA Wharton | 2.15 | 231 | Early | PBA Bolt | 1.77 | 239 | Early/mid |
| Kaspa | 2.01 | 239 | Mid | CIPAL1422 | 1.73 | 240 | Mid |
| PBA Oura | 1.99 | 229 | Early | PBA Blitz | 1.31 | 235 | Early |
| PBA Percy | 1.99 | 224 | Early | Nugget | 1.26 | 243 | Mid/late |
| **Crop Mean** | **2.15** | | | **Crop Mean** | **1.69** | | |
| *LSD (P=0.05)* | *0.18* | | | *LSD (P=0.05)* | *0.16* | | |
| **2015 mean** | **1.83** | | | **2015 mean** | **1.36** | | |
| **2014 mean** | **1.79** | | | **2014 mean** | **1.43** | | |

## What happened?

Annual rainfall (391 mm) and growing season rainfall (268 mm) in 2016 were above average for Minnipa. Above average rainfall in the months leading up to seeding provided adequate soil moisture for good germination and early growth. Cool spring conditions combined with above average rainfall in September made for ideal conditions for the critical pod filling stage, producing more growth and higher yields compared to the previous two years.

In 2016 field peas yielded 35% above the 2011 to 2015 long term average yield (1.59 t/ha) for Minnipa and achieved the highest crop mean of 2.15 t/ha, followed closely by faba bean (2.04 t/ha), then followed by lentil (1.69 t/ha) and chickpea (1.18 t/ha) (Table 1). Faba bean, lentil and field pea had improved yields in 2016 compared to the previous two years, however chickpea were higher yielding under the more favourable conditions of 2014.

PBA Pearl, OZP1101 and PBA Twilight were the highest yielding pea varieties in 2016. OZP1101 is a mid to late maturing ‘kaspa’ type currently being bulked up for release as a Kaspa replacement and out yielded this variety by 14%. Kaspa, PBA Oura and PBA Percy were the lowest yielding varieties, with Kaspa yielding 19% lower than PBA Pearl. The white seeded early to mid-maturing variety PBA Pearl has been the top performer in this trial in 2015 and 2016, as well as the highest performing field pea variety in long term yields (2011-2015) across SA.

Faba bean had an average yield of 2.04 t/ha at Minnipa in 2016, only 5% behind field peas and no significant differences were seen between the different faba bean varieties. AF09169 is an advanced breeding line adapted to medium and low rainfall areas and has generally produced significantly higher yields than current varieties in regions that are generally considered marginal for faba bean production. Faba beans performed well in 2014 with yields slightly better than field pea, however under a dry finish in 2015 yields dropped significantly.

Lentils averaged 1.69 t/ha, yielding 27% lower than field peas. CIPAL1301, PBA Hurricane XT and PBA Jumbo2 were the highest yielding varieties. CIPAL1301 is a PBA Bolt replacement and yielded 11% higher than this variety. PBA Hurricane XT yielded 13% higher than CIPAL1422, an advanced breeding line with the same herbicide tolerance characteristics. Generally CIPAL1422 has been similar yielding to PBA Hurricane XT across National Variety Trials (NVT) in SA. It has improved resistance to botrytis grey mould (BGM) over PBA Hurricane XT and a medium seed size offering an alternative marketing option to this popular variety. Both CIPAL1301 and CIPAL1422 are anticipated to be available to farmers for seeding in 2018. PBA Blitz and commercial standard Nugget yielded significantly lower than all other varieties last year.

Chickpea was again the lowest yielding pulse crop in 2016, with average yields nearly half those of field peas. The early maturing desi variety PBA Striker was the highest yielding variety along with kabuli types PBA Monarch and GenesisTM079. PBA Striker yielded 26% higher than mid maturing desi variety PBA Slasher, while GenesisTM079 yielded significantly higher than fellow small seeded kabuli variety GenesisTM090 with a 40% yield advantage.

Significant differences were seen in lentil yield between varieties within and across seasons (Figure 1). This demonstrates that variety performance is dependent upon seasonal conditions and that correct variety choice is paramount for achieving high yields if choosing to grow lentils in low rainfall cropping environments. Nugget performed similarly across the seasons with a slight yield increase, while PBA Blitz performed similarly with a slight decrease in yield. PBA Hurricane XT has generally been one of the highest yielding varieties across seasons in these trials but had significantly lower yield under the dry spring finishing conditions of 2015. PBA Bolt followed the same trend as PBA Hurricane XT however was higher yielding than the latter in 2015.

## What does this mean?

The 2016 season saw higher yields than previous two seasons in field pea, lentil and faba bean. Chickpeas however performed better at Minnipa in 2014 due to adequate rainfall during the growing season and warmer temperatures during critical flower and pod fill stages. A virulence change in the ascochyta blight (AB) pathogen in southern Australia now means that all current chickpea varieties are rated as either susceptible or moderately susceptible. Although often relatively lower yielding in low rainfall regions, moderately susceptible varieties GenesisTM090 and PBA Slasher will have a reduced production risk and require fewer fungicides than the higher yielding susceptible varieties such as PBA Striker. Chickpeas are generally less suited than other pulse options in many cropping regions in SA due to their relatively late maturity and increased sensitivity to cold temperatures during the flowering and pod filling phase.

Sowing dates over the previous three years have been relatively early (early-mid May), with flowering and pod filling growth stages generally lining up with mild conditions, critical for maximizing yield in faba bean. If delayed sowing is combined with dry finishing conditions as experienced in 2015 it is likely that the critical flowering period will be shortened and yields will be penalised. Hence, faba beans are an opportunistic pulse crop option in low rainfall regions best suited to years with a good early season break and favourable outlook conditions.

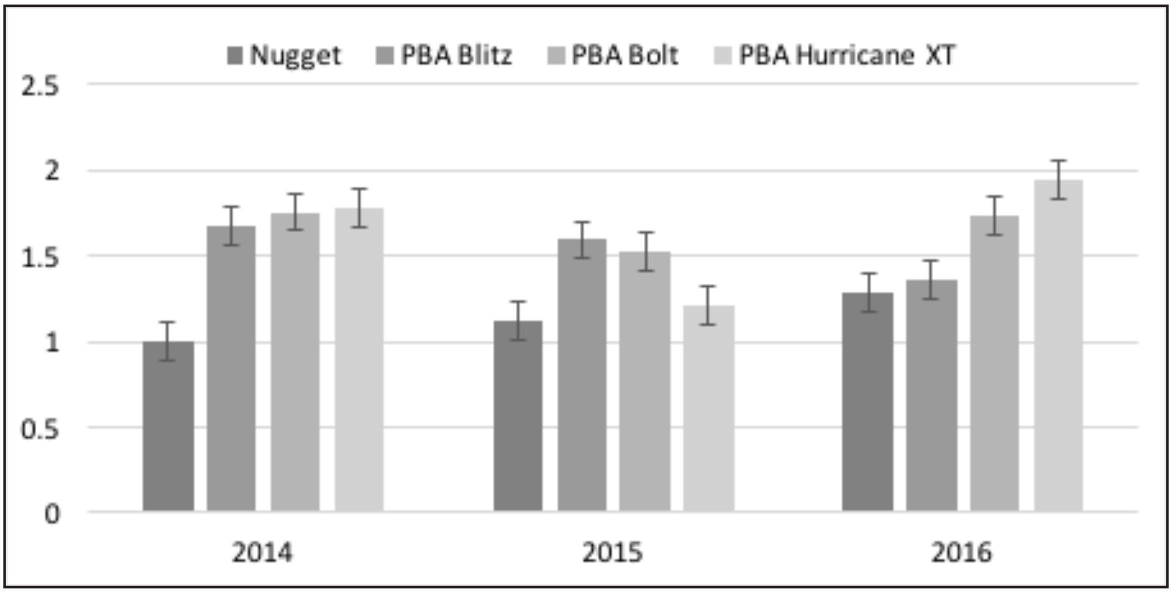


*Figure 1 Long term lentil variety performance, Minnipa 2014-2016*



Break Crops

Lentils have become increasingly popular across South Australia including low rainfall regions where they have not traditionally been grown. Lentil production in the upper and Eastern Eyre Peninsula is now estimated at similar levels to field pea production in these areas (PIRSA Crop Estimates, 2017). Lentils have performed well at Minnipa in the past three years under favourable conditions, however the newly released varieties need further evaluation in less favourable seasons to compare their performance to field peas. Field peas are well suited to low rainfall areas due to their relatively early maturity, high levels of winter biomass production and broader adaptation to different soil types. They have also proved to be the most reliable and stable pulse option over variable seasonal conditions in low rainfall cropping environments compared to alternative pulse options and will likely be the best pulse option in poor seasonal conditions, particularly if current high relative prices are not sustained in other options.

Lentil production in many cases has been successful across low rainfall areas in recent years with improved variety choice allowing growers to take advantage of favourable seasons and high grain prices. If the opportunity arises with a good season break and outlook there are a number of things that growers need to consider before growing alternative pulse crops such as lentils. This includes paddock selection and soil type (particularly flat, free draining paddocks free of sticks and stones to improve harvestability), early time of sowing, correct agronomic management and variety choice, marketing and storage. Growers need to be aware of any specific market requirements and in some cases on farm storage may be required. The ability to complete lentil harvest timely and store grain on-farm must also be considered when growing lentils as seed quality is quickly reduced by rain events on the mature grain.

Correct variety choice is an important factor to consider, with newly released varieties offering earlier maturity and improvements in harvestability, disease resistance and tolerance to herbicide. Selections should be based upon all available information. The availability of the variety PBA Hurricane XT with improved tolerance to Group B residual herbicides has greatly improved the ease of production in these areas and is a popular choice for this reason. PBA Bolt with improved tolerance to boron and salinity and improved harvestability over many other varieties has also been popular. Both of these varieties require fungicide protection for botrytis grey mould, which is not normally a problem in these areas but present in many crops last year.

With all information taken into consideration, further expansion of lentil into nontraditional growing regions is possible provided that all essential criteria for successful production are met. Growers need to be mindful that current relative high prices for alternative pulse options such as chickpea are unlikely to be sustainable and crop choice should be made on long term average grain yields and realistic prices. Faba bean remain an opportunistic pulse crop following a good season break and favourable season outlook in many soil types in these areas.

## Acknowledgements

GRDC for funding project Southern Region Pulse Agronomy (DAV00150), and the SARDI team at MAC for conducting the trial across the last three seasons.

# Re-thinking Ascochyta blight control strategy in field peas

**Christine Walela[1], Larn McMurray[1], Jenny Davidson[2] and Leigh Davis[3]**
[1]SARDI, Clare; [2]SARDI, Waite; [3]SARDI, Minnipa Agricultural Centre

RESEARCH



**Searching for answers**

**Location:**
Minnipa Ag Centre, paddock S10
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 2.39 t/ha (Pulses)
Actual: 1.67 t/ha (Peas)
(chlorothalonil fungicide treatment)
**Paddock History**
2015: Barley
2014: Barley
2013: Vetch
**Soil Type**
Clay loam
**Plot Size**
2 m x 10 m x 3 reps
**Yield Limiting Factors**
Ascochyta blight disease infection

**Location:**
Hart Field Site group,
Mid North, SA
**Rainfall**
Av. Annual: 400 mm
Av. GSR: 305 mm
2016 Total: 485 mm
2016 GSR: 356 mm
**Yield**
Actual: 2.67 t/ha (Peas)
(chlorothalonil fungicide treatment)
**Paddock History**
2015: Oaten hay
2014: Commander barley
2013: Emu Rock wheat
**Soil Type**
Clay loam
**Plot Size**
2 m x 10 m x 3 reps
**Yield Limiting Factors**
Ascochyta blight disease infection

## Key messages

- **The recommended field pea industry practice of P-Pickel T® seed treatment and 2 foliar fungicides of Mancozeb failed to significantly reduce disease infection levels or increase grain yield over untreated control treatments under high blackspot disease pressure in 2016.**
- **Early disease control applications (four weeks after sowing) were important for reducing initial blackspot infection levels at Minnipa, conversely later spring applications were important at the higher rainfall site of Hart.**
- **Over two consecutive years, a yield benefit of at least 15% has been obtained from application of new experimental fungicide actives over the current industry practice treatment of two foliar sprays of Mancozeb.**
- **Further research is required to understand the interaction in efficacy between fungicides and timing of disease infection, together with the drivers of Ascochyta blight onset and progression in different field pea growing environments.**

## Why do the trial?

Ascochyta blight (AB), commonly known as blackspot, is an important disease in field peas, and a concern in low rainfall zones where, in high disease forecast situations, the risk is managed by delaying sowing which often leads to yield loss. To enable earlier sowings, foliar fungicides for the control of AB are an important component of disease management which assists in maintaining yield potential.

The current trials are in the second year, as part of ongoing research aimed at developing improved AB disease control management strategies through the use of fungicides. The existing industry practice for AB control in field peas was developed by SARDI (McMurray, *et al*.) and includes the use of a fungicide application strategy of P-Pickel T® seed dressing followed by two foliar applications of Mancozeb (2 kg/ha at 9 node and early flowering). This strategy developed in 2011 has been shown to suppress AB and is generally a viable economical option for crops yielding 1.5 t/ha or greater. Research conducted in 2015 to test the efficacy of alternative fungicides alongside the current industry practice has improved AB disease control together with a yield benefit of up to 15% over the current industry practice. This research also identified that the severity of disease onset was higher at an earlier growth stage in low rainfall environments such as Minnipa, SA. As such, the timing of the first foliar fungicide, at 8 weeks after sowing (WAS) was thought to be too late for effective control of AB in these environments. Further, in medium rainfall environments, more favourable spring conditions often extend late season disease progression and therefore sprays towards the back-end of the growing season may be required. The aim of the 2016 trials was to further assess these new experimental fungicides alongside the current strategy and also include variations in fungicide application timings to improve disease control efficacy.

## How was it done?

Field trials were conducted in two major field pea production areas in South Australia; Hart (medium rainfall zone, Mid North) and Minnipa (lower rainfall zone, upper Eyre Peninsula). Trials were designed as Randomized Complete Block Design (RCBD), replicated three times with twelve fungicide treatments including an untreated control (Nil). Fungicides were applied either as a seed dressing, as fluid injection, or as combinations of seed dressing/fluid injection and foliar fungicide(s) at strategic growth stages as shown in Table 1. Fortnightly applications of Chlorothalonil were included as a second control treatment which was aimed at maximum control of AB disease. The dual purpose (grain/forage) field pea type PBA Coogee was sown at 55 plants/m$^2$ at all sites, selected for its increased biomass production, lodging and AB susceptibility over Kaspa. The plot sizes were 10 m by 1.35 m with six rows sown on 30 cm (12 inch) spacings. Trial sowing dates were 10 May at Hart and 6 May at Minnipa. The sowing dates at the two sites corresponded to a medium blackspot risk sowing window as forecasted by the Blackspot Manager, DAFWA Crop Disease Forecasts, May 2016.

In order to accelerate AB infection in both trials field pea stubble infested with AB from the previous season was uniformly spread adjacent to seedlings at 1 to 2 nodes growth stage. The disease severity of AB within a plot was assessed as the percentage of plants covered by AB symptoms (purplish-black necrotic lesions on leaves) x frequency of infected plants per plot at vegetative (7 node) and early bud development (13 node) growth stages. Further, a quantitative assessment on the vertical progression of AB on individual plants was conducted at mid to late flowering stage by randomly selecting five plants per plot and assessing the number of girdled nodes as a proportion of total nodes per plant per plot and thereafter using the scores to develop a disease index (DI).

***Table 1 Summary of fungicide treatments and application timings as applied to field pea AB management trials at Hart (Mid-North) and Minnipa (upper Eyre Peninsula), SA 2016***

| Treatment* | Seed treatment | Seeding | 4 WAS ^ | 6 WAS ^ | 9 WAS ^ | Early flower | Mid Flower | Late Flower |
|---|---|---|---|---|---|---|---|---|
| Nil | | | | | | | | |
| PPT | PPT | | | | | | | |
| Chloro | PPT | | Chloro | 10 sprays (fortnightly applied) | | | | |
| Sys | PPT | | | | | | | |
| Flu | | Flu | | | | | | |
| Av.Xpro | PPT | | | Av.Xpro | | Av.Xpro | | |
| Ami.Xtra | PPT | | | Ami.Xtra | | Ami.Xtra | | |
| Uni+Ami.Xtra | | Uni | | Ami.Xtra | | Ami.Xtra | | |
| Flu+Avi.Xpro | | Flu | | Av.Xpro | | Av.Xpro | | |
| Ami.Xtra | PPT | | | Ami.Xtra | | Ami.Xtra | | |
| Av.Xpro early + Manc | PPT | | Av.Xpro | | Av.Xpro | Manc. | | |
| Manc. Low | PPT | | Manc. | | Manc. | Manc. | Manc. | Manc. |
| Manc Std. | PPT | | | Manc. | | Manc. | | |

*^ WAS = weeks after sowing*
*All treatments were treated with Apron® (350 g/L Matalaxyl-M) seed dressing to control downy mildew*

*Fungicide treatment legend and application rates
1. Nil = No treatment applied
2. PPT = P Pickle T® (PPT) - 200 ml/100 kg seed
3. Chloro = Chlorothalonil - 2 L/ha
4. Sys = Systiva – 150 ml/100 kg seed
5. Flu = Fluid injection: Flutriafol – 400 ml/ha
6. Uni = Fluid injection: Uniform – 400 ml/ha
7. Avi.Xpro = Aviator Xpro® - 600 ml/ha
8. Ami.Xtra = Amistar Xtra® - 600 ml/ha
9. Manc low = Mancozeb – 0.5 kg/ha
10. Manc Std. = Mancozeb – 2 kg/ha

## What happened?

In 2016, the growing season rainfall (GSR) was above long term averages at both sites. A total of 356 and 268 mm was recorded for the months of April to October, at Hart and Minnipa respectively. The two trials were sown in late Autumn in relatively dry seed bed conditions, however, this was followed by wet conditions in winter and a relatively cool spring which resulted in prolonged maturation of the crop, especially at Hart.

### *Effect of fungicide treatments on disease severity*

The results obtained from the assessment of disease severity at the late vegetative (7 node) and early bud development (13 node) growth stage indicated a site x fungicide treatment interaction suggesting that fungicide treatment response in controlling AB disease changed significantly with environmental (site) conditions. Assessment of AB disease responses at 7 node only evaluated the effect of fungicides that had been applied at seeding, 4 and 6 WAS (weeks after sowing), while the assessment conducted at 13 node evaluated the effect of fungicides that had been applied at seeding, 4, 6, and 9 WAS.

Disease severity at the 7 node assessment period was higher in the Nil treatment at Minnipa (42%) than at Hart (13%) (Table 2). This was a similar to the finding in 2015 highlighting the importance of early season disease control at Minnipa. Aviator Xpro® applied at 4 WAS and fortnightly Chlorothalonil treatments (first treatment commenced at 4 WAS) showed varying but improved disease control over all other treatments at both sites. This indicated that early application timings at between 2 and 4 node improved early season disease control over later application at 6 WAS (5-6 node). The current industry practice, Mancozeb (2 kg/ha) applied at 6 WAS reduced infection levels compared to Nil at Hart but not at Minnipa where disease severity was higher. This finding suggests that there may be differences in efficacy between fungicides depending upon the level of disease pressure.

At the 13 node assessment period, the current industry practice, Mancozeb (2 kg/ha) treatment, reduced infection levels similar to the fortnightly Chlorothalonil and all the Aviator Xpro® treatments at Hart only (Table 2). This suggested that in some instances where AB infection is relatively low, these three fungicides may offer similar levels of disease control. At Minnipa, however, the fortnightly Chlorothalonil had the highest level of disease control over all other treatments. Differences between other foliar fungicides were less obvious and only the Flutriafol + Aviator Xpro® treatment applied at 6 WAS showed improved disease control over the Nil treatment. In most instances, Amistar Xtra® treatments and the lower rate of Mancozeb (500 g/ha) treatment did not reduce infection levels over the Nil or the current industry standard of Mancozeb (2 kg/ha) treatments.

*Table 2 Ascochyta blight disease severity assessed at 7 and 13 node (percentage plot severity) in field pea (PBA Coogee) under different fungicide treatments at Hart (Mid-North) and Minnipa (upper Eyre Peninsula), SA, 2016*

| | Disease severity at 7 node (% plant disease) | | | | Disease severity at 13 node (% plant disease) | |
|---|---|---|---|---|---|---|
| Fungicide Treatment | Hart Log (base 10) | Hart Raw data | Minnipa Log (base 10) | Minnipa Raw data | Hart | Minnipa |
| Nil | 1.12 | 13.1 | 1.62 | 41.6 | 32 | 51 |
| Sys | 1.03 | 10.6 | 1.58 | 38.3 | 35 | 45 |
| PPT | 0.84 | 6.8 | 1.62 | 41.6 | 36 | 46 |
| Flu | 0.77 | 5.8 | 1.60 | 40.0 | 24 | 51 |
| Manc.Std | 0.77 | 5.8 | 1.60 | 40.0 | 24 | 47 |
| Manc. Low | 0.82 | 6.5 | 1.60 | 40.0 | 32 | 47 |
| Ami.Xtra | 0.84 | 6.8 | 1.62 | 41.6 | 33 | 49 |
| Avi.Xpro | 0.77 | 5.8 | 1.60 | 40.0 | 24 | 46 |
| Uni+Ami.Xtra | 1.05 | 11.3 | 1.58 | 38.3 | 32 | 47 |
| Flu + Avi.Xpro | 0.50 | 3.2 | 1.54 | 35.0 | 19 | 41 |
| Avi.Xpro early + Manc | 0 | 1.0 | 0.90 | 7.90 | 17 | 42 |
| Chloro | 0.10 | 1.3 | 0.50 | 3.10 | 14 | 25 |
| *LSD (P<0.05)* | *0.19* | | *0.19* | | *7.8* | |

Break Crops

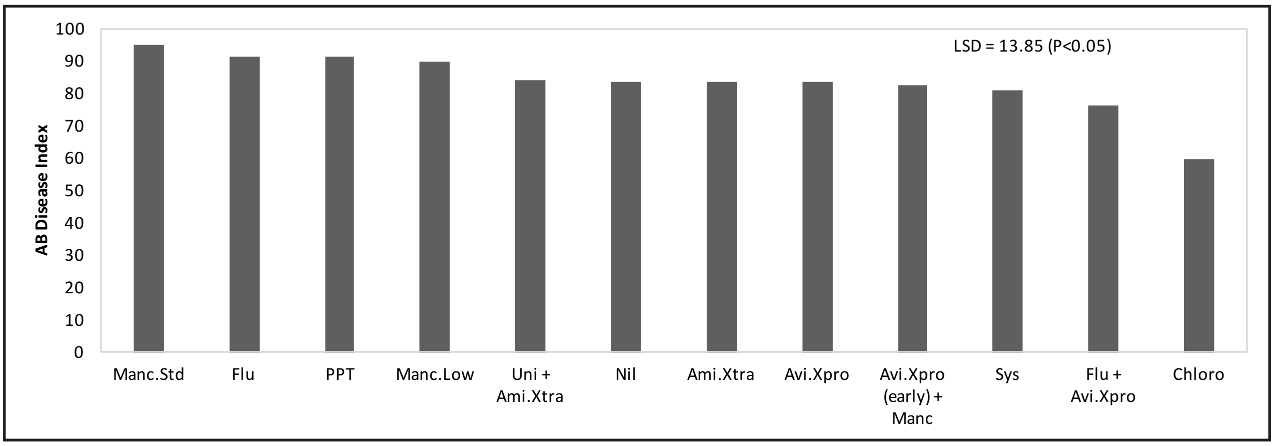


***Figure 1 Ascochyta blight disease index developed from a quantitative assessment of the number of girdled nodes on individual field pea plants at mid-late flowering under different fungicide treatments at Hart (Mid-North) and Minnipa (upper Eyre Peninsula), SA, 2016***

The disease index scores at the mid flowering stage showed that the effect of fungicide treatments in controlling disease was similar across both sites. Notably, disease infection was high among all treatments including the fortnightly Chlorothalonil treatment which was shown to have up to 60% infection level across both sites (Figure 1). However this treatment, as expected, still had an improved level of disease control over all other treatments at both sites. This was followed by the Flutriafol + Aviator Xpro® treatment which also had lower AB infection levels than the current industry practice of Mancozeb (2 kg/ha). Again this observation suggested that Aviator Xpro® as a product had better efficacy in improving disease control (20%) over the industry practice Mancozeb (2 kg/ha) treatment especially at this critical period of mid-late flowering and pod-filling.

***Effect of fungicide treatments on grain yield***

There was a site by fungicide interaction for grain yield. Higher yields were recorded at Hart (1.74 t/ha) than at Minnipa (1.30 t/ha) which is likely to be due to higher rainfall and a longer and more favourable season finish (Table 3). The disease index scores showed that disease was strongly correlated ($R^2$=0.72, P≤ 0.05, data not presented) with grain yields across the two sites hence disease was a major driver in yield loss in 2016. At Hart, the highest grain yields were recorded from the fortnightly Chlorothalonil (2.67 t/ha) treatment over all other treatments. This treatment received its last fungicide spray in early spring, 8 November, which was almost three and half months after the early flowering stage compared to when most other treatments had ceased having foliar sprays (15 August). Comparatively at Minnipa the last Chlorothalonil spray was applied on 19 October, two months after the early flowering stage sprays (17 August) highlighting the longer and more favourable finishing conditions experienced at Hart. Yields at Hart were improved by 20% from the use of Aviator Xpro® and Amistar Xtra® treatment over the current industry practice, Mancozeb (2 kg/ha) and the Nil treatment which both yielded similarly.

At Minnipa, the fortnightly Chlorothalonil treatment yielded similar to a number of treatments including all Aviator Xpro® treatments, one of the Amistar Xtra® and the lower rate of Mancozeb (500 g/ha) which was applied at five separate occasions. The performance of these fungicides in grain yield response was quite remarkable given that the fortnightly Chlorothalonil treatment had received up to 10 sprays whereas the other treatments had only received sprays ranging from 2 to 5 in number. Notably, there was no yield improvement from the application of the current industry practice, Mancozeb (2 kg/ha) over the Nil treatment. These results suggested that both application timing and type of product were important for disease control under high disease pressure conditions at both sites in 2016.

## What does this mean?

Environmental conditions of above average rainfall together with effective inoculation of AB favoured early and high disease development and progression at Minnipa. In contrast cooler spring conditions and higher rainfall amounts led to a longer maturation period and prolonged exposure of unprotected new plant growth to late AB disease infection at Hart. These differences in environmental conditions are likely to have accounted for site by fungicide treatment interaction for disease severity and grain yield response between the two sites.

***Table 3 Mean yield (t/ha) of field pea (PBA Coogee) under different fungicide treatments at Hart (Mid-North) and Minnipa (upper Eyre Peninsula) SA, 2016***

| | Grain yield (t/ha) | |
|---|---|---|
| **Fungicide treatment*** | **Hart** | **Minnipa** |
| Nil | 1.49 | 0.95 |
| Sys | 1.55 | 1.19 |
| PPT | 1.33 | 1.05 |
| Flu | 1.49 | 1.10 |
| Manc. Std | 1.54 | 1.19 |
| Manc. Low | 1.60 | 1.37 |
| Ami.Xtra | 1.84 | 1.32 |
| Avi.Xpro | 1.93 | 1.40 |
| Uni. + Ami.Xtra | 1.91 | 1.21 |
| Flu. + Avi.Xpro | 1.89 | 1.57 |
| Avi.Xpro (early) + Manc. | 1.65 | 1.58 |
| Chloro | 2.67 | 1.67 |
| *LSD (P<0.05)* | *0.336* | |

The current industry practice recommendation of two strategic foliar sprays of Mancozeb (2 kg/ha) at vegetative and early flowering growth stages did not effectively control disease or result in a yield improvement over the unsprayed Nil treatment in a susceptible field pea variety under high disease pressure in 2016. In comparison, Aviator Xpro® and Amistar Xtra® in various combinations, showed improved levels of disease control over the current industry practice of Mancozeb (2 kg/ha) and the Nil treatment. At Minnipa the early application of Aviator Xpro® showed improved control and reduced early infection levels over later application timings of similar treatments. Reducing the rate of application of Mancozeb from 2 kg/ha to 500 g/ha and staggering this latter application over five application timings instead of just two showed improved disease control at Hart but not at Minnipa, where disease pressure was significantly higher early in the season. While the fortnightly Chlorothalonil treatment reduced disease pressure considerably over other treatments it only achieved a disease index rating of 60% across both sites at the early flowering stage, indicating a large amount of disease infection still occurred. Higher relative yields at Hart from the prolonged application of the fortnightly Chlorothalonil treatment demonstrate the importance of late disease control especially in longer more favourable seasons and environments.

In comparison to the current industry practice, of Mancozeb (2 kg/ha), the two experimental fungicide products, Aviator Xpro® and Amistar Xtra® showed yield benefits of at least 19% across the two sites under high disease severity. A similar trial conducted in 2015 also showed a yield benefit of approximately 15% from the application of these new fungicide products. Further testing will be carried out in the 2017 season to confirm these findings across seasons and environments. It is also worth noting that the levels of AB inoculation from infested pea stubble may be higher than those commonly encountered in the paddocks, therefore our results should be interpreted with caution. Further research will also be carried out to try and understand the drivers of early disease infection in low rainfall environments such as Minnipa and the use of strategic late applications in more favourable environments.


## Acknowledgements

Funding for this work was provided through GRDC project DAV00150 (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 former Bayer CropScience Pty Ltd for providing Aviator Xpro.


***Note: 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.***

## References


[1]McMurray LS, Davidson JA, Lines MD, Leonforte A, Salam MU (2011) *Combining pathological, agronomic and breeding advances to maximise Pisum sativum yields under changing climatic conditions in south-eastern Australia*. Euphytica 180, 69-88.


SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Government of South Australia

Southern PULSE Agronomy

# SAGIT vetch trials on EP

**Stuart Nagel[1], Gregg Kirby[1] and Leigh Davis[2]**
[1]SARDI, Waite; [2]SARDI, Minnipa Agricultural Centre

RESEARCH

**Almost ready**

**Location:**
Minnipa Agricultural Centre, paddock S10
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 2-2.25 t/ha (grain)
5-6.0 t/ha (dry matter)
Actual: Grain: Site mean 2.6 t/ha with highest yield 3.2 t/ha
Dry Matter: Site mean 3.3 t/ha, highest 3.7 t/ha
**Paddock History**
2015: Barley
2014: Barley
2013: Vetch
**Soil Type**
Clay loam
**Plot Size**
1.5 m x 10 m x 3 reps
**Yield Limiting Factors**
None

**Location:**
Piednippie/Haslam
Dion Trezona
**Rainfall**
Av. Annual: 324 mm
Av. GSR: 220 mm
2016 Total: 367 mm
2016 GSR: 316 mm
**Yield**
Potential: 2-3.00 t/ha (dry matter)
Actual: Site mean 1.9 t/ha, highest yield 2.4 t/ha
Dry Matter: Site mean 3.3 t/ha, highest 3.7 t/ha
**Paddock History**
2015: Mace wheat
2014: Grass free medic
2013: Axe wheat
**Soil Type**
Grey calcareous sand
**Disease**
No disease was observed
**Plot Size**
1.5 m x 10 m x 3 reps
**Yield Limiting Factors**
Poor sub soil moisture at sowing, with a residual chemical effect noted in July/August.

## Key messages

- **SAGIT funded trials over the last 3 years have shown the potential of vetch on Eyre Peninsula, leading to the selection of an early flowering (90-95 days) line with increased winter vigour (SA 34876) as a new variety for low rainfall mixed farming systems.**
- **The last three seasons have been particularly good at Minnipa for both grain and hay production of vetch.**
- **Piednippie trials have not been as successful as Minnipa, but have still shown with the right management vetch could produce good hay, fodder or grazing on the grey calcareous soils.**
- **On Eyre Peninsula early sowing (mid-April) can achieve good yield and hay production but is heavily reliant on either good subsoil moisture or late follow-up rain.**
- **Herbicide choices for vetch are very dependent on local conditions so talk to your local agronomist about the best options available.**

## Why do the trial?

The aim of this project (SAGIT S914) was to;

- Provide a genuine legume break crop option for cereal and mixed farmers in the marginal cropping areas of South Australia. Focusing on Western Eyre Peninsula, the Upper North and the Murray lands/Mallee.
- Trial advanced common vetch lines with specific targeted traits in replicated trials in these regions of South Australia for assessment of potential new releases.
- Validate the benefits and potential of common vetch in the targeted areas.
- Provide farmers with high yielding alternative vetch varieties that are well adapted to sandy-alkaline soils in low rainfall environments.

## How was it done?

Three replicated trials have been sown on upper Eyre Peninsula, two located on Minnipa Agricultural Centre and one at Piednippie. The trial management details are outlined in Table 1.

The selection criteria for the lines/genotypes investigated in this trial was fodder production, early vigour and winter growth. The target was to find a line which had the potential to provide winter grazing or spring hay/fodder for farmers in a mixed farming system, whilst offering the cropping phase of the rotation a genuine and reliable legume option with its associated benefits of increasing soil nitrogen and reducing disease levels in the rotation for subsequent crops.

## What happened?

The last three seasons at Minnipa have seen above average rainfall, producing yields above the long term averages in most crops. This has been evident in vetch production, with trials producing good yields of both grain and hay. In 2015, the grain trial mean was 1.4 t/ha with the top lines achieving 2.1 t/ha. In 2016 a long wet spring produced high grain yields with a site mean of 2.58 t/ha (Table 4). Hay yields across the three years reflected the seasons with mean yield of 3.7 t/ha, 4.1 t/ha and 3.3 t/ha for 2014, 2015 and 2016 respectively (Table 2).

*Table 1 2016 vetch trial details at Minnipa and Piednippie*

| | Treatment | Date of application |
|---|---|---|
| **Minnipa SAGIT Hay Trial** | | |
| Sowing date | | 6 May |
| Fertiliser | No fertiliser applied | |
| Pre sowing chemicals | 1.5 L/ha Sprayseed +1.2 L/ha Treflan | 6 May |
| Post sowing/pre-emergent chemicals | 150 g/ha Lexone + 400 g/ha Diuron + 1 L/ha Lorsban | 8 May |
| | 400 g/ha Diuron and 100 g/ha Metrabuzin | 10 May |
| Insecticides | 1 L/ha Lorsban and Karate 0.8 L/ha | 20 May |
| Grass herbicides | 400 ml/ha Select and 350 ml/ha Lemat and 1 L/100L Kwiken | 14 June |
| Harvest/cut for hay | | 8 Sep |
| **Minnipa GRDC Grain Trial** | | |
| Sowing date | | 11 May |
| Fertiliser | No fertiliser applied | |
| Pre sowing chemicals | 2.0 L/ha Roundup +1.2 L/ha Treflan+60 ml/ha Hammer+ 1 L/ha Lorsban+500 ml/100 L LI700 | 11 May |
| Insecticides | 1 L/ha Lorsban and Karate 0.8 L/ha | 20 May |
| Grass herbicides | 400 ml/ha Select and 350 ml/ha Lemat and 1 L/100 L Kwiken | 14 June |
| Grain harvest | | 31 Oct |
| **Piednippie SAGIT Hay Trial** | | |
| Sowing date | | 20 May |
| Fertiliser | No fertiliser applied | |
| Pre sowing chemicals | 2 L/ha Glyphosate DST +1.5 L/ha TriflurX+ 60 ml/ha Hammer + 800 g SoA/100 L water | 20 May |
| Post sowing pre-emergent chemicals | 1.5 L/ha Gramoxone + 1 L/ha Lorsban | 23 May |
| Post sowing pre-emergent chemicals | 300 g/ha Diuron + 100 g/ha Lexone | 23 May |
| Insecticides | 200 ml/ha Lorsban and Karate 0.8 L/ha | 27 May |
| Grass herbicides | 400 ml/ha Select and 350 ml/ha Lemat and 1 L/100 L Kwiken | 14 June |
| Insecticides | 200 ml/ha Lorsban and Karate 0.8 L/ha and 1 L/100 L Kwiken | 21 July |
| Harvest/cut for hay | | 7 Sep |

In 2014 the trial at Piednippie showed good early vigour, before suffering spray damage. It produced a mean dry matter yield of 1.6 t/ha, but showed the potential of vetch on the grey calcareous sands given the right treatments. In 2015 the trial at Piednippie 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 in 2015 was only 1.1 t/ha of dry matter. In 2016 the trial was sown in late May and again struggled with poor early vigour. It appeared to have issues with residual chemicals from 2015 and did not grow through this until late in August, reducing yields and achieving a site mean of 2.0 t/ha dry matter (Table 3).

*Table 2 Minnipa hay results*

| Genotype | 2014 (t/ha) | 2015 (t/ha) | 2016 (t/ha) |
|---|---|---|---|
| 34559 | 2.97 | 4.12 | 2.95 |
| 34748 | 4.95 | 4.01 | 3.37 |
| 34822 | 3.65 | 4.23 | 3.40 |
| 34831 | 4.47 | 4.11 | 3.69 |
| 34842 | 3.61 | 4.37 | 3.77 |
| 34876 | 4.11 | 4.14 | 3.48 |
| 34883 | 3.66 | 3.98 | 2.99 |
| 34885 | 3.31 | 4.29 | 3.17 |
| 35019 | 4.57 | 3.82 | 3.02 |
| 35036 | 4.06 | 3.85 | 3.12 |
| 35122 | 4.2 | 4.07 | 3.17 |
| 37003 | 3.03 | 4.05 | 3.21 |
| 37058 | 3.98 | 4.15 | 3.57 |
| 37107 | 4.97 | 3.69 | 3.21 |
| 37457 | - | 3.96 | 3.19 |
| 34823-2 | 4.61 | 4.20 | 3.18 |
| 35427-1 | - | 3.99 | 3.16 |
| Rasina | - | 3.98 | 3.69 |
| Timok | 3.9 | 4.26 | 3.57 |
| Volga | 3.95 | 4.01 | 3.34 |
| **Mean** | **4.00** | **4.06** | **3.31** |

*Table 3 Piednippie hay results*

| Genotype | 2014 (t/ha) | 2015 (t/ha) | 2016 (t/ha) |
|---|---|---|---|
| 34559 | 1.22 | 1.02 | 1.91 |
| 34748 | 1.99 | 1.28 | 2.02 |
| 34822 | 1.66 | 1.03 | 2.19 |
| 34831 | 1.63 | 1.22 | 1.86 |
| 34842 | 1.70 | 1.22 | 2.11 |
| 34876 | 1.74 | 1.15 | 2.09 |
| 34883 | 1.71 | 1.32 | 1.98 |
| 34885 | 1.44 | 1.26 | 2.01 |
| 35019 | 1.69 | 1.08 | 1.58 |
| 35036 | 1.60 | 1.08 | 1.84 |
| 35122 | 1.88 | 1.33 | 2.14 |
| 37003 | 1.28 | 1.07 | 1.72 |
| 37058 | 1.79 | 1.22 | 2.22 |
| 37107 | 1.84 | 1.09 | 1.84 |
| 37457 | - | 1.30 | 1.87 |
| 34823-2 | 1.74 | 1.23 | 1.96 |
| 35427-1 | - | 1.02 | 1.83 |
| Rasina | - | 1.02 | 2.16 |
| Timok | 1.68 | 1.16 | 1.85 |
| Volga | 1.91 | 1.51 | 2.49 |
| **Mean** | **1.71** | **1.18** | **1.98** |

*Table 4 Grain yield of selected lines from Minnipa GRDC primary trial*

| Genotype | 2015 (t/ha) | 2016 (t/ha) |
|---|---|---|
| 34876 | 1.72 | 2.87 |
| 37102 | 1.91 | - |
| 37107 | 1.62 | 3.19 |
| 37654 | 2.02 | - |
| 37670 | 2.09 | 2.63 |
| 37695 | 2.03 | - |
| 37731 | 2.16 | 2.40 |
| 35427-1 | 1.94 | 3.06 |
| 35444-3 | 2.04 | - |
| Blanchefleur | 1.35 | 2.56 |
| Morava | 1.15 | 2.73 |
| Rasina | 1.51 | 2.32 |
| Timok | 1.76 | 2.32 |
| Volga | 1.86 | 3.08 |
| **Mean** | **1.41** | **2.58** |

## What does this mean?

The trials conducted at Minnipa and Piednippie were replicated in the Upper North and Northern Mallee/Riverland. Grain yield was also assessed in 2015 and 2016 at multiple sites with grain yields from GRDC trials providing additional data. The results from the multiple sites across the given seasons have been;

- There was strong correlation between Minnipa and Morchard in both dry matter and grain production.
- Even though the trials at Piednippie have been poor there is correlation between the years, and some correlation with results from Minnipa and Morchard.
- The Mallee trials at Karoonda and Loxton do not correlate with the rest of the sites.
- Discussion with different farmer groups indicated that early vigour and winter growth were extremely desirable traits for a legume option in lower rainfall mixed farming systems. These traits were considered more important than maturity, as dry matter production has a direct correlation to nitrogen fixation, as well as potential fodder yields.
- Even though the seasons at Minnipa and Morchard were above average in 2015 and 2016, farmers did comment that it was important to see the potential of the crop in a good season to understand what can be achieved with this crop.
- The trials conducted in this project have shown that the line SA 34876 has the best potential to provide farmers in the lower rainfall more marginal cropping areas of South Australia with a viable and consistent legume option, with the ability to be used for grain, grazing and or hay production depending on the season and the farming system.


## Acknowledgements

SAGIT Project S914. The National Vetch Breeding Program would like to thank SAGIT, GRDC, RIRDC and SARDI for funding this program and acknowledge the ongoing support and interest provided by Australian farmers. Farmers, 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.

# Impact of sowing date on phenology and yield of lentil and faba bean

RESEARCH

**C. Mariano Cossani[1, 2], Larn McMurray[3], Lachlan Lake[4] and Victor O. Sadras[4]**

[1]SARDI, Port Lincoln; [2]SARDI, Minnipa Agricultural Centre; [3]SARDI, Clare; [4]SARDI, Waite

**Almost ready**

**Location:**
Minnipa Agricultural Centre, paddock S10
SARDI Pulse Breeding Australia
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Actual:
4.17-1.27 t/ha (faba beans)
2.37-0.81 t/ha (lentils)
**Paddock History**
2015: Barley
2014: Barley
2013: Vetch
**Soil Type**
Clay loam
**Plot Size**
1 m x 1 m x 3 reps

## Key messages

- **The yield of both pulse crops decreased in general when delaying sowing.**
- **Modifying sowing time produced changes in the phenology that affected main yield components and grain yield.**
- **In general, the later sowing dates reduced grain number/$m^2$ and produced a lower thousand grain weight.**

## Why do the trial?

Faba beans and lentils are two important pulse crops with growing interest from farmers in low rainfall areas of South Australia. Recent high prices of lentils together with their rotational benefits make these crops potential new options for some areas of the Eyre Peninsula, however frost and heat stress can compromise performance and crop yield. Sowing date and variety choice are the two main tools to manipulate time of flowering and pod-set, and thus manage the risk of extreme temperatures and the trade-off between frost and heat risk.

The objective of this work is to analyse the impact of sowing date and variety on the phenology and grain yield of faba beans and lentils on upper Eyre Peninsula.

## How was it done?

A field trial was set up at Minnipa Agricultural Centre in 2016 to test the effect of the sowing date on different varieties of lentil and faba bean. The trial consisted of a combination of six sowing dates ranging from 21 April to 26 June with ten varieties of each crop chosen in consultation with Pulse Breeding Australia lentil and faba bean programs. Faba bean varieties were Icarus, AF03001-1, PBA Rana, PBA Samira, Farah, PBA Zahra, Aquadulce, 91-69, Fiord and Nura. Lentil varieties were PBA Blitz, Northfield, CIPAL901, CIPAL1301, PBA Hurricane XT, CIPAL1422, PBA Giant, PBA Jumbo2, Nugget and Matilda.

In both crop types, three replications for each genotype and sowing date were used. Crops were hand sown in a split-plot design with sowing dates allocated to the main plot and genotypes randomized within each of them. Plots sizes were 1 m by 1 m and consisted of 3 rows, 0.27 m apart. Prior to sowing, phosphorous was applied using 60 kg/ha of MAP (11:52:0:0).

Within each experimental unit, ten plants were selected and tagged in a representative area, trying to avoid the border effect. During the growing season, an intensive assessment of the phenology dynamic was measured for each plant. The dates recorded were; the beginning of flowering, the beginning of podding, node of first flower, the node of first pod, the end of flowering and maturity date.

After maturity, a subsample of 0.5 m length was collected and dried in an oven at $70^{o}C$ until constant weight was achieved. Grains were separated from the pods, cleaned, counted and weighed. The grain per shoot was also counted in the faba bean samples.

## What happened?

Sowing date affected the yields and phenology of faba bean and lentils. In general, and as expected, grain yield decreased with the delay of sowing (Figure 1) although the effect was stronger after 20 May. The highest variability in grain yield of faba bean was observed for the earliest sowing date and was mostly due to the poor yield of the late maturing broad bean variety Aquadulce. The grain yield of faba bean averaged across varieties ranged between 2.98 t/ha at the sowing date of 17 May to 1.76 t/ha at late June. The highest grain yield of faba beans (4.17 t/ha) was observed when sowing Nura on 21 April while the lowest was obtained by Aquadulce in the latest sowing (1.27 t/ha). For lentils, the highest grain yield was 2.37 t/ha for CIPAL1301 sown on 17 May, while the lowest was for late-sown Northfield (0.81 t/ha) on 26 June.

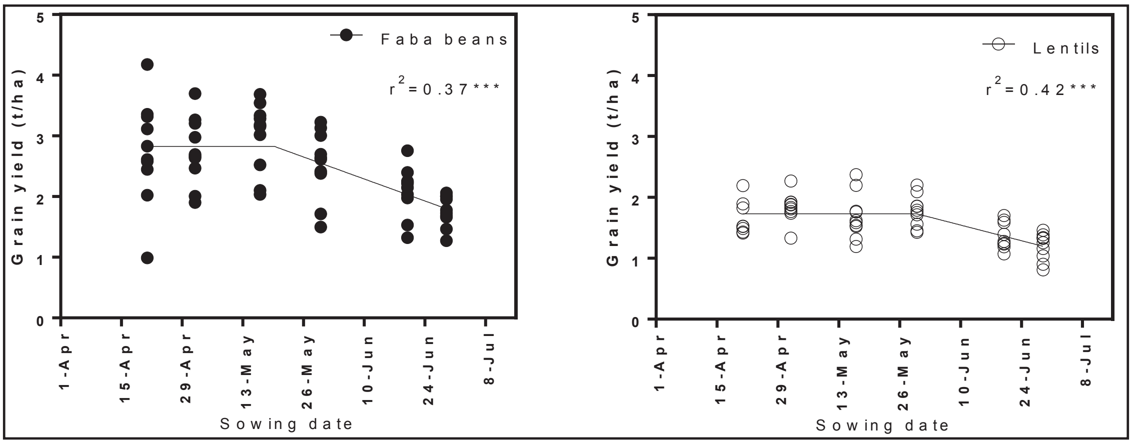


***Figure 1 Grain yield of faba bean varieties (left panel) and lentil varieties (right panel) as a function of sowing date at Minnipa in 2016. *** indicates P<0.001***

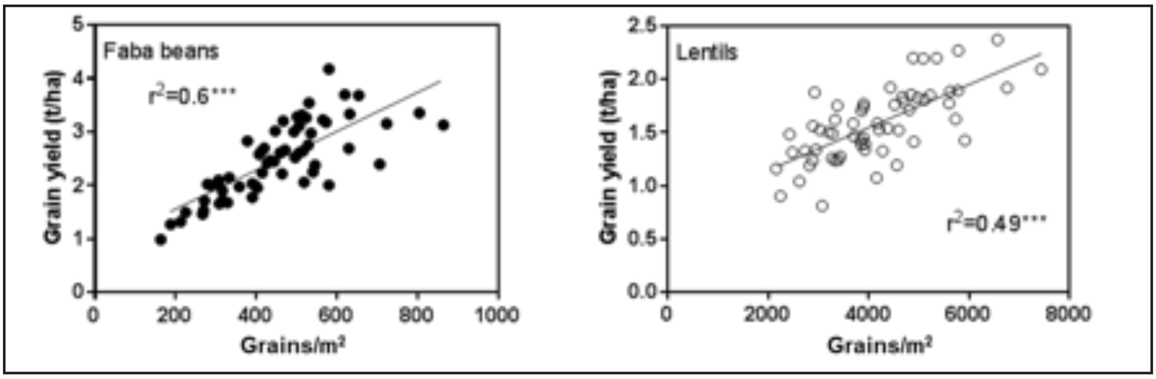


***Figure 2 Grain yield of faba beans (left panel) and lentils (right panel) as a function of grain number/m² for all sowing dates and varieties at Minnipa in 2016. *** indicates P<0.001***

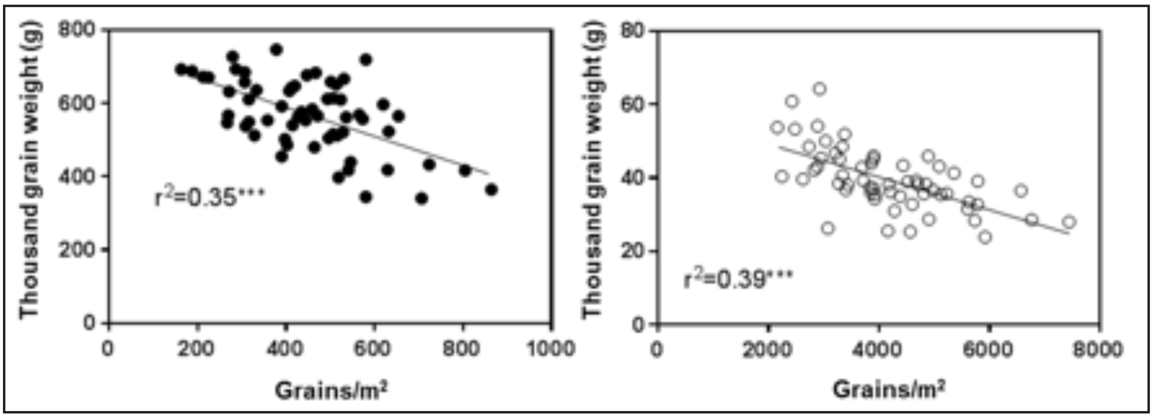


***Figure 3 Thousand grain weight as a function of the grain number/m² (left panel) and lentil (right panel) for all sowing dates and varieties at Minnipa in 2016. *** indicates P<0.001***

In both cases, the grain yield was positively related to the grains/m² (Figure 2), and unrelated to the thousand grain weight. In general grains/m² explained about 50% or more of the variation in grain yield. The range of variation of grain number was from 163 to 864 grains/m² for faba bean and 2163 to 7440 grains/m² for lentils.

There was a negative relationship between the grain number/m² and the thousand grain weight of the two crops (Figure 3).

Delaying sowing advanced flowering and podding in both crops (Figure 4). In faba bean, podding was advanced more (0.48 days per day) than flowering (0.31 days per day) with delayed sowing. Lentils showed a similar reduction of about 0.4 days per delayed day in sowing, in the time to flowering and podding (Figure 4). Delaying sowing after 21 April produced an average effect on both crops of 1 day reduction in the days to podding for every two days of delay in sowing. Furthermore, there was an average negative effect of sowing date by shortening the growing season at a rate of 5 days shorter per week when sowing date was postponed after 21 April.

Pooling the data showed that the higher yield of faba in comparison to lentil was partially related to longer duration of the flowering to maturity period (Figure 5). In general, the time between podding and maturity has a better capacity to explain the variation in grain yield than the days from beginning of flowering to maturity.

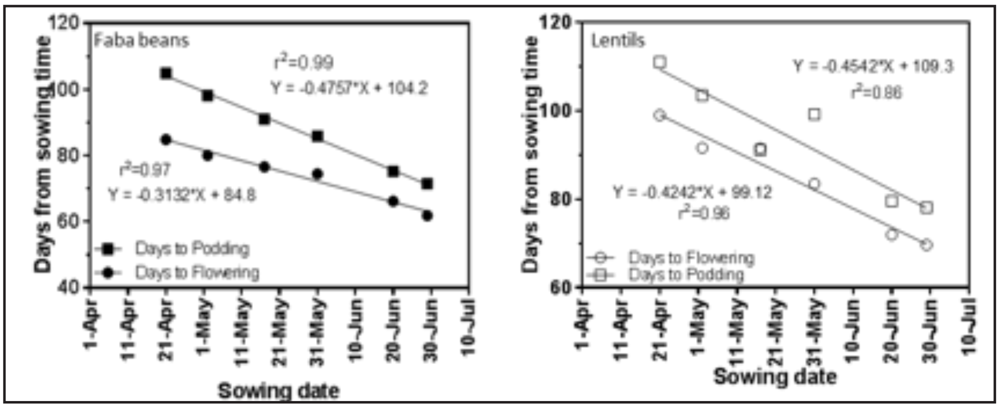


***Figure 4 Average effect of sowing date on the phenology faba bean (left panel) and lentil (right panel) for all sowing dates and varieties at Minnipa in 2016. Squares represent days to podding while circles symbols represent days to flowering***

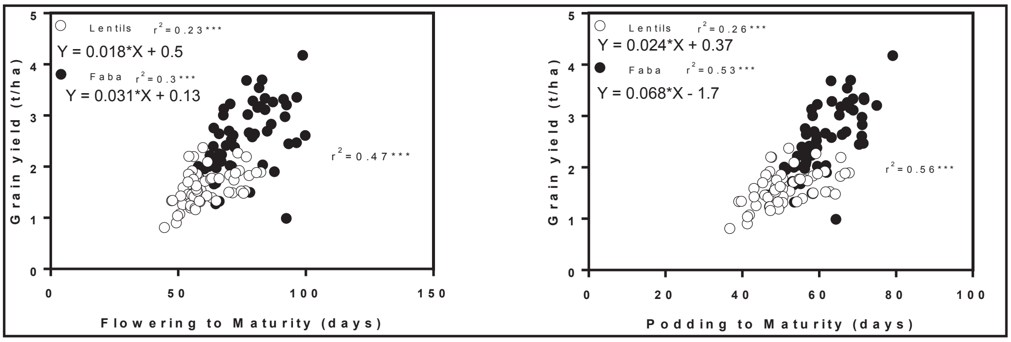


***Figure 5 Average effect of sowing date on the phenology faba beans (left panel) and lentils (right panel) for all sowing dates and varieties at Minnipa in 2016. *** indicates P<0.001***

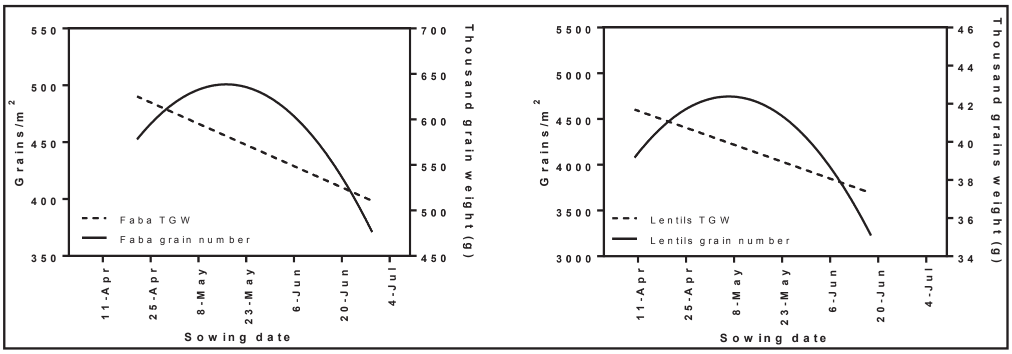


***Figure 6 Relationship for the grains/m² (left Y axis) or thousand grain weight (right Y axis) and the sowing date in faba bean and lentil at Minnipa in 2016***

## What does this mean?

First of all, a note of caution regarding the exceptional cropping conditions in 2016. In 2016 there was 27% more rainfall from April to October, with an additional benefit of lower (20%) minimum and lower (5%) maximum temperatures from August to November than the average of Minnipa. These exceptionally good conditions could have a confounding effect by underestimating the negative impact of the hot and dry spring conditions generally experienced during the yield determination period. Considering this, our results accurately characterise the main effects of delaying sowing on the phenology and yield of pulses.

The yield of both crops decreased in general when delaying sowing, however the effect was more marked from intermediate sowing dates (Mid may) onwards. It was observed that modifying sowing time produced changes in the phenology that affected main yield components and grain yield. In general, the later sowing dates reduced grain number/m² and produced lower thousand grain weight. Regarding to the very early sowing dates, both crops experienced a reduction in grain number/m², which was partially compensated by heavier grains (Figure 6). The lower grain number/m² of the early sowing dates, together with the highest variability observed in faba bean was mainly due to the extremely low yield of Aquadulce in that environment. Additional data are required to determine the reasons for that penalty. The reductions in grain size, however, were always consistent with the increase in the delay of sowing.

Further research across variable seasons is required to produce more accurate quantifications of the yield penalties imposed by sowing time, and the reductions in grain number/m² in early sowings.

## Acknowledgments

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# Disease



## Summary of 2016 season and cereal disease implications for 2017

EXTENSION

**Hugh Wallwork**
SARDI, Waite

Some early sowing and plenty of rain should have led to a proliferation of foliar diseases in South Australia in 2016. However, the generally cold winter and spring temperatures kept many diseases like leaf rust and the net blotches at reduced levels than might have been the case. In the warmer more northern parts of the EP however leaf rust was quite severe in some crops. Early in 2016 there were a large number of reports of leaf curling and mottling from the wheat curl mites, some carrying wheat streak mosaic virus, which survived on summer volunteers and spread into early sown crops. At the other end of the year, we had many reports of pink grain in harvested crops. The concern over pink grain is that export markets may think the grain is infected with Fusarium and thus carries some associated toxins. In reality the grain tested was all free of the Fusarium head scab fungus and this disease continues unrecorded in South Australia. It is most likely that the pink colour is a stain left from saprophytic growth of the yellow leaf spot fungus, although proof of that is hard to establish owing to the presence of multiple competing saprophytic fungi.

With lots of thick stubbles left in paddocks and after a wet year, there should be higher levels of yellow leaf spot and take-all inoculum for 2017. Septoria in wheat and scald in barley will also be present in stubbles to a greater degree than in recent years. Early sown crops will therefore be particularly vulnerable to these diseases in 2017.

**Rusts in wheat and barley**

Leaf rust in wheat was observed very early in 2016 and became widespread across the state in autumn. The disease was mostly kept in check by cold temperatures through winter and much of spring but also through effective fungicide management of crops, in most cases applied as a precaution against stripe rust. In the warmer northern areas of EP leaf rust did become quite severe in some untreated crops.

Stripe rust arrived late and never became established as a problem owing to timely and effective use of fungicides. Stem rust was not observed in wheat in 2016.

Barley leaf rust with virulence on Compass was observed from early August on the West Coast and then was reported more widely as the season progressed. This variety is now rated as SVS, indicating that it is not quite as susceptible to this new strain as Keel was to previous strains.

***Septoria tritici* blotch**

This disease was observed in small hotspots across much of SA in 2015 and so was expected to be more visible in 2016. With plenty of rain in winter and spring, conditions were ideal for infection where inoculum was present. Septoria was duly observed in many crops in the medium and high rainfall areas, although given the level of susceptibility in many varieties, damage was less than expected. This was perhaps due to extensive use of fungicides but also because the level of inoculum carryover from 2015 was still too low to be a serious problem. Note that septoria does not spread within a season by wind borne spores so disease spread is limited. This may change in 2017 since inoculum levels carrying over in the stubbles from 2016 will be higher than in 2015.

NVT trial data with the new more virulent fungal population has provided more reliable data on variety susceptibility in this Guide than was provided last year. 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.

**Eyespot**
The frequent wet conditions favoured infection by eyespot and the disease was observed even more widely than in 2015. This continues a trend whereby eyespot is being identified over a wider area each year. In 2016 the symptoms frequently appeared rather different from previous years. Lesions were more numerous on each stem and the normally distinct eyespot shaped lesions were much less discrete. We put these changes down to much higher rainfall and persistent damp conditions leading to more numerous infection points.

Provisional ratings have Trojan as an MS variety. Emu Rock, Darwin and Yitpi are MSS, whereas Aurora, Axe, Beckom, Cobra, Corack, Cosmick, Cutlass, Grenade CL+, Mace, Scepter, Scout, Shield, Tenfour and Wyalkatchem are all susceptible. Varieties such as Emu Rock and Wyalkatchem, which are shorter, are less susceptible to lodging from eyespot. Among the barleys Fathom and Oxford are rated MRMS, Compass and Scope MS whilst Hindmarsh and La Trobe have been MRMS on the Eyre Peninsula but S in the Mid-North.

**Net form net blotch**
The net blotches are favoured by warmer, humid temperatures so had a quieter year in 2016. Despite this, new virulence was observed on Hindmarsh, La Trobe and Spartacus in variety trials at Elliston, Kingsford and Freeling. In these areas at least Hindmarsh and La Trobe should be considered as MS whilst Spartacus should be considered as MSS.

**Spot form net blotch**
In SARDI trials at Wharminda where SFNB occurs severely every year we used Systiva and fungicide sprays to manage the disease in order the determine yield loss in varieties with different levels of resistance. We recorded yield losses to SFNB of 21% in SloopSA, 9% in Hindmarsh, 8% in Schooner, 7% in Scope and 0% in Compass. The use of Systiva alone was highly effective.

**Powdery mildew** in wheat has been an increasing problem in SA as crops have been getting thicker and more N has been applied to them. Wyalkatchem (SVS) made the problem particularly severe and when this variety was largely replaced by Mace (MSS) on the Lower EP, the problem abated to some degree. Control was enhanced because most Mace crops were treated with fungicide for stripe rust control. Scepter appears to be more susceptible to powdery mildew than Mace, similar to Wyalkatchem, and with stripe rust under better control it is possible this will lead to an increase in powdery mildew in future. We foresee the disease increasing in other medium to high rainfall areas in future. Powdery mildew exists as a range of pathotypes and it is not clear that the disease ratings applied from nurseries at the Waite accurately reflect the pathogen population in different parts of the state. Ratings should therefore be taken as a rough guide and a more resistant rating treated with some degree of caution.

**Loose smut** has been reported from many crops of Spartacus barley similar to Hindmarsh in previous years. Trial data has also shown that Rosalind in NVT trials had significant levels of loose smut which may lead to problems in crops if the levels of infection in supplied seed are similar to that in the NVT seed.

**Take-all** has generally been kept under good control for many years. However, inoculum of this disease has persisted at moderate levels in some areas particularly where rotations away from cereals and pastures have been limited. In paddocks where there has been a risk for this disease in the past, then 2017 is a year to watch out for the disease again.

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.

## 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

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 | MR | S | MRMS | MSS | MS | MS | SVS | MS | MS | MR | Red feed |
| Arrow | S | S | SVS | S | MS | MRMS | RMR | MRMS | MRMS | S | MS | MSS | – | AH |
| Axe | MS | RMR | SVS | SVS | S | S | MS | MSS | MS | S | MSS | S | S | AH |
| Beckom | MRMS | MRMS | MSS | SVS | R | MSS | MS | MS | MS | S | MSS | MR | – | AH |
| Chief CL Plus | RMR | S | R | S | – | MRMS | RMR | – | – | – | – | – | – | APW |
| Cobra | RMR | MSS | MR | MS | MS | MRMS | MSS | MSS | MSS | S | MSS | S | MSS | AH |
| Corack | MR | MS | SVS | S | RMR | MR | SVS | MSS | S | S | MS | S | S | APW |
| Cosmick | MS | MS | SVS | SVS | S | MRMS | MSS | MSS | MSS | S | MSS | SVS | – | AH |
| Cutlass | R | MS | R | S | MR | MSS | S | MS | MSS | S | MS | MRMS | – | APW |
| Darwin | MRMS | MR | S | SVS | MS | S | MRMS | MSS | S | S | MSS | MR | MR | AH |
| Emu Rock | MRMS | MRMS | S | SVS | S | MRMS | MSS | MSS | S | MS | MSS | MS | MS | AH |
| Forrest | RMR | RMR | MSS | SVS | S | MRMS | MS | S | SVS | SVS | MS | MR | MR | APW |
| Grenade CL Plus | MR | MRMS | S | S | MR | S | MS | MSS | S | S | MRMS | MR | MS | AH |
| Harper | MRMS | MS | S | MSS | MRMS | S | S | S | MSS | S | MRMS | RMR | – | APW |
| Hatchet CL Plus | MS | MRMS | SVS | VS | MR | S | MRMS | MS | MSS | S | MS | RMR | – | AH |
| Impala | MR | MR | SVS | VS | MSS | MSS | R | SVS | S | S | MSS | SVS | MRMS | Soft |
| Kiora | RMR | RMR | MRMS | S | MSS | MSS | MS | MSS | MRMS | S | MS | MRMS | MS | AH |
| Kord CL Plus | MR | MRMS | MS | MS | MR | MSS | MS | MSS | MS | S | MRMS | MR | MRMS | AH |
| Mace | MR | SVS | MSS | S | MRMS | MRMS | MSS | MS | MS | S | MS | S | MRMS | AH |
| Manning | MR | RMR | MS | MR | S | MRMS | MS | MSS | S | VS | SVS | R | MRMS | Feed |
| Orion | MR | MSS | R | MS | MS | MSS | SVS | MS | MSS | S | MSS | S | S | Soft / Hay |
| Revenue | RMR | R | VS | S | S | MS | R | MSS | MSS | S | SVS | S | MS | Feed |
| Scepter | MR | MSS | MSS | SVS | MRMS | MRMS | SVS | S | MSS | S | MS | MSS | – | AH |
| Scout | MR | MS | MS | S | R | SVS | MRMS | S | MS | MSS | S | MR | S | AH |
| Shield | RMR | MR | R | S | MRMS | MSS | MR | MS | MSS | S | MRMS | S | MS | AH |
| Tenfour | S | SVS | MSS | SVS | MS | MRMS | MS | MSS | MS | S | MS | RMR | – | Feed |
| Trojan | MRMS | MR | MRMS | MSS | MS | MSS | S | MSS | MSS | MS | MS | SVS | MRMS | APW |
| Wyalkatchem | MS | S | S | SVS | S | MR | SVS | MRMS | MS | S | MSS | SVS | MS | 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.

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 | RMR | MRMS | MSS | MRMS | MR | MS | RMR | VS | MRMS | R | MS | Durum |
| Caparoi | RMR | MR | RMR | RMR | MS | MR | MS | MSS | MR | VS | MS | R | MSS | Durum |
| Hyperno | RMR | MR | R | MS | 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 | RMR | MS | MS | MRMS | S | MS | MR | VS | MS | R | MSS | 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 | RMR | MRMS | MSS | MS | R | – | Triticale |
| Bison | RMR | R | RMR | R | R | MR | R | MR | MR | MSS | MRMS | R | – | Triticale |
| Fusion | R | RMR | RMR | R | R | MRMS | R | RMR | MS | MS | S | R | MSS | Triticale |
| Goanna | R | MR ^ | RMR | R | R | MR | R | MRMS | SVS | – | – | – | – | Triticale |
| Hawkeye | RMR | MR ^ | R | R | R | MR | R | MR | MS | MS | MSS | – | – | Triticale |
| Rufus | RMR | MS | R | R | MR | R | R | RMR | RMR | MS | MS | – | – | 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* | |
| Biere | MRMS-S | S | MSS | MR-S | S | R | – | MS | MS | MR | MRMS | – |
| Buloke | MS-SVS | MR | MS-S | MS-S | S | R-MR | RMR | MS | MS | MRMS | MS | MRMS |
| Charger | MR-S | VS | S | S-VS | R | R | RMR | MSS | MS | MR | MRMS | MRMS |
| Commander | MS-S | MS-S | MSS | S-SVS | R | MRMS | R | RMR | MS | MRMS | MRMS | MSS |
| Compass | MR-SVS | MR-MRMS | MR-MSS | MS-SVS | R | MRMS | R | R | MS | MRMS | MR | MSS |
| Explorer | R-MRMS | R-S | S | SVS | R | R | – | MRMS | MS | MRMS | MRMS | – |
| Fathom | MRMS-S | MR-VS | RMR | R-MS | R | MRMS | R | MR | MSS | MRMS | MRMS | S |
| Flagship | MS-S | MR | MRMS | MS-SVS | R | S | RMR | MRMS | S | MRMS | MRMS | MSS |
| Fleet | MRMS-S | S-VS | MR | MR-SVS | R | MRMS | RMR | MR | S | MRMS | MRMS | MS |
| GrangeR | MR-MS | R-MRMS | S | S-SVS | R | R | R | RMR | S | MRMS | MRMS | MS |
| Hindmarsh | MRMS-S | MR | S | R-VS | R | MR-S | MR | MS | S | MRMS | MRMS | MSS |
| La Trobe | MRMS-S | MR | MSS | R-VS | R | MR-S | RMR | MS | S | MRMS | MRMS | MS |
| Maritime | MRMS-S | R-VS | MRMS | MS-SVS | R | SVS | S | MS | MSS | MR | – | MS |
| Oxford | R-MRMS | MR-SVS | S | MR-SVS | S | R | R | MRMS | MSS | MR | MRMS | MR |
| Rosalind | MR-MS | MR | MSS | MR-SVS | R | MR-S | – | MRMS | S | MS | MR | MS |
| 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 | MS |
| Shinestar | MS | RMR-MS | MRMS | MSS-S | R | MS-SVS | – | MS | MS | MRMS | MRMS | – |
| Spartacus CL | MRMS-S | MR-MSS | S | R-VS | R | MR-S | RMR | MS | MS | MS | MRMS | MS |
| Westminster | R-MRMS | MR | S | R-S | – | R | R | MR | MSS | 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[1] | *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 | – |
| Durack | S | R-S | R | MI-MT | – | I | MR-S | MS | MS-S | S | – |
| Forester | R-S | MR-MS | MS | MI | S | I | MS-S | MR | MR-S | MR | – |
| Glider | MR-S | MS-S | MS | I | R | T | R | MR | 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 | – |
| Tammar | MR-S | MR-MS | MR | MT | R | T | MR | MR-MS | MS | MR | – |
| Tungoo | MS-S | MS | R | MT | R | T | MR | MR | 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 | – |

* 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]BYDV = Barley Yellow Dwarf Virus

# Fluid delivery systems and fungicides in wheat

**Amanda Cook, Ian Richter, Nigel Wilhelm and Sue Budarick**
SARDI, Minnipa Agricultural Centre

**Searching for answers**

**Location:**
Warramboo
Darren Sampson and family
**Rainfall**
Av. Annual: 313 mm
Av. GSR: 227 mm
2016 Total: 333 mm
2016 GSR: 251 mm
**Yield**
Potential: 2.8 t/ha (W)
Actual: 2.1 t/ha
**Paddock History**
2016: Mace wheat
2015: 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
2016 Total: 485 mm
2016 GSR: 323 mm
**Yield**
Potential: 5.0 t/ha (W)
Actual: 2.3 t/ha
**Paddock History**
2016: Mace wheat
2015: Medic pasture
**Soil Type**
Grey calcareous sandy loam
**Plot Size**
20 m x 2 m x 3 reps

## Key messages

- **Phosphoric acid as a fertiliser and granular P performed similarly at Streaky Bay in the wetter 2016 season. In the previous two years, phosphoric acid resulted in 13 and 8% higher yields in 2014 and 2015, respectively.**
- **In 2016 there was a small yield response to phosphoric acid over granular P at Warramboo.**
- **Fungicides and the addition of extra 40 kg/ha urea at seeding separately reduced Rhizoctonia seminal root infection compared to the control at both sites.**
- **Including fungicides will increase input cost and risk over a cropping program.**
- **The addition of a trace element mix or manganese did not improve yields at Streaky Bay or Warramboo.**

## Why do the trial?

The aim of this SAGIT-funded project was to build on previous research by updating knowledge of the benefits, including disease control and nutrition, of fluid delivery systems. Fluid systems have the potential to increase production through efficient delivery of micro and macro nutrients, reduced cost of trace element delivery and increased control of cereal, root and leaf diseases.

Historically, fungicidal control of Rhizoctonia, which can infect all of the major crops grown in southern Australia, has generally been poor, but fluid systems are a new option for delivery of fungicides, which may improve disease control and increase production. Trials were undertaken to assess the benefits of fluid delivery of nutrients and fungicides, under various application strategies, to wheat grown in two upper Eyre Peninsula environments.

The previous two years of trials in this project are reported in Eyre Peninsula Farming Systems Summary 2015, *Fluid delivery systems and fungicides in wheat* p114 and Eyre Peninsula Farming Systems Summary 2014, *Fluid delivery systems and fungicides in wheat at Warramboo and Streaky Bay* p98.

## How was it done?

In 2016, three replicated trials were established, one at Warramboo on a red sandy soil and two at Streaky Bay on a grey calcareous sand. Both sites 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 split fluids both below the seed at approximately 3 cm, and in the seeder furrow behind the press wheel in a 1 cm band width.

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 used. 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 the standard rate being 1.5 kg Mn/ha and 3 kg/ha as a high rate. 1 kg/ha Zn, as zinc sulphate and 0.2 kg/ha Cu as copper sulphate were dissolved in the standard rates of trace elements, which were also delivered as foliar applications at 4-5 leaf stage on 14 July in Streaky Bay and 21 July at Warramboo. The extra nitrogen at seeding treatment was applied as 40 kg/ha of granular urea.

The fungicides azoxystrobin + metalaxyl-M (Uniform), penflufen (new formulation of EverGol Prime) and sedaxane (Vibrance seed dressing) were assessed for Rhizoctonia disease suppression at different rates and in split applications. Triadimenol and flutriafol were also applied on fertiliser as treatments.

The Streaky Bay trial was sown on 19 May. Herbicides were applied and included 1.5 L/ha of trifluralin, 2 L/ha of glyphosphate and 80 ml/ha of carfentrazone-ethyl and a wetter. All treatments were sprayed on 28 June with tralkoxydim at 500 g/ha, clopyralid at 75 ml/ha, sulphate of ammonia at 800 g/100 L and paraffin oil, to control weeds in-crop. Snail bait was also applied. The Warramboo trial was sown on 26 May and received the same pre-emergent herbicide mix as at Streaky Bay. In-crop pest control on 1 July included 1 L/ha of flumetsulam, 750 ml/ha of chlorpyrofos insecticide and snail bait.

Trace element treatments were delivered as foliar applications at 4-5 leaf stage on 14 July in Streaky Bay and 21 July at Warramboo.

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 eight weeks after seeding, on 19 July at Streaky Bay and 3 August at Warramboo. Crown roots per plant were also counted on these samples with the number of roots infected with Rhizoctonia used to calculate % crown root infection.

Due to the good seasonal conditions all treatments received an extra 70 kg/ha of urea broadcast in-crop after root sampling on the 22 July at Streaky Bay and 9 August at Warramboo. Trials were harvested on 15 November at Streaky Bay and 23 November at Warramboo. Data were analysed using Analysis of Variance in GENSTAT version 16.

## What happened?

Initial Predicta B inoculum was high risk of Rhizoctonia at Streaky Bay (201 pg DNA/g soil), and a low Rhizoctonia risk at Warramboo. All other tested diseases were low at both sites.

Both sites have alkaline pH, reasonable soil phosphorus levels and adequate nutrient levels (Cu and Zn marginal at Streaky Bay) (Table 1). Mineral nitrogen level was much higher at Streaky Bay than Warramboo and the PBI is also higher, especially in the 0-10 cm zone.

Plant establishment in ideal seeding conditions at Streaky Bay averaged 142 wheat plants/$m^2$. Rhizoctonia patches were visible in the Streaky Bay trial early in the season, however disease symptoms were much lower than in previous years, as soil moisture stress was low and early plant growth was not as limited. The trial at Warramboo was sown later due to low soil moisture, but had good plant establishment, with an average of 147 plants/$m^2$. There were no differences in plant establishment due to treatments applied at either site. The trial at Warramboo had lower risk of rhizoctonia infection, which may be due to the inclusion of a pasture phase in 2015, which may have reduced inoculum levels compared with a wheat phase (Cook, *et al* 2010), but some Rhizoctonia patches were present in the trial area early in the season.

The Streaky Bay nutrition trial had no visual differences in early growth this season, unlike previous seasons when the phosphoric acid treatments looked better than other treatments. There were no differences in late dry matter or yield attributable to the nutrition treatments in 2016 at Streaky Bay (Table 2). Grain quality at Streaky Bay was not affected by treatments and averaged test weights of 80 kg/hL, protein of 9.8% and screenings of 1% for both trials (data not presented).

The fungicide trial was slightly more even in growth earlier in the season than the nutrition trial, but Rhizoctonia patches were still present. The additional nitrogen treatments were visually better in the fungicide trial early in the season. There were no differences in late season dry matter or Rhizoctonia crown root infection (76%) in the fungicide treatments in 2016 (Table 3). There were slight differences in yield but only the phosphoric acid + trace element + fungicide (Uniform) split + extra nitrogen treatment was significantly different to the control. This treatment and the similar treatment without the extra nitrogen, and the EverGol Prime (new formulation) with extra nitrogen also had lower Rhizoctonia seminal root infection scores than the control treatment in 2016.

*Table 1 Soil analysis of Streaky Bay and Warramboo sites in 2016*

| Location | Depth (cm) | pH (CaCl) | Cowell P (mg/kg) | PBI | Total soil N (kg/ha) | DTPA Cu (mg/kg) | DTPA Mn (mg/kg) | DTPA Zn (mg/kg) | Bicarb Sulphur (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| Streaky Bay | 0-10 | 8.5 | 24.7 | 206 | 28.9 | 0.14 | 1.60 | 0.24 | 15.6 |
| | 10-30 | 8.8 | 12.1 | 275 | 46.8 | <0.1 | 0.87 | <0.1 | 10.7 |
| | Total reserves (0-100) | | | | 208.0 | | | | |
| Warramboo | 0-10 | 8.7 | 18.1 | 84 | 16.6 | 0.20 | 2.61 | 0.83 | 4.7 |
| | 10-30 | 8.7 | 5.4 | 150 | 9.6 | 0.21 | 1.15 | 0.22 | 4.9 |
| | Total reserves (0-100) | | | | 49.5 | | | | |

*Table 2 Fluid delivery nutrition trial growth measurements (dry matter), yield and grain quality for Mace wheat at Streaky Bay, 2016*

| Treatment | Plant establishment (plants/m$^2$) | Early dry matter (g/plant) | Late dry matter (t/ha) | Yield (t/ha) | 2016 gross margin ($/ha)* |
|---|---|---|---|---|---|
| Phosphoric acid + gran urea + 1.5 kg/ha MnSO4 liquid | 133 | 0.29 | 5.66 | 2.42 | 283 |
| Phosphoric acid + Gran Urea + 3 kg/ha MnSO4 liquid | 134 | 0.30 | 5.71 | 2.34 | 266 |
| Phosphoric acid + Gran Urea (equivalent 50 kg/ha DAP) | 133 | 0.30 | 6.34 | 2.38 | 277 |
| Phosphoric acid + Gran Urea + Liquid TE | 145 | 0.30 | 5.45 | 2.36 | 270 |
| APP + UAN (equivalent 50 kg/ha DAP) + Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha | 159 | 0.30 | 6.38 | 2.39 | 284 |
| DAP + Liquid Trace elements Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha | 156 | 0.28 | 6.17 | 2.33 | 278 |
| DAP with Mn coated fertiliser 1.5 kg/ha | 154 | 0.26 | 6.18 | 2.34 | 282 |
| DAP + Foliar Mn @ 1.5 kg/ha (4-5 leaf stage) | 119 | 0.29 | 5.73 | 2.45 | 303 |
| Control | 149 | 0.26 | 5.66 | 2.32 | 280 |
| DAP + Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha | 154 | 0.30 | 4.98 | 2.31 | 274 |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* | |

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Disease

*Table 3 Fluid delivery fungicide trial growth measurements (dry matter), yield and grain quality for Mace wheat at Streaky Bay, 2016*

| Treatment | Seminal root score (0-5) | Crown root infection (%) | Late DM (t/ha) | Yield (t/ha) | 2016 gross margin ($/ha)* |
|---|---|---|---|---|---|
| Phosphoric acid + granular urea (equivalent to 50 kg/ha DAP) + Liquid Trace elements (TE) of Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @0.2 kg/ha +Uniform @ 300 ml/ha SPLIT APPLICATION +extra 40 kg/ha granular urea at seeding | 2.72 [c] | 68.6 | 7.46 [a] | 2.62 [a] | 279 |
| Phosphoric acid + urea + Liquid TE +new formulation of penflufen @ 80 ml/ha SPLIT APPLICATION + extra 40 kg/ha granular urea at seeding | 2.73 [c] | 78.7 | 6.53 [abc] | 2.37 [abcd] | ** |
| Phosphoric acid + urea + Liquid TE + Uniform @ 300 ml/ha SPLIT APPLICATION | 2.77 [c] | 82.0 | 6.82 [ab] | 2.37 [abcd] | 251 |
| DAP +Liquid TE + new formulation of penflufen @ 80 ml/ha | 3.03 [abc] | 76.5 | 5.65 [bcd] | 2.16 [bcdef] | ** |
| DAP +Liquid TE +Uniform @ 300 ml/ha SPLIT APPLICATION | 3.20 [ab] | 75.8 | 5.55 [bcd] | 2.41 [abc] | 277 |
| DAP + Liquid TE + triadimenol @ 250 g/ha APPLIED ON FERTILISER | 3.34 [a] | 83.3 | 5.75 [bcd] | 2.00 [f] | 215 |
| DAP + Liquid TE + Uniform @ 300 ml/ha + Vibrance seed dressing @ 300 ml/100 kg seed | 3.14 [ab] | 82.7 | 4.87 [d] | 2.12 [cdef] | 211 |
| DAP + Liquid TE + Uniform @ 300 ml/ha APPLIED ON FERTILISER | 3.22 [ab] | 78.7 | 5.49 [bcd] | 2.09 [def] | 215 |
| DAP + Liquid TE + new formulation of penflufen @ 80 ml/ha SPLIT APPLICATION | 3.20 [ab] | 76.3 | 5.37 [bcd] | 2.18 [bcdef] | ** |
| DAP + Liquid TE + Flutrifol @800 ml/100 kg DAP APPLIED ON FERTILISER | 3.13 [ab] | 66.8 | 5.35 [bcd] | 2.35 [abcde] | 284 |
| Phosphoric acid + urea + Liquid TE + new formulation of penflufen @ 80 ml/ha SPLIT APPLICATION | 2.93 [bc] | 66.3 | 5.70 [bcd] | 2.46 [ab] | ** |
| Control - 50 kg/ha DAP | 3.13 [ab] | 78.2 | 6.39 [abcd] | 2.21 [bcdef] | 258 |
| DAP+ Liquid TE + EverGol Prime applied as seed dressing @ 80 ml/100 kg/seed | 2.95 [bc] | 76.8 | 5.19 [cd] | 2.05 [ef] | 207 |
| *LSD (P=0.05)* | *0.31* | *ns* | *1.57* | *0.31* | |

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***new formulation of penflufen, cost unknown*

At Warramboo, in drier conditions, phosphoric acid + trace element +fungicide (Uniform and EverGol Prime new formulation of penflufen) split + extra nitrogen treatments had lower Rhizoctonia seminal root infection than the control. There were no differences in crown root infection (average 56%) (Table 4). Only the phosphoric acid +with trace element +, fungicide (Uniform) split +and extra nitrogen treatment had higher late dry matter than the control (Table 3). The first five treatments in Table 4 had higher grain yields than the control in this trial in 2016 and all of these had phosphoric acid as the base fertiliser. Grain quality showed no differences with the trial averages being; test weight of 80.0 kg/hL, protein 9.7%, screenings 2.5% (data not presented).

In previous seasons there has been a 0.11 t/ha (8% from 1.25 t/ha using granular DAP to 1.36 t/ha in 2015) yield increase and 0.13 t/ha yield increase (13% in 2014) using phosphoric acid in Streaky Bay in drier seasons (Cook *et al*, 2015). In 2016 there was no benefit to using phosphoric acid at Streaky Bay. In previous seasons there has been no fertiliser response at Warramboo, however there was a response to phosphorus source this season.

The 2016 gross margins show the difference compared to the control but the increase in the input costs will result in higher risk over a whole cropping program. The results in the 2016 season have confirmed that soil type and also soil moisture conditions influence the response to phosphorus source.

*Table 4 Fluid delivery trial growth measurements (dry matter), yield and grain quality for Mace wheat at Warramboo, 2016*

| Treatment | Seminal root score (0-5) | Crown root infection (%) | Late DM (t/ha) | Yield (t/ha) | 2016 gross margin ($/ha)* |
|---|---|---|---|---|---|
| Phosphoric acid + granular urea (equivalent to 50kg/ha DAP) + Liquid Trace elements (TE) of Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @0.2 kg/ha + Uniform @ 300 ml/ha SPLIT APPLICATION + extra 40 kg/ha granular urea at seeding | 2.85 d | 55 | 6.77 a | 2.41 a | 288 |
| Phosphoric acid + urea (equivalent to 50kg/ha DAP) +Liquid TE + new formulation penflufen @ 80 ml/ha SPLIT APPLICATION + extra 40 kg/ha granular urea at seeding | 2.90 cd | 54 | 6.39 ab | 2.36 ab | ** |
| Phosphoric acid + urea (equivalent to 50 kg/ha DAP) + Liquid TE | - | - | 5.82 bcde | 2.28 abc | 299 |
| Phosphoric acid + urea + 3 kg/ha MnSO4 liquid | - | - | 6.15 abc | 2.27 abcd | 298 |
| Phosphoric acid + Liquid TE + Uniform @ 300 ml/ha SPLIT APPLICATION | 3.10 abcd | 51 | 5.44 cdef | 2.27 abcd | 278 |
| DAP +Liquid TE + new formulation of penflufen @ 80 ml/ha | 3.17 abc | 58 | 5.36 def | 2.23 bcde | ** |
| DAP + Liquid TE + Uniform @ 300 ml/ha SPLIT APPLICATION | 3.10 abcd | 51 | 5.17 ef | 2.16 cdef | 272 |
| Phosphoric acid + urea + 1.5 kg/ha MnSO4 liquid | - | - | 6.37 ab | 2.16 cdef | 278 |
| DAP + Liquid TE +triadimenol @ 250 g/ha APPLIED ON FERTILISER | 3.20 ab | 58 | 5.40 cdef | 2.15 cdef | 289 |
| DAP and Liquid TE and Uniform @ 300 ml/ha and Vibrance seed dressing @ 300 ml/100 kg seed | 3.08 abcd | 49 | 5.36 def | 2.15 cdef | 264 |
| DAP + Liquid TE + Uniform @ 300 ml/ha APPLIED ON FERTILISER | 3.32 ab | 60 | 5.15 ef | 2.15 cdef | 270 |
| DAP and Liquid TE and new formulation penflufen @ 80 ml/ha SPLIT APPLICATION | 3.30 ab | 56 | 5.24 ef | 2.13 cdef | ** |
| DAP + Liquid + flutriafol @800 ml/100 kg DAP APPLIED ON FERTILISER | 3.25 ab | 66 | 5.39 cdef | 2.13 cdef | 285 |
| DAP + Foliar Trace elements Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @0.2 kg/ha (4-5 leaf stage) | - | - | 6.04 abcd | 2.13 cdef | 285 |
| Phosphoric acid + urea + Liquid TE + new formulation of penflufen @ 80 ml/ha SPLIT APPLICATION | 3.03 bcd | 54 | 5.58 cde | 2.13 cdef | ** |
| DAP + Liquid TE | | | 4.79 f | 2.12 def | 283 |
| Control 50 kg/ha DAP | 3.34 a | 63 | 5.63 bcde | 2.08 ef | 278 |
| DAP + Liquid TE + EverGol Prime applied as seed dressing @ 80 ml/100 kg/seed | 3.07 abcd | 51 | 5.16 ef | 2.08 ef | 266 |
| Phosphoric acid + urea | - | - | 5.92 bcde | 2.08 ef | 264 |
| APP + UAN (equivalent 50 kg/ha DAP) + Liquid TE | - | - | 5.55 cdef | 2.06 f | 265 |
| DAP + granular Mn fertiliser @ 1.5 kg/ha | - | - | 5.44 cdef | 2.03 f | 267 |
| DAP + Foliar Mn @ 1.5 kg/ha (4-5 leaf stage) | - | - | 5.44 cdef | 2.02 f | 265 |
| *LSD (P=0.05)* | *0.29* | *ns* | *0.77* | *0.15* | |

**ASW wheat Port Lincoln 1 December 2016 $193, Urea $445 Port Lincoln February 2016*
***new formulation of penflufen, cost unknown*

## What does this mean?

The trial results in 2014 and 2015 showed improvements in grain yield through using a fluid form of phosphorous (phosphoric acid) over a granular product on the highly calcareous sandy loam soils of Streaky Bay. However in 2016 at Streaky Bay the phosphorus source did not show a yield response. Yield improvements to the fluid form of phosphorous (phosphoric acid) were not observed on the red sandy soil at Warramboo in either 2014 or 2015.

Previous research has shown in drier soil conditions the movement of phosphorus to the plant roots in the soil water is restricted. Fluid fertilisers are able to diffuse away from the point of application in lower soil moisture conditions and are less likely to be fixed by calcium in soils with high levels of calcium carbonate (Holloway *et al*, 2001, Lombi *et al*, 2004). Having a responsive soil type is important before changing to a fluid fertiliser system for phosphorus and soil moisture conditions may play a role in the responsiveness of the fluid phosphorous fertilisers.

In 2016 at both Streaky Bay and Warramboo there were seminal root infection differences for Rhizoctonia with the split application of fungicides and extra nitrogen and a yield advantage over the control. The most reliable method to reduce Rhizoctonia inoculum and disease levels has been to include a break crop rotation before a cereal crop (Gupta, *et al*, 2013). All current information, including the increased input costs, should be taken into account when formulating a management plan to control rhizoctonia in high risk situations.

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## Acknowledgements

Thank you to 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

# Fluid delivery systems in canola

**Amanda Cook and Ian Richter**
SARDI, Minnipa Agricultural Centre

RESEARCH



**Searching for answers**

**Location:**
Wangary
Morgan family
**Rainfall**
Av. Annual: 525 mm
Av. GSR: 465 mm
2016 Total: 604 mm (no data for Dec 2016)
2016 GSR: 480 mm
**Yield**
Potential: 5.9 t/ha (C)
Actual: 2.2 t/ha
**Paddock History**
2016: CL canola
2015: Lupins
2014: Wheat
**Soil Type**
Grey loamy clay
**Plot Size**
20 m x 2 m x 3 reps

## Key messages

- **Fungicides as seed treatments or in-furrow did not increase canola yield in 2015 or 2016.**
- **In 2016 Intake (on fertiliser) and Jockey (on seed) which is current standard practice, lowered Blackleg stem infection, and in 2014 this treatment increased yield.**

## 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. This trial investigated the relative benefits of a range of fungicide strategies for blackleg control on canola.

The previous two years of trials in this project are reported in Eyre Peninsula Farming Systems Summary 2015, *Fluid delivery systems in canola* p118 and Eyre Peninsula Farming Systems Summary 2014, *Fluid delivery systems in canola* p104.

## How was it done?

The trial was sown on 10 May 2016 at Wangary. Base fertiliser was 100 kg/ha of DAP (18:20:0:0) with in furrow fungicides and trace elements delivered as fluids. The trace element mix was Mn at 1.5 kg/ha of manganese sulphate, 1 kg/ha Zn as zinc sulphate and 0.2 kg/ha Cu as copper sulphate delivered at a water rate of 100 L/ha. The fungicides Jockey, Intake, Aviator and Prosaro were evaluated for blackleg disease control.

Plant establishment, blackleg infection and grain yield were measured during the season. Blackleg infection was scored by assessing 20 stems per plot, cut at the base, in mid-November. The trial experienced some late hail damage so scoring for % pod infection was not undertaken as planned.

The paddock was sprayed on 10 May with 2 L/ha glyphosate with wetter, 1.5 L/ha of trifluralin and 80 ml/ha of carfentrazone-ethyl. Weed control was achieved on 20 June with L clopyralid @ 150 ml/ha and clethodim @ 500 ml/ha with a wetter. Urea was applied @ 80 kg/ha on 26 June and again on 25 July.

Foliar Aviator and Prosaro were applied at 400 ml/ha and 550ml/ha respectively, on 15 June at the 4 leaf stage.

The trial was desiccated on 8 November with glyphosate @ 3 L/ha (470 g/L as potassium and mon-ammonium salts) and alcohol alkoxylate @ 200 ml/100L. The trial was harvested on 25 November 2016.

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

## What happened?

The trial was located at Wangary within an intensive canola cropping region with a potentially high Blackleg disease pressure. Establishment was reduced by nearly 20% with Jockey on seed (Table 1), but plant numbers were still reasonable at 38 plants/m$^2$.

Blackleg infection was moderate but quite variable across the site as were grain yields. Blackleg stem infection averaged 18% across the site. The blackleg stem infection was reduced by using both a seed dressing and an in-furrow fungicide in 2016, although this did not result in a significant yield increase (Table 1).

*Table 1 Disease scores, growth measurements and yield for CL canola with fungicide treatments in Coulta trial, 2016*

| Fungicide treatment | Canola establishment (plants/m²) | Blackleg score (% infection) | Yield (t/ha) |
|---|---|---|---|
| Intake (in furrow) | 39.7 ab | 22 a | 2.4 |
| Intake (on fertiliser) | 41.8 ab | 12 bc | 2.7 |
| Intake (on fertiliser) and Jockey (on seed) | 38.3 b | 9 c | 2.2 |
| Jockey (seed) | 38.3 b | 23 a | 2.0 |
| Control | 47.1 ab | 20 ab | 1.9 |
| Aviator Foliar | 47.1 ab | 14 abc | 2.3 |
| Prosaro Foliar | 57.5 a | 18 abc | 2.3 |
| *LSD (P=0.05)* | *10.9* | *9.6* | *ns* |

## What does this mean?

In 2015 and 2016 there were no consistent differences canola yields due to fungicides. In 2016 there was a significant decline in blackleg stem infection with the use Intake (on fertiliser) and Jockey (on seed). In 2014 the same combined fungicides increased yield over the nil fungicide control, but there were no significant differences in blackleg infection.

The application methods for blackleg fungicides in the trial have shown little or no change in either blackleg disease control or yield with their use. Further evaluation with the newer products in the lower EP environment will continue. The selection of resistant varieties with high blackleg ratings is important, as is paddock rotation with other break crops to lower the disease pressure.

## Acknowledgements

Thank you to the Morgan family for having the trial on their property. Trial funded by SAGIT Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems, S614.

Registered products: see chemical trademark list.

# Rhizoctonia bare patch disease inoculum build-up in different cereal crops and varieties

RESEARCH

**Gupta, V.V.S.R.[1], Alan McKay[2], Andrew Ware[3] and Nigel Wilhelm[2]**
[1]CSIRO, Waite; [2]SARDI, Waite; [3]SARDI, Port Lincoln



**Searching for answers**

**Location:**
Karoonda, Streaky Bay & Nunjikompita
**Plot size**
25-40 m x 1.8 m x 4 reps

## Key messages

- **A significant variation in the rhizoctonia inoculum build-up exists between cereal crops wheat, barley, triticale and cereal rye and their varieties. Inoculum build-up was generally higher in the barley varieties compared to that in other crops. Results are in general agreement with observations in other experiments in the Mallee and on calcareous soils in Eyre Peninsula.**
- **Differences in inoculum levels carried through summer and seen at sowing in 2016 suggest that farmers may select between cereal crops and their varieties to limit inoculum building during the cereal phase. However, non-cereal break crops are the best option to reduce the pathogen inoculum in a cropping system.**
- **Soil physical (compaction), chemical (organic C and nutrients) and biological (activity and composition) characteristics and seasonal (temperature and rainfall) factors can influence the growth of R. *solani* AG8 fungi and the severity of rhizoctonia disease.**

## Why do the trial?

In the lower rainfall southern Australian agricultural region rhizoctonia rootrot is an important soilborne disease in cereal crops. *Rhizoctonia solani* AG8 grows on crop residues and soil organic matter and is a good saprophyte adapted to dry conditions and lower fertility soils. An effective control of rhizoctonia disease impacts requires an integrated management program over multiple years to (i) reduce the pathogen inoculum levels and (ii) control infection and impacts on plant growth. Non-cereal crops in rotation have been shown to reduce the pathogen inoculum levels, however, reduction of inoculum build-up under cereal crops/varieties is considered to be a useful trait in the cereal phase dominated cropping systems commonly followed in the rainfed regions of Southern and Western Australia. Soil disturbance below seeding depth, N levels at seeding, soil temperature and moisture during the seedling growth stage and fungicides applied as liquid banding as part of an integrated management strategy could help reduce disease impacts.

The aim of this work is to determine the variation in the build-up of *R. solani* AG8 inoculum between cereal crops wheat, barley, triticale and cereal rye and varieties in a cropping system.

## How was it done?

In 2015, a field experiment was conducted at Karoonda, SA with different varieties of wheat (Emu Rock, Harper, Mace, Scout, Yitpi), barley (Buloke, Skipper, Schooner, Fathom, Scope, Commander), cereal rye (SA Commercial, Bevy) and triticale (Fusion, Bogong) to determine the pattern of rhizoctonia inoculum build-up within the crop. After the harvest of 2015 crops, plots were maintained during the summer with chemical weed control and in 2016 Scope barley was sown @ 70kg/ha on 6 June on all plots using one pass sowing equipment with knife points. Surface soil (0-10 cm) samples collected in 2015 crop and at sowing 2016 were analysed for *R. solani* AG8 DNA concentrations and plant samples collected at 8 weeks were analysed for root disease incidence. Root disease incidence at 8 weeks after sowing, plant growth and grain yield were monitored. Additionally, during 2014 and 2015 crop seasons, *R. solani* AG8 inoculum and root growth measurements were made in field trials at Streaky Bay and Nunjikompita in Eyre Peninsula (barley and wheat experiments conducted by Andrew Ware, SARDI).

## What happened?

At sowing in 2016, *R. solani* AG8 inoculum DNA concentrations were higher after the previous barley crop compared to other cereal crops (Figure 1c). Between the two cereal rye varieties, inoculum levels were higher after Bevy (354 $\pm$ 35 pg DNA/g) compared to SA Commercial (202 $\pm$ 38 pg DNA/g). With triticale varieties, inoculum levels were higher after Fusion compared to Bogong variety. Inoculum levels at sowing in 2016 reflect the inoculum build-up in the 2015 crop and its decline after harvest during summer (January to May 2016). With its extensive root system and high amount of crop residues, soil microbial activity after cereal rye crops is generally greater than that after cereal crops such as barley and wheat.

*R. solani* AG8 inoculum DNA concentrations in all the crop varieties and in both seasons were significantly higher ($P<0.01$) on-row compared to that in the soil from in between row (Figures 1 & 2) and an overall >4-fold difference between lowest and highest values. Differences in rhizoctonia inoculum levels were generally higher in 'on-row soils' compared to that in in-between-row soils for both wheat, barley and triticale, however for cereal rye varieties inoculum levels in the on-row and off-row samples were similar (Figure 1a & 1b). Significant varietal based variation in the rhizoctonia inoculum levels was observed in soils from both sampling times (Figures 1a, 1b & 2). At Karoonda, inoculum build-up was generally higher in barley and wheat varieties such as Schooner, Fathom, Scout and Yitpi (800-1100 pg DNA/g) compared to Buloke and Emu Rock (275-440 pg DNA/g) (Figure 3). Even though inoculum levels were generally lower in the off-row, lower microbial activity in the inter-row space has the potential to contribute to the higher disease incidence, in particular in lower organic matter mallee soils.

There was a significant variation in the wheat and barley root DNA levels between varieties of both wheat and barley and root DNA concentrations. Root DNA concentrations were generally lower in the alkaline calcareous soils at Streaky Bay compared to that in the Mallee soils at Geranium and Lameroo. Although the general trends in the variation between different varieties were similar at both sampling times in 2015, there were changes in the order for amount of rhizoctonia DNA level for some varieties suggesting that root growth pattern and root architecture may play some role in the inoculum build-up. But, there was no consistent and significant relationship between root DNA and rhizoctonia DNA levels at both locations (i.e. on-row and in-between-row) and for both crops ($R^2$ values 0.01 to 0.3). Crop root DNA concentrations were also generally higher in on-row soils compared to that in in-between-row soils. There was a significant variation in the root DNA levels between varieties of both wheat and barley supporting the previous evidence that root distribution is a highly variable trait.

Differences in the mineral N levels in the soil profile at the sowing of 2016 barley crop were only seen in the cereal rye variety Bevy and not with other crops or varieties and there were no differences in soil moisture levels. There was a 25% variation in the barley plant biomass at anthesis (flowering) between highest and lowest performing previous season's variety, with highest biomass after the cereal rye (variety SA-Commercial). The effect on the grain yield was lower (9.5%) mostly due to the good in-crop rainfall, reducing the negative effects of disease on root growth. The effect of the previous season's cereal crop type and variety on the performance of 2016 barley crop is attributable to differences in mineral N levels, rhizoctonia pathogen inoculum, microbial turnover influencing nutrient (e.g. N) supply within the crop and microbial composition in roots etc.

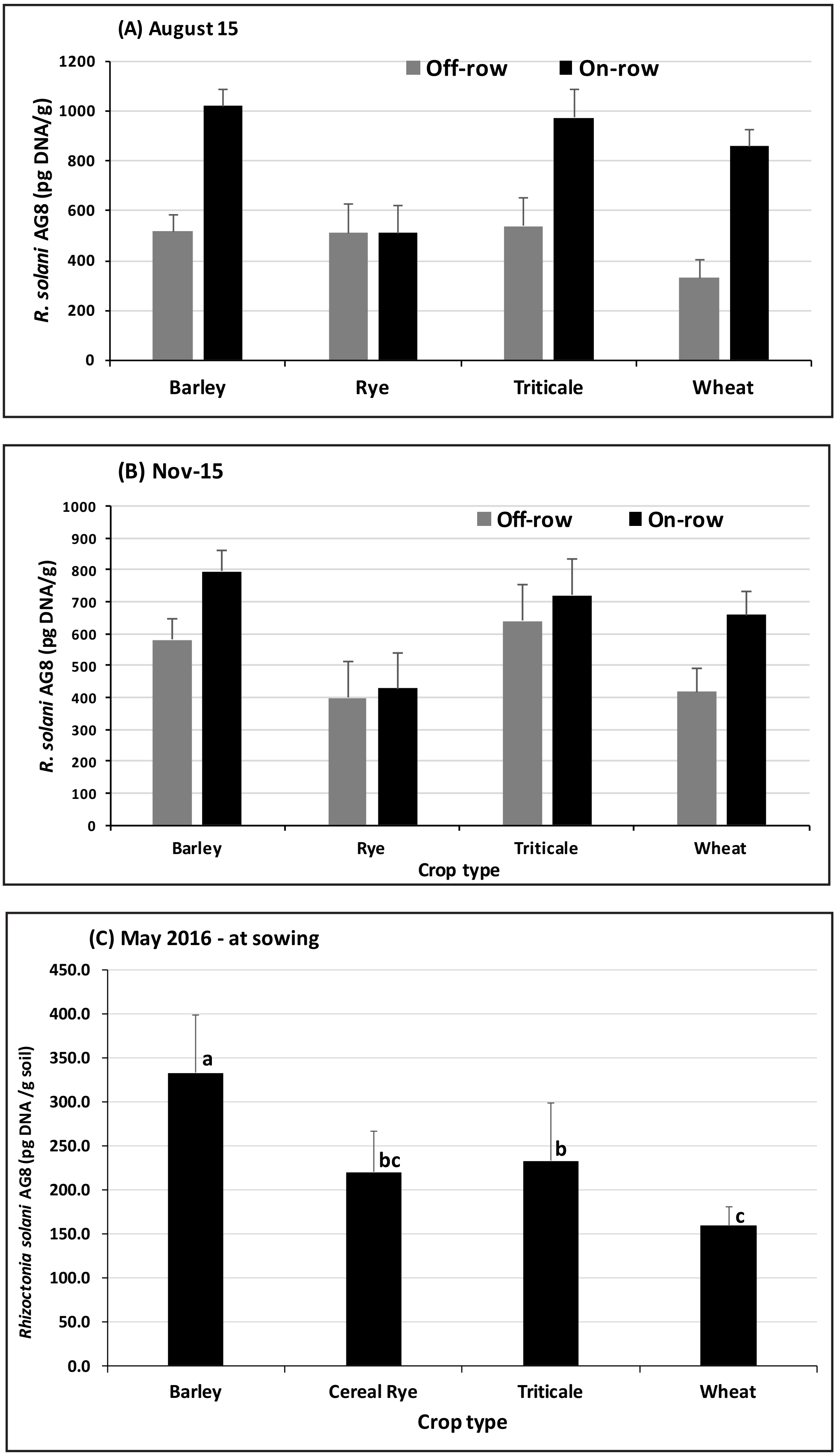


***Figure 1*** **R. solani** ***AG8 DNA concentrations in surface soils from on-row and off-row as influenced by cereal crop type during the (A & B) 2015 crop season and (C) at sowing in 2016 season in a field experiment at Karoonda, SA***
*Note: A & B - Letters above bars indicate statistical significance of comparison between on-row/off-row samples; C – Letters above bars indicated statistical significance between crop types.*

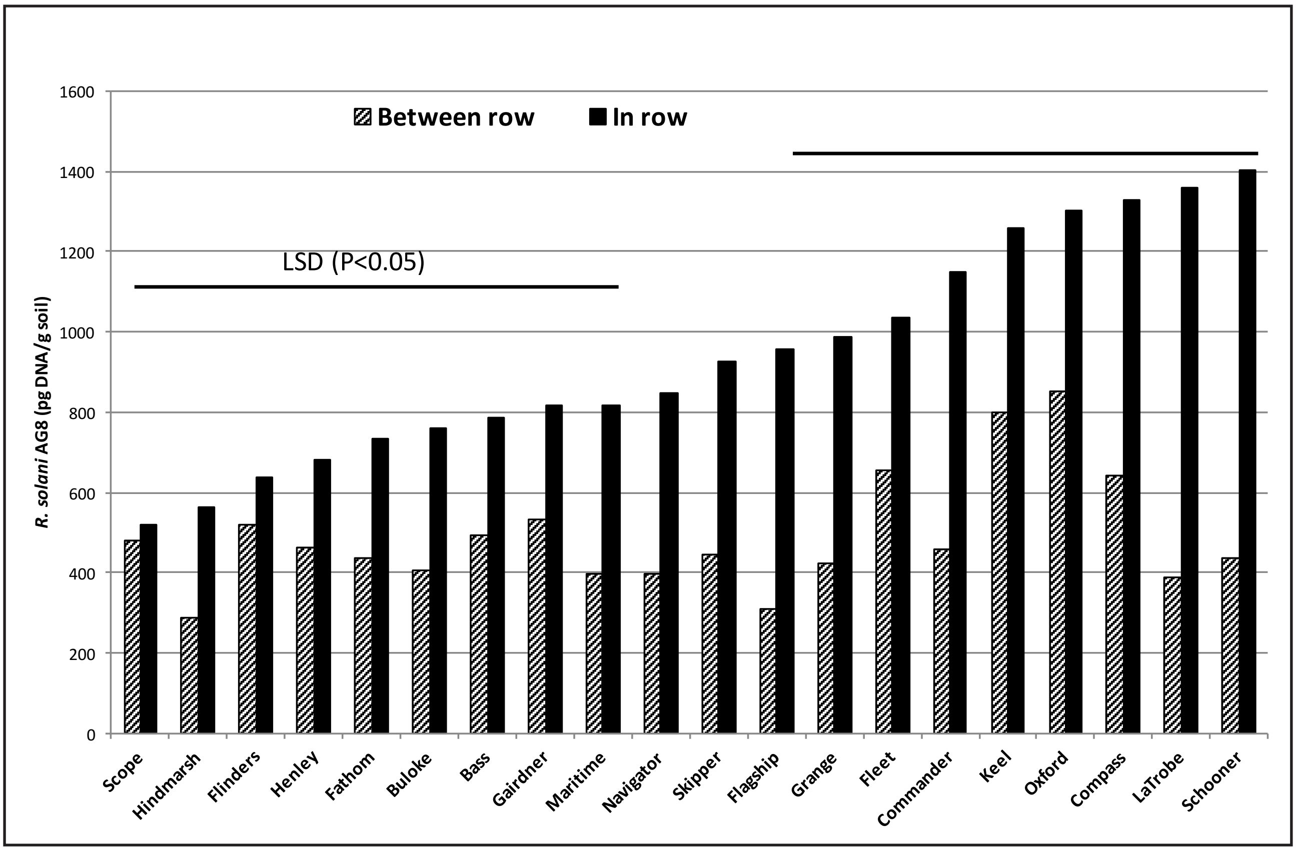


***Figure 2*** **R. solani** ***AG8 DNA concentrations in soils from barley variety experiment at Streaky Bay during August 2014***

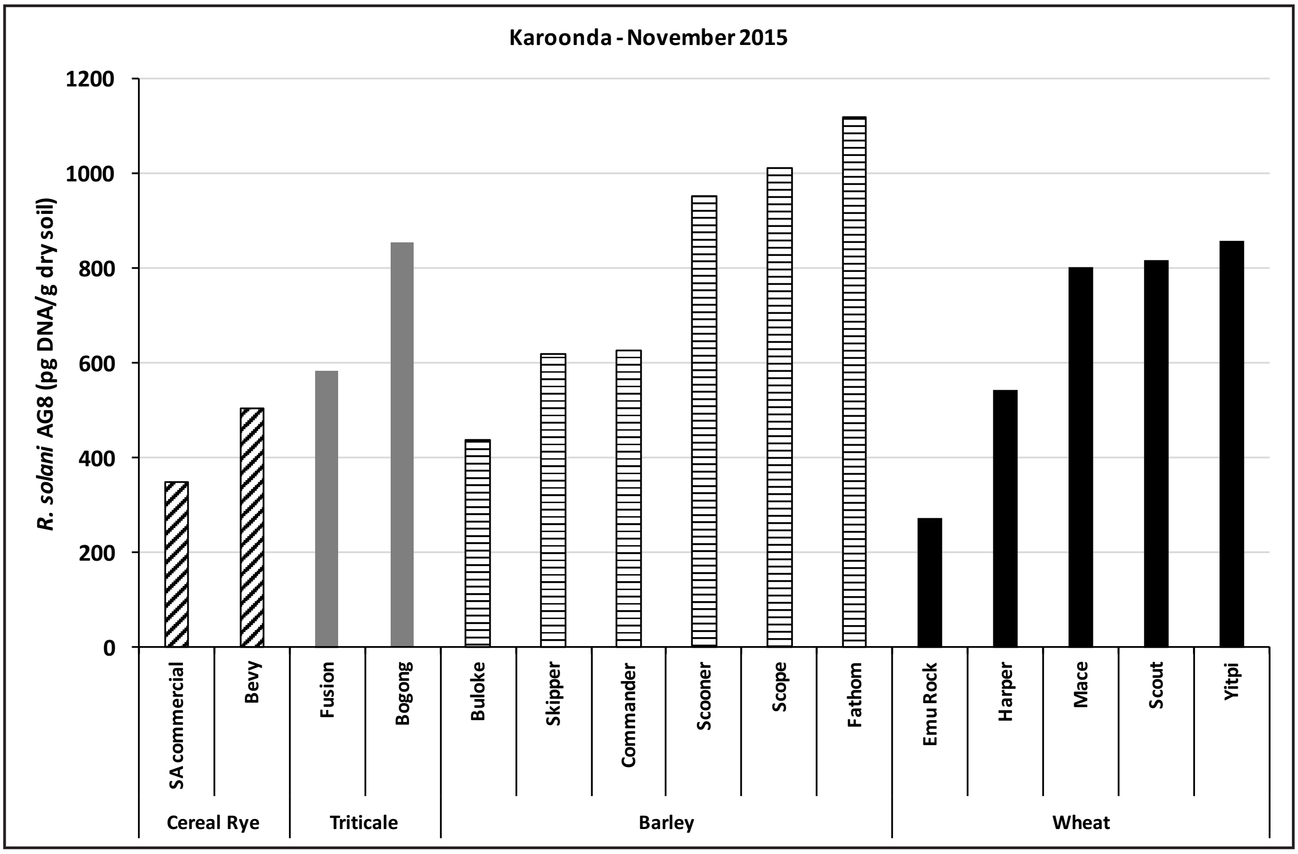


***Figure 3*** **R. solani** ***AG8 DNA concentrations in surface soils as influenced by cereal crop varieties at the end of 2015 crop season in a field experiment at Karoonda, SA***

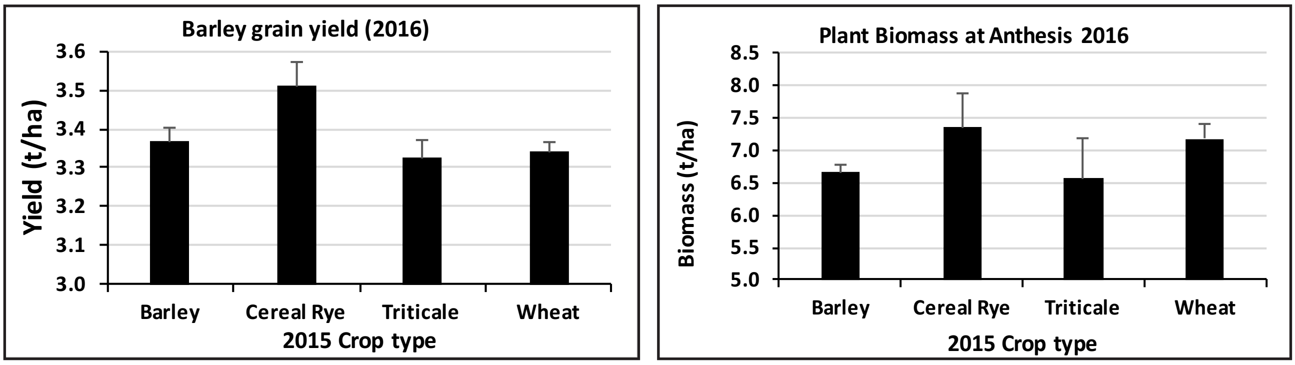


***Figure 4 Plant biomass at anthesis and grain yield of barley following previous season's crop type in a field experiment at Karoonda, SA***

## What does this mean?

A significant variation in the rhizoctonia inoculum build-up exists between cereal crops wheat, barley, cereal rye and triticale and between varieties of each crop. Previous research has shown that non-cereal break crops can reduce pathogen inoculum levels significantly but farmers may also be able to utilize the variation between cereal crops and their varieties to manage rhizoctonia disease impacts in an integrated management strategy over multiple seasons.

A research strategy targeting the identification of mechanisms that enable cereal cultivars to limit build-up of *R. solani* AG8 is required to determine if the benefits justify breeders selecting this trait. This can be complemented with improved understanding of why rhizoctonia pathogen infect these crops but not build up inoculum during the season.

## Acknowledgements

GRDC for funding, project codes DAS00125, MSF00003. Farmers at Karoonda (Loller family), Streaky Bay and Nunjikompita for allowing us to conduct the rhizoctonia trials on their farm during 2014, 2015 and 2016 seasons. Willie Shoobridge, Bill Davoren, Stasia Kroker, Paul Adkins, Marcus Hicks, Leigh Davis, Brenton Spriggs and Sue Budarick for field and laboratory work.

GRDC Factsheet - https://grdc.com.au/Resources/Factsheets/2016/02/Rhizoctonia

Section 4

**Section Editor:**
**Nigel Wilhelm**
SARDI, Minnipa Agricultural Centre

# Farming Systems

## Farming systems projects on Eyre Peninsula in 2016

INFO

**Naomi Scholz**
SARDI, Minnipa Agricultural Centre

There are four major farming systems projects funded by GRDC, currently being delivered on upper Eyre Peninsula (Table 1) and four SAGIT funded projects (Table 2).

***Table 1 GRDC funded farming systems projects on Eyre Peninsula in 2016***

| **Title** | **Maintaining profitable farming systems with retained stubble** | **Application of CTF in low rainfall zone** | **Eyre Peninsula Grain & Graze 3** | **Overdependence 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. |

| Title | Maintaining profitable farming systems with retained stubble | Application of CTF in low rainfall zone | Eyre Peninsula Grain & Graze 3 | Overdependence 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 2016** | Lock – Polkinghorne, comparing crop establishment based on seeding rate and position on non-wetting sand. MAC – South 7, sowing into stubbles, height and in-row vs inter row. MAC – S3S, cereal after two year pasture break. MAC – S3N, herbicide efficacy in stubbles. Mt Cooper – Gunn, establishment of pasture in heavy barley stubble. MAC and Minnipa farm demonstrations – grass weed seed management strategies (narrow windrows and chaff carts). | Research site MAC S3S – range of compaction treatments applied in wet and dry conditions, to see if there are impacts on yield.<br><br>Seeking grower demonstration site on upper EP. | MAC – S7, high vs low input and grazed vs ungrazed mixed farming systems trial. Piednippie – medic pasture trial with inoculation, sowing and grazing treatments. MAC– N5S, impact of grazing and N application on three wheat and two barley cultivars. Minnipa – demo, value of stubble in the system including wheat, barley and canola stubble. | MAC – S3N, row spacing and seeding rate and the influence on weed numbers by crop competition. MAC – S5, 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. |

*Table 2 SAGIT funded farming systems projects on Eyre Peninsula in 2016*

| **Title** | **Using soil water information to make better decisions on Eyre Peninsula** | **Identifying the causes of unreliable N fixation by medic based pastures** | **Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems** | **Burning of weed seeds in low rainfall farming systems** |
|---|---|---|---|---|
| **Project code** | EP216 | SARDI1515 | S614 | S416 |
| **Funder** | SAGIT | SAGIT | SAGIT | SAGIT |
| **Partners** | Lead: EPARF<br>SARDI (delivery) | Lead: SARDI | Lead: SARDI | Lead: SARDI<br>University of Adelaide, Upper North Farming Systems, Mallee Sustainable Farming, EPARF |
| **Duration** | 3 years, to 30/06/2019 | 3 years, to 30/06/2018 | 3 years, to 30/06/2017 | 1 year, to 30/06/2017 |
| **Area covered** | Eyre Peninsula | Upper Eyre Peninsula | Upper Eyre Peninsula | Eyre Peninsula, Upper North SA, SA/VIC Mallee |
| **Aim** | To use an existing network of soil moisture probes across Eyre Peninsula to provide growers across the region with information on how data the soil moisture probes collect can be converted into easily utilized decision support tools that will assist in targeting yield potential and tailoring inputs to match. | Assess the impacts of current herbicides, adjuvants and rhizobial inoculants on N fixation by medics under field conditions typical of the upper EP and other low rainfall mallee systems. Also assess the impact of nutrition (esp N and P) on N fixation by medics under field conditions and investigate their effects on tolerance to current herbicides. | To provide guidelines to farmers on the best options for fluid delivery systems at seeding for increases in crop yields and decrease impacts of crop diseases across southern cropping regions. | Temperature thresholds for killing the seeds of common weeds for low rainfall farming systems in South Australia will be determined. This will allow farmers to assess the value of narrow windrow and other burning strategies as integrated management tools to manage weeds more effectively. |
| **Topics to be addressed** | Using soil water information to make better N decisions. | Current herbicide effects on medic nodulation.<br>N contribution of medics in different soil types in low rainfall farming systems. | Comparison of fluid systems vs granular fertilisers for phosphorus and trace elements.<br>Effectiveness of fungicides to reduce impact of Rhizoctonia in wheat and Blackleg in canola. | Burning temperatures required to kill weed seeds.<br>Burning temperatures achieved in burning stubbles. |

| Title | Using soil water information to make better decisions on Eyre Peninsula | Identifying the causes of unreliable N fixation by medic based pastures | Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems | Burning of weed seeds in low rainfall farming systems |
|---|---|---|---|---|
| **Trial/demo sites in 2016** | >30 sites across EP. Visit www.eparf.com.au to access soil moisture probe network – view sites and data. Username: eparf Password: eparf | Piednippie (grey calcareous sand) Pinbong (loamy sand) | Fungicides - Streaky Bay, Warramboo (wheat), Wangary (canola), Nutrition - Streaky Bay, Warramboo (wheat), Piednippie (canola). In-crop monitoring of 5 farmer fluid demonstrations. | Weed seeds and burning temperatures to be collected across EP, Upper North, SA/VIC Mallee. |
| **Outputs to be delivered** | Web based soil moisture probe network (20 sites) established on EP. Grower group meetings to discuss data and implications. At sites where Yield Prophet indicates benefit from addition of extra N, in crop trials will be conducted. At end of each season an analysis of the information generated from soil moisture probes, how that related to the Yield Prophet data, and what management decisions could have been improved through the use of the data will be provided to growers and advisors. | To help growers understand which chemicals to use or not to use when they are after sheep feed (medic DM), good weed control or more free N. Results presented at farmer meetings, MAC field day and published in EPFS Summary 2016. | To provide guidelines for the adoption of fluid delivery systems if appropriate and determine the economic returns of additions to the system over current fertiliser and disease control strategies. Results presented at farmer meetings and published in EPFS Summary 2016. | Results presented at farmer meetings and published in EPFS Summary 2017. |

# Herbicide efficacy in retained stubble systems

**Amanda Cook and Ian Richter**
SARDI, Minnipa Agricultural Centre

**Searching for answers**

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

## Key messages

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

## Why do the trial?

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

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

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

## How was it done?

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

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

Measurements taken were stubble load pre-seeding, plant emergence counts, early, in- crop and late grass weed counts and dry matter production, grain yield and grain quality. Soil was collected on 26 February for weed seed bank germination, with monthly assessments on emergence over the next 12 months.

Soil moisture and soil nutrition were sampled on 18 April. Stubble load was measured on 30 May. Plant establishment and weed counts were taken on 22 June. Late weed counts were taken on 11 October. The trial was harvested on 4 November.

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

## What happened?

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

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

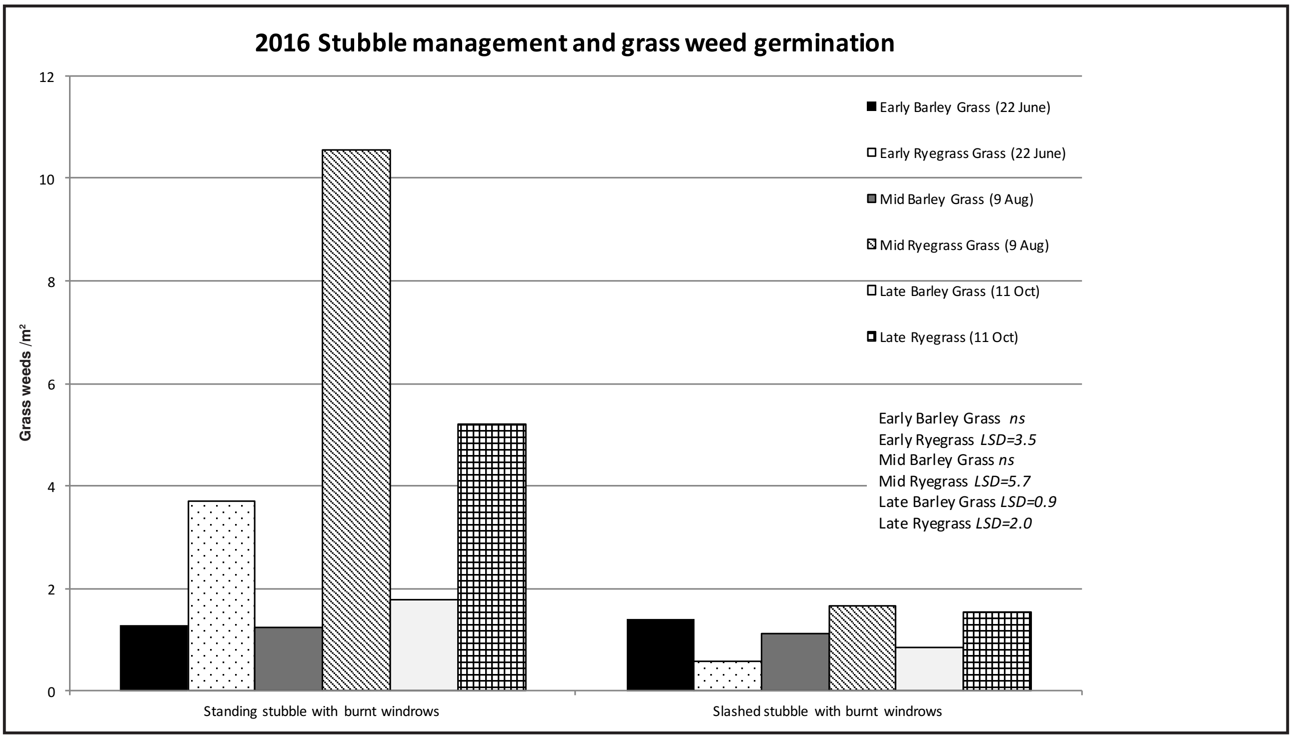


***Figure 1 Stubble management and grass weeds/m² at different timings during the 2016 season (LSDs in the graph are comparing between stubble treatments for the same weed species at the same time at P=0.05)***

### *Stubble treatments*

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

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

### *Herbicide treatments*

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

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

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

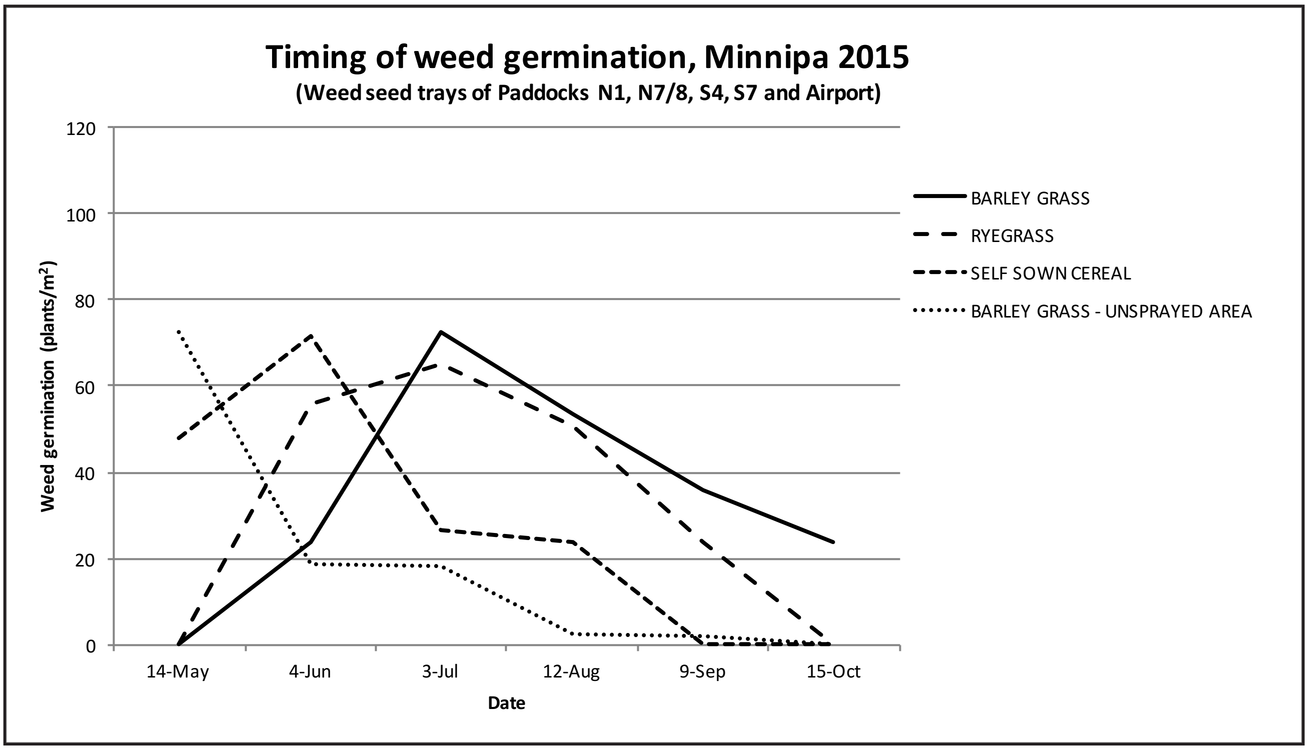


*Figure 2 Weed germination patterns from in-crop soil samples taken from harvest 2014 to early 2015*

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

| | Establishment (plants/m$^2$) | Early crop dry matter (t/ha) | Late dry matter (t/ha) | Yield (t/ha) |
|---|---|---|---|---|
| Standing stubble with burnt windrows | 94.6 | 0.38 | 4.35 | 2.17 |
| Slashed stubble with burnt windrows | 98.0 | 0.41 | 4.67 | 2.25 |
| *LSD (P=0.05)* | *ns* | *0.03* | *0.20* | *0.04* |

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

## What does this mean?

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

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

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

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

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

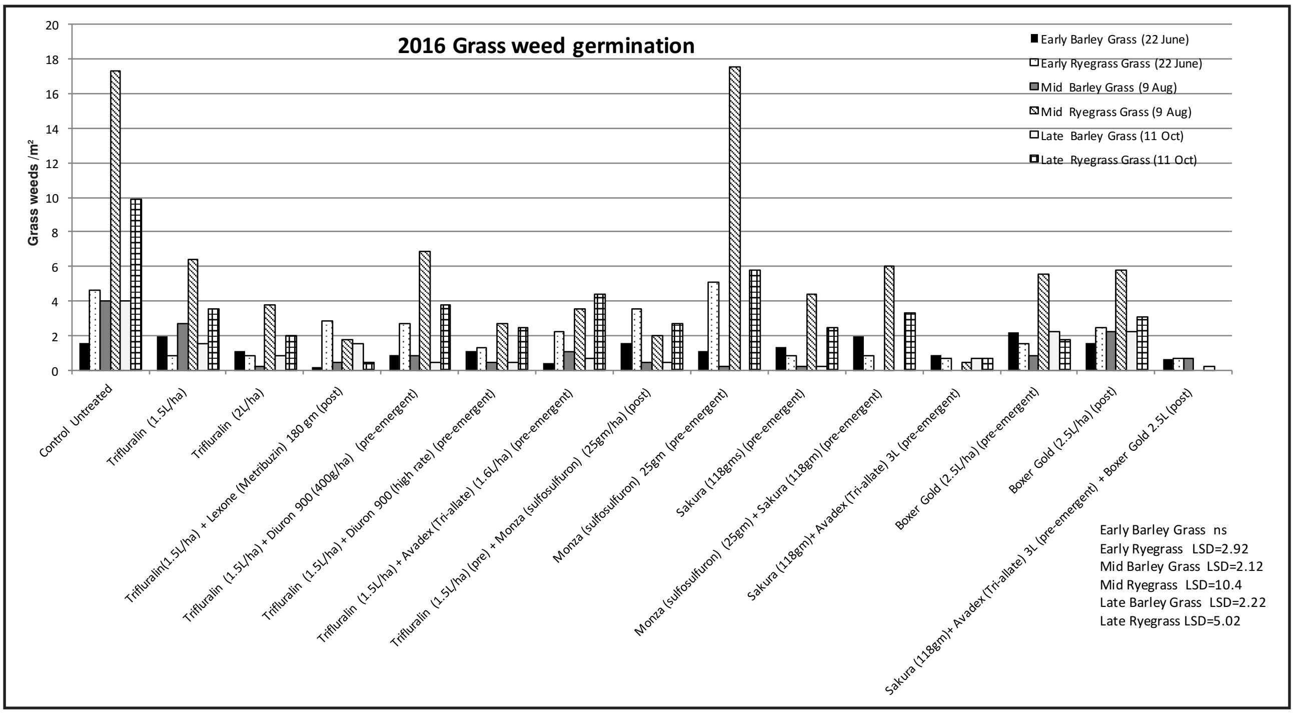


***Figure 3 Effect of herbicide treatments on grass weed control during the season (LSDs in the graph are comparing between stubble treatments for the same weed species at the same time at P=0.05)***
***some treatments in the trial are for research purposes only*

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

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

## Acknowledgements

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

Registered products: see chemical trademark list.

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# Grass weed management in pasture

**Amanda Cook[1], Ian Richter[1] and Chris Dyson[2]**
[1]SARDI, Minnipa Agricultural Centre; [2]SARDI, Waite



**Searching for answers**

**Location:**
Minnipa Agricultural Centre, paddock S3S
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield:**
Potential: 3.6 t/ha (W)
Actual: 2.6 t/ha
**Paddock History**
2016: Mace wheat
2015: Mace wheat
2014: Regenerated medic pasture
**Soil Type**
Red loam
**Plot Size**
10 m x 2 m x 3 reps

## Key messages

- **A two year pasture break has been more beneficial in the first cereal year than a one year break, resulting in lower grass weed numbers, higher soil reserves of N and low disease levels.**
- **The impact of pasture management and pre-seeding tillage on grain yield and quality was greater following a medic pasture in 2015 than in 2016.**

## 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 and 2016.

## How was it done?

The replicated trial was established in 2013 in MAC S3S paddock. 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.

In 2014 on 1 March the 3 blocks were each split into:

(i) worked (a light tillage with an off-set disc)

(ii) unworked areas.

In 2015 pre-sowing treatments were:

(i) harrowing to remove medic stubble,

(ii) disc/light tillage,

(iii) full cut tillage and

(iv) direct drill across the worked and unworked split plots.

In 2015 the trial was sown with Mace on 20 May and harvested on 12 November. See Eyre Peninsula Farming Systems Summary 2015 p136 for details of the treatments imposed in previous seasons.

In 2016 the trial was direct drilled with Mace wheat @ 60 kg/ha and base fertiliser of 18:20:0:0 @ 60 kg/ha on 13 May. The trial was first sprayed on 13 May with a knockdown of 1.5 L/ha of trifluralin, 1.5 L/ha of glyphosphate and 80 ml/ha of carfentrazone-ethyl. The trial was also sprayed with 75 ml/ha clopyralid on 17 June, and 1 L/ha of 2-ethylhexyl ester and a wetter on 24 August for wild oats. It was also sprayed with tebuconazole at 290 ml/ha for leaf rust on 25 August. The trial was harvested on 7 November.

Measurements taken during the season were soil moisture and nutrition, soil-borne disease inoculum, emergence counts, dry matter, grass weed counts (pre-seeding, at establishment and at harvest), grain yield and grain quality.

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

## What happened?

Table 1 shows the soil profile at the trial site is alkaline in pH, with just adequate phosphorus and high mineral nitrogen reserves (especially after working), moderate phosphorus buffering index (PBI) and salinity in the low range near the surface. The soil available sulphur level in March on this red loam was lower than expected with 3 and 6 mg/kg being minimum levels for wheat and canola respectively. Rhizoctonia risk was high, and Pratylenchus risk of both species (*P. neglectus* and *P. thornei*) was low after one year of wheat. All other cereal disease inoculum levels were below detection.

*Table 1 Soil analysis of direct drilled treatments after a cereal following two years of medic pasture in 2016*

| Depth (cm) | pH (CaCl) | Cowell P (mg/kg) | PBI | EC (1:5) | ECe (dS/m) | Available S (mg/kg) | Total soil N (kg/ha) | | Volumetric soil moisture April 2016 (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *unworked* | *worked* | *unworked* | *worked* |
| 0-10 | 7.7 | 23 | 103 | 0.20 | 2.0 | 2.3 | 55 | 73 | 8 | 8 |
| 10-30 | 7.8 | 2 | 140 | 0.13 | 1.3 | 1.2 | 34 | 35 | 18 | 18 |
| 30-60 | | | | | | | 11 | 20 | 27 | 27 |
| 60-100 | | | | | | | 50 | 93 | 40 | 36 |
| Total reserves (0-100) | | | | | | | 149 | 221 | 93 | 88 |

Wheat establishment in 2016 was slightly higher in the disc treatments than in the full cut treatments (Table 2).

The trial yielded well with an average of 2.56 t/ha with 11.0 % protein and 1.7% screenings, due to the mild finish to the season. There were no differences in 2016 grain yield due to any of the treatments imposed in previous seasons although grain protein was slightly higher after discing in 2015 compared to harrowing (Table 2).

Pre-seeding grass weed counts were low in 2016 with an average of 2.6 grass weeds/m$^2$, but the selective grass control treatment in 2013 with a working in 2014, is showing a trend to slightly higher grass weed numbers (5.8 grass weeds/m$^2$) than hay cut or pasture topping, regardless of the 2015 tillage systems (data not presented). The late weed counts in October were very low with no differences in treatments with an average of 0.07 barley grass/m$^2$ and 0.03 ryegrass/m$^2$ across the trial (data not presented).

## What does this mean?

Two years of medic pasture in 2013 and 2014 with different grass weed management regimes resulted in high soil nitrogen and lowered disease inoculum to minimum levels, including *Rhizoctonia solani*. Soil nitrogen was in excess nitrogen for a typical second year cereal, but it was located deeper in the soil profile (60-100 cm). However one year of wheat in the rotation increased disease levels of Rhizoctonia to high risk and Pratylenchus to low risk, which supports previous Rhizoctonia research with the one year break effect for non-cereal crops.

Extractable sulphur on this red loam is lower than expected with 3 mg/kg being an adequate level for wheat, which may have limited yield this season rather than nitrogen. This is a nutrient which growers may need to monitor due to the removal in grain over the previous good seasons.

In 2015 tillage impacted on wheat yield with full cut tillage yielding highest and discing the lowest, however in 2016 there was no yield effect due to previous tillage treatments. The light disc imposed in 2015 before seeding had very slightly higher protein in 2016 compared to the harrowed treatment, but the disc also had a lower yield 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 in 2015. In 2016 the selective grass control and worked treatment from 2014 is showing slightly higher grass weed numbers than hay cut or pasture topping, regardless of the 2015 tillage system.

Overall the effect of the two year pasture break has been more beneficial in the first year cereal after pasture, with low grass weed numbers and low disease levels. The high nitrogen levels fixed by the medic pasture were adequate for two cereal crops, but located deeper in the soil profile by the second season. The impact of pasture management and pre-seeding tillage on grain yield and quality was greater in the season directly after the medic pasture than in the second year.

## Acknowledgements

Thanks to Sue Budarick, Tegan Watts, Lauren Cook and Katrina Brands for helping with sampling and processing samples. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

Registered products: see chemical trademark list.

***Table 2 Establishment, grain yield and grain quality of wheat in 2016 as affected by previous medic pasture management***

| 2013 treatment* | 2014 treatment | 2015 yield (t/ha) | 2015 protein (%) | 2016 establishment (plants/m²) | 2016 yield (t/ha) | 2016 protein (%) |
|---|---|---|---|---|---|---|
| | | **2015 Tillage Treatment** | | | | |
| | | **Disc** | | | | |
| Pasture topped | unworked | 2.00 | 14.9 | 83.8 | 2.69 | 11.0 |
| | worked | 1.84 | 15.5 | 89.1 | 2.58 | 11.1 |
| Mowing/haycut | unworked | 2.25 | 14.3 | 89.5 | 2.54 | 10.9 |
| | worked | 2.07 | 14.9 | 97.2 | 2.53 | 10.9 |
| Selective grass only | unworked | 1.77 | 15.6 | 89.4 | 2.51 | 11.5 |
| | worked | 1.55 | 16.2 | 95.4 | 2.57 | 11.5 |
| | **Average** | **1.91** | **15.2** | **90.7** | **2.57** | **11.1** |
| | | **Full cut** | | | | |
| Pasture topped | unworked | 2.30 | 14.5 | 81.5 | 2.66 | 10.9 |
| | worked | 2.17 | 14.9 | 78.1 | 2.60 | 11.0 |
| Mowing/haycut | unworked | 2.33 | 13.8 | 85.0 | 2.55 | 10.8 |
| | worked | 2.15 | 14.7 | 84.3 | 2.54 | 11.0 |
| Selective grass only | unworked | 1.98 | 14.1 | 95.9 | 2.54 | 11.2 |
| | worked | 1.77 | 15.5 | 84.0 | 2.53 | 11.4 |
| | **Average** | **2.12** | **14.6** | **84.8** | **2.57** | **11.1** |
| | | **Harrowed** | | | | |
| Pasture topped | unworked | 2.21 | 15.0 | 88.6 | 2.65 | 11.0 |
| | worked | 2.14 | 15.2 | 90.9 | 2.60 | 10.8 |
| Mowing/haycut | unworked | 2.27 | 14.0 | 92.7 | 2.50 | 10.8 |
| | worked | 2.20 | 14.8 | 90.0 | 2.53 | 11.6 |
| Selective grass only | unworked | 1.93 | 15.1 | 86.0 | 2.47 | 11.6 |
| | worked | 1.77 | 15.7 | 80.9 | 2.55 | 11.6 |
| | **Average** | **2.09** | **15.0** | **88.2** | **2.55** | **11.0** |
| | | **Direct drilled** | | | | |
| Pasture topped | unworked | 2.15 | 14.6 | 85.6 | 2.63 | 11.0 |
| | worked | 1.95 | 15.3 | 87.9 | 2.55 | 11.0 |
| Mowing/haycut | unworked | 2.31 | 13.9 | 81.1 | 2.55 | 10.7 |
| | worked | 2.28 | 14.6 | 82.8 | 2.56 | 11.0 |
| Selective grass only | unworked | 1.78 | 15.4 | 95.4 | 2.53 | 11.3 |
| | worked | 1.60 | 16.2 | 86.3 | 2.53 | 11.4 |
| | **Average** | **2.01** | **15.0** | **86.5** | **2.56** | **11.1** |
| *LSD (P=0.05) Individual treatments* | | *0.12* | *0.54* | *10.4* | *0.08* | *0.27* |
| ***2015 tillage averages*** | | ***0.05*** | ***0.22*** | ***4.3*** | ***ns*** | ***0.11*** |

Farming Systems

# Impact of retaining stubble in low rainfall farming systems

**Amanda Cook[1], Ian Richter[1] and Chris Dyson[2]**
[1]SARDI, Minnipa Agricultural Centre; [2]SARDI, Waite

**Searching for answers**

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

## Key messages

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

## Why do the trial?

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

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

## How was it done?

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

In each season the trial was sown either (i) Inter row (between last season's stubble) or (ii) On row (in same position every season over the top of the previous crop rows) with a base fertiliser of DAP (18:20:0:0) @ 60 kg/ha. See previous Eyre Peninsula Farming Systems Summaries for details of the treatments imposed.

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

The trial was sprayed on 13 May 2016 with a knockdown of 1.5 L/ha of trifluralin, 1.5 L/ha of glyphosate and 80 ml/ha of carfentrazone-ethyl. The trial was sprayed with 750 ml/ha of imazamix and imazapyr on 20 June. The trial was scored for Rhizoctonia damage and samples for root scoring taken on 28 July. The trial was harvested on 3 November 2016.

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

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

## What happened?

### *Site characteristics*

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

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

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

### *Yield and biomass production*

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

In 2016 the retained stubble load was higher in low standing stubble compared to the other stubble treatments, which follows the trend which has occurred in the other seasons (Table 1). Standing stubble yielded higher (between 0.15-0.33 t/ha) than cultivated or removed stubble in 2016 (Table 2). Grain yield averaged over the 2015 and 2016 seasons decreased where stubble had been removed (Table 2).

The extra nitrogen applied this season did not increase grain yield but increased grain protein from 10.0% to 10.9% (Table 2). Screenings were high in all treatments (average 22.8%) with the addition of extra nitrogen increasing screenings from 20.0% to 25.5% (data not presented).

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

Farming Systems

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

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

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

### *Agronomic factors*

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

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

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

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

| 2013-15 stubble treatments | 2016 stubble load (t/ha) | Plant establishment (plants/m²) | Early dry matter (kg/m²) | Seminal root score (0-5) | Crown root infection (%) | Rhizoctonia patch score (1-5) | 2016 yield (t/ha) | Protein (%) | 2015 and 2016 mean yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|
| Stubble standing high | 4.28 | 88.1 | 0.56 | 3.19 | 67 | 0.89 | 2.14 [a] | 10.5 | 1.66 [a] |
| Stubble standing low | 5.07 | 85.0 | 0.52 | 3.19 | 65 | 1.19 | 2.24 [a] | 10.2 | 1.76 [a] |
| Stubble cultivated | 3.95 | 82.1 | 0.50 | 3.27 | 55 | 1.15 | 1.99 [b] | 10.6 | 1.62 [ab] |
| Stubble removed | (data removed from analysis) | 89.1 | 0.47 | 3.19 | 70 | 1.65 | 1.91 [b] | 10.5 | 1.56 [b] |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* | *6* | *0.37* | *0.14* | *0.40* | *0.10* |
| Inter row | 4.29 | 84.1 | 0.52 | 3.19 | 64 | 1.22 | 2.11 | 10.3 | 1.68 |
| On row | 4.58 | 88.1 | 0.50 | 3.24 | 64 | 1.22 | 2.02 | 10.6 | 1.62 |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *0.28* | *ns* |
| No extra N | 4.24 | 86.9 | 0.49 | 3.22 | 64 | 1.35 | 2.06 | 10.0 | 1.64 |
| *60 kg/ha N | 4.63 | 85.3 | 0.53 | 3.20 | 64 | 1.09 | 2.08 | 10.9 | 1.66 |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* | *ns* | *0.20* | *ns* | *0.28* | *ns* |

*Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments *N treatment applied from 2015*

## What does this mean?

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

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

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

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

## Acknowledgements

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

EPARF Eyre Peninsula Agricultural Research Foundation Inc.

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Crop establishment on non-wetting sand

**Amanda Cook and Ian Richter**
SARDI, Minnipa Agricultural Centre

RESEARCH



**Searching for answers**

**Location:**
Lock
**Rainfall**
Av. Annual: 336 mm
Av. GSR: 250 mm
2016 Total: 401 mm
2016 GSR: 314 mm
**Yield**
Potential: 4.1 t/ha (W)
Actual: 0.96 t/ha
**Paddock History**
2016: Kord wheat
2015: Mace wheat
2014: Medic pasture
**Soil Type**
Non-wetting sand
**Plot Size**
12 m x 2 m x 3 reps

## Key messages

- **Crop establishment was not improved by on-row seeding or by increasing seeding rate in 2016.**
- **Higher seeding rate increased early dry matter but this effect declined during the growing season.**
- **In 2016 row placement or seeding rate did not affect grain yield or grain quality.**
- **Sowing on-row may be an advantage on non-wetting soils with low moisture at seeding.**

## 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 was undertaken from 2013 to 2015 at Murlong (near Lock) to compare how crop establishment and performance is affected by time of sowing, sowing rate, row position and sowing depth on a non-wetting sand. The trial site was moved in 2016 to another non-wetting site near Lock.

2015 results are reported in EP Farming Systems Summary 2015, p140.

## How was it done?

In 2016 the non-wetting trial was moved to a new site and was sown into existing cereal rows. It was simplified to two different row placements; on previous crop rows and between previous crop rows (inter) with two sowing rates of 50 and 70 kg/ha. The trial was sown with CL Kord wheat on 23 May at 30 cm row spacings and into good soil moisture. Base fertiliser was 18:20:0:0 (DAP) @ 60 kg/ha and 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 was also delivered as banded fluid at seeding.

The trial was sprayed with a knockdown of 1.5 L/ha of glyphosate, 1.5 L/ha trifluralin, 80 ml/ha of carfentrazone-ethyl and a wetter on 23 May. The whole trial was sprayed with imazepic and imazepyr on 6 of July and received an application of 50 kg/ha of urea spread on 6 August.

Measurements taken during the season were disease inoculum using PreDictaB, pre-seeding soil moisture, soil nutrition, emergence counts, early and late dry matter, grain yield and grain quality. The trial was harvested on 8 December.

## What happened?

The sand had a near neutral pH (6.9 in $CaCl_2$), very high P reserves (Colwell P of 50 mg/kg in 0-30 cm), reasonable N reserves (mineral N was 111 kg/ha in the top 100 cm in March, 72 kg/ha in 0-30 cm) and very low phosphorus buffering index (8 in 0-30 cm). The initial soil moisture was 37 mm within the profile to 100 cm, which was lower than other sites measured. The MED non-wetting soil test was 1.2 which is moderate.

The site had a medium risk for Rhizoctonia (164 pg DNA/g soil) but all other disease risk levels were low.

Plant establishment was similar with either row placement or seeding rate (Table 1). Early plant dry matter was better with the higher seeding rate, however this had evened out across treatments by late in the season. Grain yield and quality were similar for both row placements and seeding rates. Grass weed numbers were low in 2016 at this site and were similar for all treatments.

*Table 1 Plant growth, grain yield and quality as affected by seed placement and seeding rate at Lock in 2016*

| | | Establishment (plants/m$^2$) | Early dry matter (t/ha) | Late dry matter (t/ha) | Yield (t/ha) | Protein (%) | Screenings (%) |
|---|---|---|---|---|---|---|---|
| **Placement** | On-row | 51.3 | 0.32 | 2.82 | 0.86 | 11.2 | 13.0 |
| | Inter-row | 63.6 | 0.34 | 3.09 | 1.06 | 11.4 | 11.6 |
| ***LSD (P=0.05)*** | | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| **Sowing rate** | 50 kg/ha | 50.1 | 0.29 | 2.88 | 0.93 | 11.2 | 12.8 |
| | 70 kg/ha | 64.8 | 0.38 | 3.03 | 0.99 | 11.3 | 11.8 |
| ***LSD (P=0.05)*** | | *ns* | *0.08* | *ns* | *ns* | *ns* | *ns* |

## What does this mean?

In 2016, for the non-wetting soil trial at a different location and with better soil moisture at seeding, there were no differences in crop establishment or yield due to seed placement or seeding rate. In 2015 in a similar trial but with a drier start to the season the seeding position of on-row resulted in better crop establishment which increased crop competition with brome grass.

In 2016 there were early dry matter differences due to the higher seeding rate but these reduced during the growing season. By the end of the season there were no differences in grain yield or grain quality due to seed placement or seeding rate.

In drier seeding conditions in 2015 seeding on-row increased crop establishment which also decreased brome grass germination, however in 2016 with low weed numbers at the site there were no detectable differences. Sowing on-row may be an advantage on non-wetting soils with low moisture at seeding.

This trial will be repeated at the same site for one more season.

## Acknowledgements

Thank you to the Polkinghorne family for having this trial on their property, and the Hentschke family in previous seasons. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

# Eyre Peninsula Grain and Graze 3 outcomes

INFO

**Jessica Crettenden and Naomi Scholz**
SARDI, Minnipa Agricultural Centre

## Key messages

- **Research, development and extension into mixed farming systems in Southern Australia by the G&G3 project confirmed that integration and diversity created by combining cropping and livestock systems generates a high level of complexity.**
- **Significant outcomes of the project include the development of feedbase options, better managed grazing practices, improved risk and decision making skills and an enhanced understanding of the issues and opportunities associated with mixed farming businesses.**

## Why do the trial?

Grain and Graze 3 (G&G3) is the third phase of mixed farming investment by the Grains Research & Development Corporation (GRDC) (and previously other industry funders) and covers the low, medium and high rainfall zones in Southern Australia. The project was delivered through group activities, on farm demonstrations and extension from 2014 to 2017. Ultimately the G&G3 program aspired to help farmers and advisors use processes (or tools/ packages) to design and manage flexible farming systems, equip them to adapt and respond to changing environments and market conditions and thus to manage risk and generate profits (Figure 1). Three mixed farming issues were identified that if addressed would contribute to the desired outcome, and, in turn, three practices were identified to tackle these issues (Figure 1).

The GRDC provided funding of nearly $2 million for the National G&G3 program to be carried out over three years across four regions in southern Australia; Eyre Peninsula, East South Australia, South Victoria and North Victoria. A seperate but similar project was delivered in Western Australia.

The Eyre Peninsula G&G3 (EP G&G3) project has collaborated with a number of organisations including the Eyre Peninsula Agricultural Research Foundation (EPARF), who provided guidance and support throughout the three-year period, Lower Eyre Agricultural Development Association (LEADA), Eyre Peninsula Natural Resources Management Board (EPNRM), Ag Ex Alliance (AEA), PIRSA Rural Solutions SA and the Low Rainfall Collaboration Group (LRCG).

## Research outcomes

Research outcomes from EP G&G3 are described under the three National practices below.

### *Enhanced grazing of cropped land*

Winter crops offer a significant potential feed source that can provide improved returns for mixed farmers. Currently we believe this resource is not being fully utilised and farmers seem to consider the grazing of cereals out of necessity (in a poor season) rather than as a standard practice, hinting at a lack of belief that this can be successfully managed in a good season. Despite nearly a decade of investigation and promotion of grazing crops, there are still many farmers not using grazed cereal crops, but who could potentially benefit from doing so.

EP G&G3 participated in market research to understand why crops are not being grazed more frequently, as well as the pros and cons of grazing crops and stubbles. This led to modelling in our region to better recognise how grazing crops change the risk profile of mixed farms, how they affect the enterprise balance, and which inputs and seasonal conditions are required for grazing crops to be advantageous in low rainfall mixed farming systems. The messages from this modelling will be developed into a resource manual and will be available later in the year on the G&G3 website[1]. In addition to being used in the modelling, EP data has also contributed to the development of a stubble assessment tool which provides farmers with a better indication of the quantity and quality of stubbles in their environment.

Four large scale demonstrations were undertaken on commercial crops grazed in winter over the course of EP G&G3, including barley, vetch and oat crops. Biomass, feed quality, grazing pressure, yield and grain quality measurements were carried out on both grazed and ungrazed systems with the information collated with the other G&G project regions, assisting in the development of '*Grazing Cropped Land, 2016 – a summary of the latest information on grazing winter crops from the Grain & Graze program*'[2].

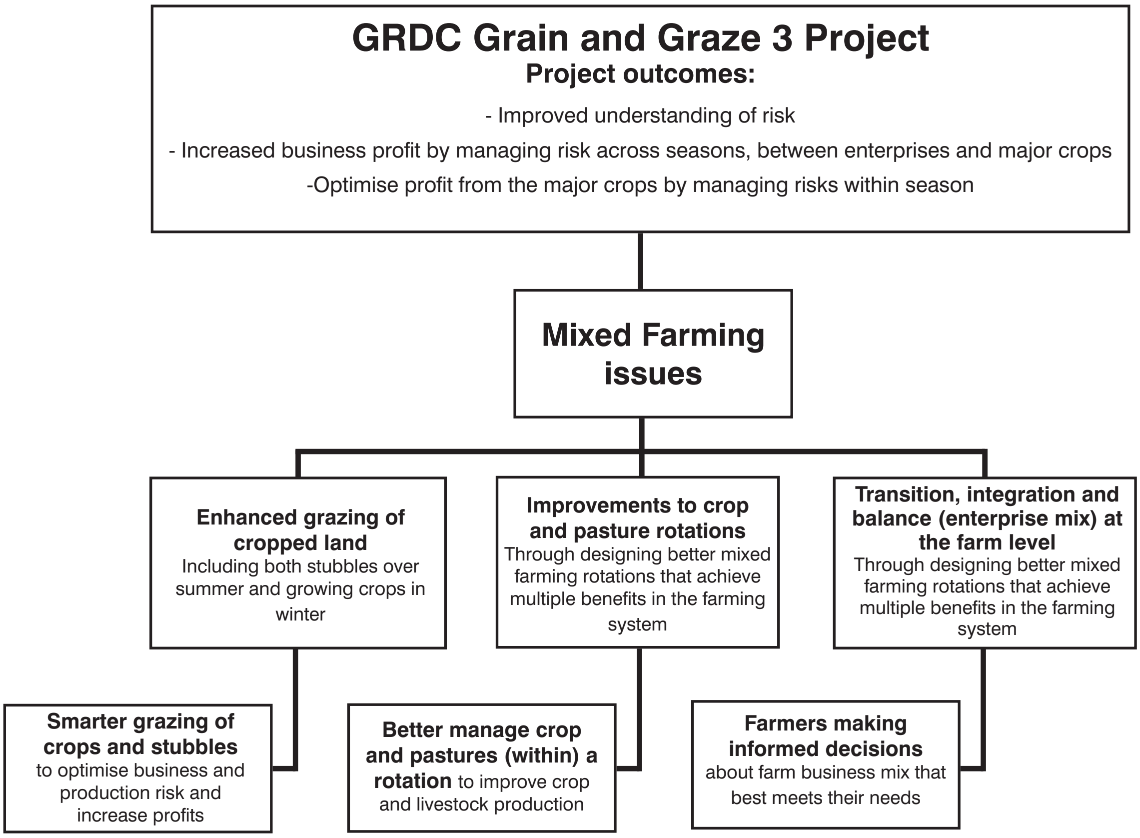


***Figure 1 Hierarchy of GRDC Grain and Graze 3 program logic: outcome, issues, and practices***

A multi-year trial was undertaken on EP to determine if the grain yield recovery potential after grazing of common wheat and barley varieties differs, apart from the rate in which they develop and mature. Whether nitrogen is able to assist in grazing recovery and yield and/or protein compensation was also investigated. Similar trials, with some variations including reducing or increasing seasonal rainfall, were undertaken in 2015 and 2016 across the other G&G3 regions, with the collective results currently being written up into a scientific paper.

Two other products that will be developed out of the 'enhanced grazing of cropped land' practice are a document describing alternatives to owning livestock and a factsheet on the considerations of summer weed control in mixed farming systems from modelled insights, both of which will be accessible through the G&G3 website[1].

***Improvements to crop and pasture rotations***

Mixed farming systems are inherently complex as there are more choices than for crop or livestock only farms. This complexity is most obvious when decisions around rotations and integration are to be made. Many farmers and advisors are not convinced that integrated complex mixed farming systems provide better returns than cropping and livestock enterprises treated as separate units. They are concerned that it will compromise the cropping system and the additional workload is not sufficiently rewarding. However, rapidly emerging problems such as herbicide resistant weeds and the increasing need for more bagged nitrogen in intensively cropped systems means farmers and advisors are having to find new solutions to these issues. This provides an opportunity to position greater integration of crops and livestock as a possible solution.

EP G&G3 studied the effects of incorporating sheep into a rotation specifically investigating the perception that sheep would negatively affect wheat performance. A long-term trial was undertaken on Minnipa Agricultural Centre (MAC), beginning in 2008 in Grain & Graze 1, where sheep were grazed on medic pastures and wheat stubbles in a wheat-wheat-medic rotation over a nine-year period. The trial found no negative effects on wheat performance or soil organic carbon, while sheep actually improved weed and pest control and nutrient cycling. These results have been reported in the Eyre Peninsula Farming Systems (EPFS) Summaries 2008-2016, as well as other extension methods including the 'Australian Grain' national magazine, newspaper articles and presentations at farmer workshops and field days.

Research into components of growing crops and pastures such as crop sequencing, pasture demos, species selection, timing, and sowing rates have been carried out in projects complementary to EP G&G3, with reports generated for the EPFS Summaries and information extended out to sheep groups, field days and other farmer workshops. Other research trials have investigated profitable and productive pasture options in low rainfall areas, including varieties, sowing methods, nitrogen fixation, inoculation, herbicides, regenerating pastures and how grazing affects these factors in mixed farming systems.

Other products from investigations into 'Improvements to crop and pasture rotations' include case studies and testimonials surrounding rotations in mixed farming systems. These have been collated across the G&G3 project regions, including three from Eyre Peninsula, and will be extended out in relevant materials. An Excel-based 'Grain Game' is an interactive virtual farming system exercise which illustrates how decisions made about inputs are impacted by seasonal variability. This game has been delivered at several EP workshops and will be accessible for farmers and advisors through the G&G3 website.

***Transition, integration and balance (enterprise mix) at the farm level***

Because mixed farming systems are more complex than cropping or livestock operations alone, it requires another layer of thinking: having to integrate the two enterprises effectively and to also consider the risk of not only each enterprise, but also the combination of the two. The G&G program is attempting to quantify how this change in enterprise mix alters the risk profile of the business. The shift to more cropping was partly due to changes in commodity prices but has also occurred during a period of generational change in farming businesses. Considerable livestock knowledge has been lost and therefore the ability to consider how to introduce livestock (back) into a farming operation and how this would impact on the financial performance and risk is challenging. The progress of farmers shifting from taking a tactical approach to running their business (reacting to issues as they occur) to having a long term strategic plan and business thinking (including the higher level business risk) has also been addressed in the project.

A guide has been developed through the G&G project, '*Farm decision making – the interaction of personality, farm business and risk to make more informed decisions*, 2015'[3], that comprehensively covers the topics mentioned above. It has a particular focus on: decision making, people involved in mixed farming systems, farm business basics and risk.

Processes were developed to incorporate succession planning into farm business management, and a document of strategic planning for farming families integrating succession planning and a farm board are both in the final stages of development, and will be available on the G&G3 website upon completion. The @ risk analysis plus other work in adaptive management around volatility, risk and complex decision-making were used to undertake advisor training on EP in 2014 and 2016.

Another product that will be developed out of 'transition, integration and balance (enterprise mix) at the farm level' is a simplified gross margin calculator developed for mixed farming systems that will be accessible on the G&G3 website.

## Delivery to growers

From 2014-2016, the EP G&G3 project has been involved with and extended information via 6 field days, 27 articles (technical, scientific and newspaper), 41 workshops, 19 paddock walks, 2 radio interviews and 23 emails. The field days, workshops and paddock walks were attended by approximately 2200 farmers, 880 advisors, 350 researchers and 90 experts from the finance sector over the three years. The articles, radio and email extension methods reached an audience ranging from approximately 400 people in the local EP region to 1200 people throughout the state and over 5000 people nation-wide.

***Field days***

The EP G&G3 was showcased at the MAC annual field days in September, in addition to some EPARF member field days throughout the duration of the project. An opportunity to present findings from an EP G&G3 research trial also occurred at LambEx in Adelaide during 2014, giving the project exposure to over 900 people in the livestock sector.

***Articles***

All research results from the EP G&G3 project were published in the annual EPFS Summaries from 2014-2016. Some articles were distributed into other parts of SA, Vic and NSW through the Mallee Sustainable Farming Research Compendium, targeting approximately 1500 people. Local newspapers and the state-wide Stock Journal published six articles from the EP G&G3 project, and four articles were published nationally.

### *Workshops*

From 2014-2016, 20 sheep group workshops were undertaken on EP, supported by EP G&G3, SheepConnect SA, Rural Solutions SA and EPNRM. Topics presented included livestock nutrition, health, genetics, reproduction, feedbase options and assessment, grazing systems, technology, livestock equipment and risk in mixed farming businesses. The workshops were attended by over 220 farmers and 35 advisors over the three years. Each year, growers from 14 agricultural bureaus and groups on upper EP attended meetings, where key messages and research results from the G&G3 project were presented from the previous season. A total of 363 farmers and advisors attended the workshops in March in 2015 and 2016, with the 2016 results yet to be presented at eight workshops in March 2017. Two successful women's agronomy workshops were undertaken with support from G&G3 in 2016 and were attended by approximately 40 people. EP G&G3 hosted a workshop for advisors to explore risk management and communication with farmers, which was held in 2016, attracting 15 advisors, 6 researchers and 4 people from the finance sector.

### *Paddock walks*

Annual 'Sticky beak days' are held in spring on upper EP, where growers visit local properties and discuss trials or issues. The 15-day series of paddock walks were utilised as an extension network by EP G&G3 in 2016 and were attended by approximately 730 farmers and advisors in total. Other paddock walks undertaken on Eyre Peninsula included the women's agronomy group, a grower group field day, MAC open day and student research site visit, which were attended by approximately 150 people.

### *Other communication*

On two occasions, radio interviews were conducted with the ABC radio network on its 'Country Hour' show about the EP G&G3 project, including trials and results over the past three years, with the broadcast extending statewide to a network of approximately 10,000 listeners. Regular emails have been sent to a contact list of around 400 farmers with EP G&G3 updates, information and key messages over the three-year life of the project.

## Future RD&E

The Grain and Graze program has been operating from 2003 to 2016 across large sections of the mixed farming zone of Australia with the program starting through a collaboration of the Grains Research and Development Corporation (GRDC), Meat and Livestock Australia, Australian Wool Innovation and Land and Water Australia. The second phase from 2009 to 2013 involved the GRDC in partnership with the federal Department of Agriculture and the final smaller extension phase in G&G3 was funded by GRDC (2014 to 2016). Mixed farming has an essential role to play in the diversification, risk management and sustainability of farming in the future. The high level of complexity in the interactions between cropping and livestock systems highlights the importance of research, development and extension into the mixed farming systems arena.

## Resources

[1]For more information about the project or for access to G&G publications and tools, please visit www.grainandgraze3.com.au. These books are available on the G&G3 website or through Ground Cover Direct (www.grdc.com.au/bookshop, ground-cover-direct@canprint.com.au or 1800 11 00 44).

[2]Grazing on Cropped Land – A summary of the latest information on grazing winter crops from the Grain and Graze program (2016), C. Nicholson, A. Frischke and P. Barrett-Lennard, Grain and Graze GRDC project code: SFS000028[3].

[3]Farm Decision Making: The interaction of personality, farm business and risk to make more informed decisions (2015), C. Nicholson, J. Long, D. England, B. Long, Z. Creelman, B. Mudge and D. Cornish, Grain and Graze GRDC project code: SFS000028[3].

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Section Editor:
Blake Gontar
SARDI, Port Lincoln

# Section 5

# Weeds

## Seeding rate by row spacing for barley grass management

RESEARCH

**Amanda Cook and Ian Richter**
SARDI, Minnipa Agricultural Centre

**Searching for answers**

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

### Key messages

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

### Why do the trial?

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

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

### How was it done?

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

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

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

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

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

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

## What happened?

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

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

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

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

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

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

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

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

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

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

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

## What does this mean?

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

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

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

| Seeding rate target (plants/m²) | Row spacing (cm) | Early (plants/m²) | | LAI (μmols) | Late | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Barley grass | Rye grass | | Grass weeds DM (t/ha) | Barley grass (plants/m²) | Barley grass seed/m² | Ryegrass (plants/m²) | Ryegrass seed /m² |
| | 18 | 29 | 12 | 381 | 0.24 (42% reduction) | 12.3 | 582 (44% reduction) | 6.0 | 193 (8% reduction) |
| | 30 | 35 | 17 | 458 | 0.41 | 18.4 | 1037 | 5.4 | 209 |
| *LSD (P=0.05) row spacing* | | *ns* | *ns* | *73* | *0.14* | *5.6* | *322* | *ns* | *ns* |
| 60 | | 33 | 18 | 517 | 0.50 (47% increase) | 16.3 | 1245 (50% increase) | 7.3 | 328 (95% increase) |
| 120 (district practice) | | 37 | 13 | 408 | 0.34 | 18.0 | 828 | 5.2 | 168 |
| 240 | | 25 | 13 | 334 | 0.12 (65% reduction) | 11.8 | 356 (57% reduction) | 4.7 | 107 (36% reduction) |
| *LSD (P=0.05) seeding rate* | | *ns* | *ns* | *63* | *0.12* | *4.8* | *279* | *3.7* | *58* |

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

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

Research into using crop competition for weed control in barley and wheat in 2015 at Hart showed varying the seeding rates (increasing from 100 to 300 plants/m²) reduced the yield loss due to weed competition (Goss, 2015). This research also showed there were differences in wheat and barley varieties' ability to compete with grass weeds, and it also found no difference between normal or spreader seeding boots (Goss, 2015). Spreader boots were used to try reduce the row spacing (by spreading the seed) and increase grass weed competition, however this effect has not occurred at Minnipa in the last two seasons.

Research in the Upper North of SA showed barley sown at higher seeding rates is more effective than wheat at reducing barley grass seed set, particularly with more vigorous varieties such as Fathom, compared to less vigorous varieties such as Hindmarsh (Mudge, EPFS Summary 2016).

At Minnipa the seeding system boots showed little difference in either weed competition or crop yield.

Achieving 166 plants/m² instead of 87 plants /m² (targeted rate was district practice rate of 120 plants/m²) has reduced barley grass seed set by 57% and ryegrass by 36%. Sowing to achieve a district practice seeding rate of 60 kg/ha (actually108 plants/m²) at 18 cm spacing instead of 30 cm has led to a 44% decrease in barley grass seed production. Overall the reduction in barley grass numbers demonstrates using crop competition (either by using a narrow 18 cm row spacing, or by increasing plant density) are potentially effective non-chemical methods to reduce barley grass and ryegrass numbers in current farming systems. Using narrow row spacings of 18 cm in greater than 2 t/ha wheat crops have also shown a yield advantage in this environment.

## References


GRDC Factsheet, *Crop placement and Row Spacing*, Jan. 2011.

*Row spacing of winter crops in broad scale agriculture in southern Australia* (2013) Scott, BJ, Martin P, Riethmuller GP. Monograph No. 3, Graham Centre.

Goss, S and Wheeler, R. (2015) *Using crop competition for weed control in barley and wheat*, GRDC Update Papers, Adelaide, 2015.


## Acknowledgements


Thank you to Sue Budarick, Tegan Watts and Katrina Brands for doing the weed counts. Funded by the GRDC Overdependence on Agrochemicals project (CWF00020).

# Row orientation, seeding system and weed competition

**Amanda Cook[1], Ian Richter[1], Chris Dyson[2] and Nigel Wilhelm[1]**
[1]SARDI, Minnipa Agricultural Centre; [2]SARDI, Waite

RESEARCH

**Searching for answers**

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

## Key messages

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

## Why do the trial?

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

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

## How was it done?

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

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

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

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

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

## What happened?

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

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

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

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

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

Weeds

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

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

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

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

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

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

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

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

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

**LSD not available due to lack of replication (>8 required for statistical comparison)*
*- Analysed data not provided*
*^ not applicable (no weeds)*

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

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

## What does this mean?

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

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

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

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

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

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

## References


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

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Scott, BJ, Martin P, Riethmuller GP. (2013) *Row spacing of winter crops in broad scale agriculture* in southern Australia Monograph No. 3, Graham Centre

Goss, S and Wheeler, R. (2015) *Using crop competition for weed control in barley and wheat*, GRDC Update Papers, Adelaide, 2015, p 245


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# Grass weed management in retained stubble systems - farm demonstrations

**Amanda Cook[1], Ben Fleet[2], Ian Richter[1], Sue Budarick[1], Bruce Heddle[3], Jake Hull[1] and Wade Shepperd[1]**
[1]SARDI, Minnipa Agricultural Centre; [2]University of Adelaide; [3]Minnipa farmer

DEMO

**Searching for answers**

**Location:**
Minnipa
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm

**Location:**
Yeelanna
**Rainfall**
Av. Annual: 395 mm
Av. GSR: 314 mm

## Key messages

- **The ability to capture barley grass seeds at harvest is limited.**
- **If seed can be captured and placed in windrows, windrow burning can reduce grass weeds.**
- **Seed capture at harvest is higher with annual ryegrass than with barley grass.**
- **Burnt narrow windrows sustained temperatures above 400$^{o}$C for longer than 10 seconds, which is sufficient to sterilise annual ryegrass seed.**
- **Snail numbers were reduced with windrow burning.**
- **Barley grass germinates later in Minnipa Agricultural Centre cropped paddocks than in non-cropped areas.**

## Why do the demonstration?

The GRDC 'Maintaining profitable farming systems with retained stubble' projects on upper and lower Eyre Peninsula (EP) aim to improve farm profitability while retaining stubble in farming systems. Grass weed management is one of the key issues of current cropping systems with annual ryegrass and barley grass being of most importance on lower EP (LEP) and upper EP (UEP) respectively. Herbicides continue to be the main strategy for weed control, and on LEP the intensification of cropping rotations and the decrease in livestock from farming systems has resulted in even further pressure on herbicides, resulting in the accelerated development of herbicide resistance in ryegrass.

An integrated approach to weed management (IWM) is required to slow the development of herbicide resistance and improve the sustainability of our farming systems. IWM aims to lower the weed seed bank with the use of herbicides as well as non-chemical techniques such as cultivation, higher sowing rates, and harvest weed seed management such as burning stubble, narrow windrow and chaff cart dumps. Demonstration paddocks were monitored to assess grass weed management strategies in current farming systems. This information will be used to improve the Ryegrass Integrated Management (RIM) model for EP systems, and potentially produce other grass weed management models (barley grass).

## How was it done?

In 2016 monitoring of farm paddocks was undertaken to assess grass weed management strategies by;

- Monitoring grass weed numbers in narrow windrows from harvest 2015 in MAC paddocks 'Airport', 'S3N' and 'N6W' (canola).
- Monitoring grass weed numbers, narrow windrows and chaff dumps in grower's paddocks 'CE42' (lentils) and 'Carina' (canola).
- Monitoring weed seed banks of ryegrass in narrow windrows from harvest 2015 on a property south east of Cummins. Two paddocks, '80 Acre' and 'Salt Lake' were monitored. See EPFS Summary 2015 p155-158 for more detail regarding this property.

Only broad conclusions from the farmer demonstrations can be made in regards to weed seed capture, as there was a large amount of variation in the weed population in the paddocks being monitored which clouds management effects.

***Paddock monitoring for grass weed populations***

Grass weed density was assessed in crop at 10 GPS points along a transect before grass weed spraying. Six crop and weed counts were taken at each of the 10 locations. The same transect was assessed again before harvest.

***Assessing weed seed capture and burning in narrow windrows***

Soil samples for weed seed banks were collected in February and March 2015 along a transect across the paddock comprising 10 GPS-located sampling points. The soil sampling method was 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 (see EPFS Summary 2015, p150-151 for further details) and weed seeds in soil or chaff were germinated in 2015. Germinating trays, 35 cm x 29 cm, were partially filled with sterilised soil mix and the collected weed seed bank soil or chaff was then spread over the top to 1-2 cm depth, with another light coating of the sterilised soil mix spread over the soil or chaff. The trays were placed in a rabbit proof open area and watered if required during the season. Trays were assessed for weed germination approximately every four weeks. Counted weeds were removed from the trays. Control plots with barley grass seed collected from MAC oil mallee area (sprinkled into trays) were located across the germination area to assess timing of barley grass germination relative to a non-cropped population.

Percent reduction in seed by burning is the reduction of weed seeds within the windrow due to burning. This was calculated by (number of weeds in row burnt)/(number of weeds in row before burning (soil)) as a percentage (S Kleemann, per comm. 2015). This only explains the fate of weeds that end up in windrows.

In the paddocks sampled, approximately 10 m of crop and weeds was collected by the header front and the chaff and weed seed were deposited into a 0.7-1.0 m wide row resulting in a concentration of crop material (including weed seeds) by a factor of 10 – 14 times, depending on the actual size of the header front and the windrow width (Figure 1). To calculate the actual weed control efficacy of burning windrows we need to consider both the amount of weed seed in the row controlled by fire as well as the proportion of the seed that was captured by the header and placed into the windrow for burning. To calculate the proportion of the weed seeds collected at harvest the following calculations were used:

> Weed seed captured in the windrow can be calculated before burning by [(weed seeds in windrow) – (weed seeds from inter row) / (windrow concentration factor)]. This will give the amount of seeds/$m^2$ entering the windrow. This can be converted to a % of total weed seed capture by [(seeds removed to windrow) / (seeds removed to windrow + seeds in inter row)]*100. The final efficacy is the % of weed seed captured in the windrow multiplied by the % reduction by burning the seeds in the windrow (B Fleet, per comm. 2016).

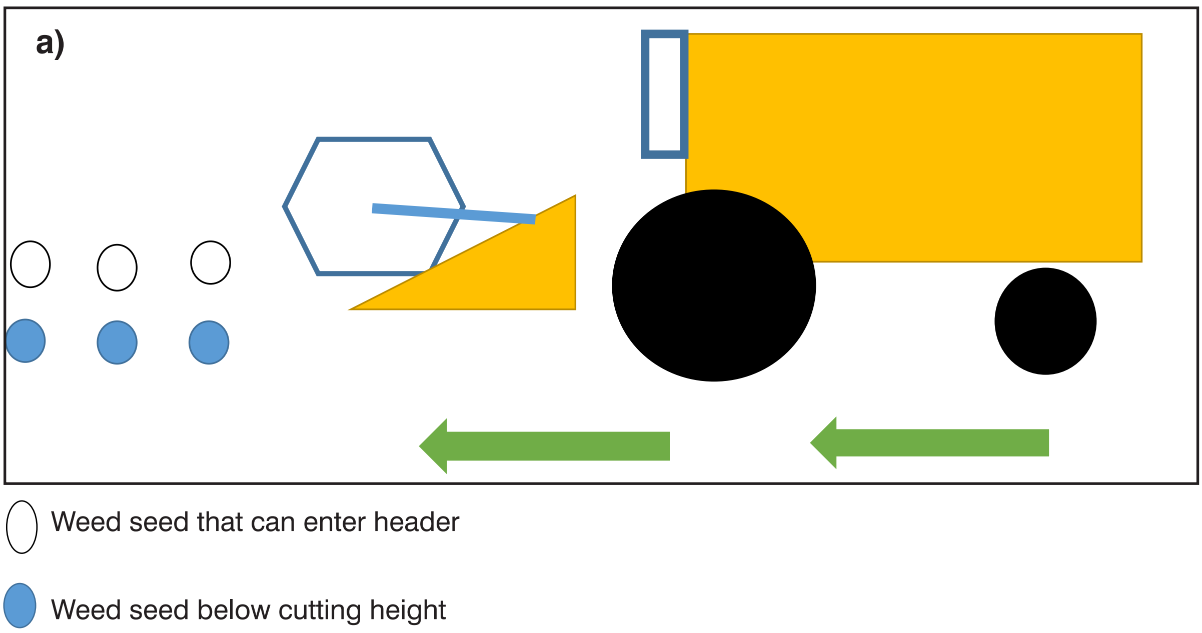
Snail numbers were recorded after windrow burning to asses live and dead snails across the paddock.

***Assessing weed seed capture in chaff dumps after harvesting***

Chaff was collected from 10 chaff dumps with 10 samples per dump, taken approximately 40 cm into the dump (which were approximately 1 m high), to determine the weed seed species being collected at harvest. Fifty grams of chaff were added to each germination tray with three replications (30 samples per chaff dump, 300 samples per paddock monitored).

***Recording windrow burning temperatures***

Temperatures of the burning windrow were recorded with a temperature gun (as used for recording machinery bearing temperatures). Temperatures were recorded every 10 seconds for 240 seconds, and then separately recorded at 300 and 360 seconds. This was repeated on 10 windrows.



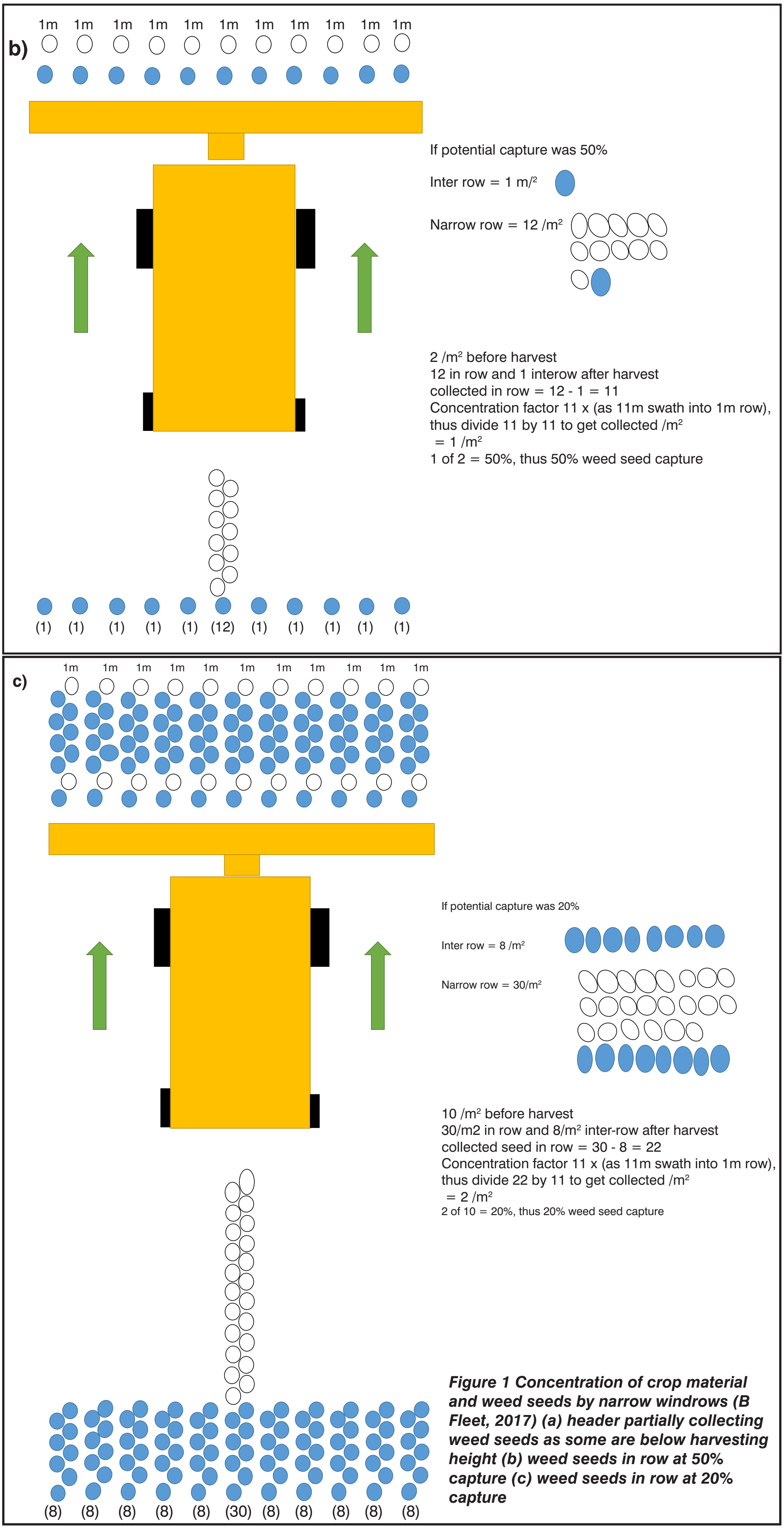



***Figure 1 Concentration of crop material and weed seeds by narrow windrows (B Fleet, 2017) (a) header partially collecting weed seeds as some are below harvesting height (b) weed seeds in row at 50% capture (c) weed seeds in row at 20% capture***

## What happened?

Barley grass germination from in-crop paddock samples in 2015 differed from barley grass collected in a non-cropped area of the oil mallee paddock, which has not been sprayed since 2007 (Figure 2). The germination patterns indicate that by removing early germinating genotypes from the population, cropping has strongly selected for later germinating barley grass (Figure 2).

Paddocks MAC Airport and MAC S3N were windrow burnt on 31 March 2016 with 19 km/h winds in a west to north westerly direction, temperature of 25°C and relative humidity of 24%. MAC N6W canola windrows were burnt on 1 April 2016 with 15 km/h winds in a northerly direction, temperature of 27°C and relative humidity of 20%. Burning temperature remained higher than 400°C for longer than 10 seconds (Figure 3), which is the temperature required to sterilise or kill ryegrass seed (Walsh, 2007).

In the MAC Airport paddock, the crop was harvested at 25.2 cm (higher than desirable for weed seed collection) and snails were an issue. The snails moved into the windrow stubble over summer. After burning, there were 3.3 dead snails/m$^2$ in burnt windrows and 0.5 snails/m$^2$ surviving snails in nearby stubble counts.

The rotation of the paddock monitored at Carina has been; 2012 Clearfield wheat, 2013 Clearfield wheat with burnt windrows, 2014 medic brown manured for grass control, 2015 Emu Rock wheat and in 2016 ATR Stingray canola. Monitoring of grass weed numbers within windrow paddocks on EP has shown large variation in grass weed numbers (Table 1 and 2). A proportion of the weed seeds are captured by the harvester and placed into the windrow, resulting in higher weed numbers in-row than in the inter-row. A greater proportion of ryegrass seed is captured by the harvester and placed into windrows than for barley grass seed, as barley grass tends to shed prior to harvest. The initial data from chaff dumps show a greater numbers of ryegrass are being captured than barley grass (Table 1).

Weeds

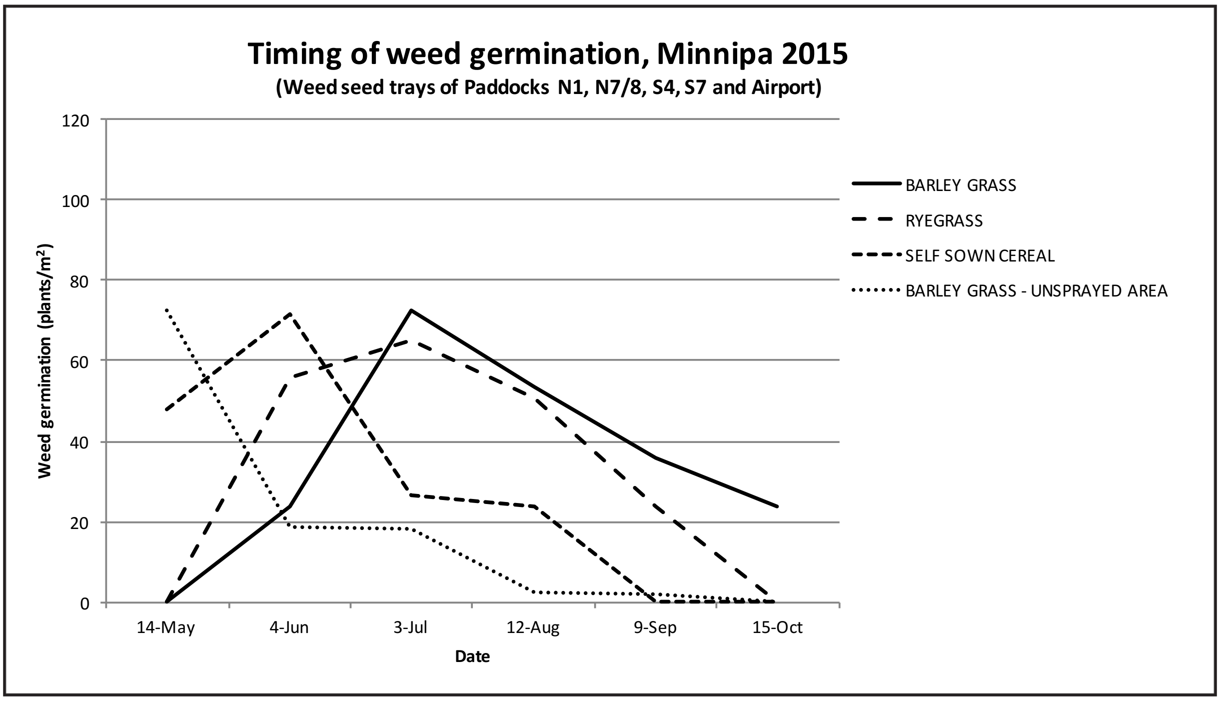



***Figure 2 Weed germination patterns from in-crop soil samples taken from harvest 2014 to early 2015***

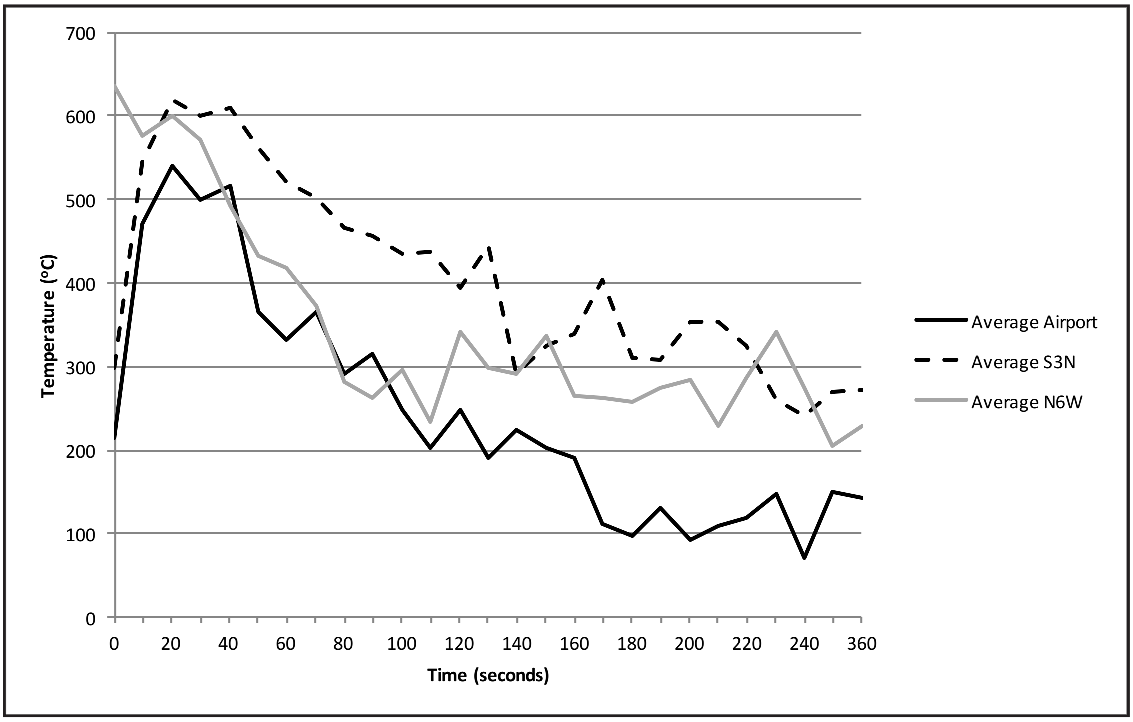



***Figure 3 Burning temperatures (°C) over time (seconds) of windrows (wheat and canola), at Minnipa in March 2016***

***Table 1 Weed seed counts (plants/m²) from weed seed banks of harvest 2015 from upper Eyre Peninsula (Bruce Heddle's Carina paddock) (SE=standard error of sample)***

| **Seeds/m²** | **Barley grass** | **SE** | **Rye grass** | **SE** | **Self-sown cereal** | **SE** |
|---|---|---|---|---|---|---|
| Inter row (before burning) | 28 | 7 | 83 | 22 | 4.8 | 2 |
| In row before burning (soil collected before burning) | 18 | 6 | 111 | 27 | 45 | 10 |
| In row burnt (soil collected after burning) | 6.4 | 2 | 73 | 22 | 2.4 | 1.3 |
| *% Reduction of weed seeds in windrow by burning* | *64%* | | *34%* | | *95%* | |
| *Final efficacy or overall % paddock seedbank reduction (with concentration effect of windrowing)* | *0* | | *1.1%* | | *43%* | |
| **Seeds/t chaff** | | | | | | |
| Windrow chaff (30 samples) | 42,667 | 9,400 | 830,667 | 151,500 | 790,000 | 98,300 |
| Chaff dumps (92 samples) | 38,478 | 5,800 | 8,537,609 | 521,700 | 941,957 | 600,000 |

***Table 2 Weed seed counts (plants/m²) from weed seed banks of harvest 2015 from lower Eyre Peninsula (SE=standard error of sample)***

| Paddock | 2015 Rotation | Treatment | Barley grass | SE | Ryegrass | SE | Self-sown cereal | SE |
|---|---|---|---|---|---|---|---|---|
| 80 Acre | Beans | Inter row (before burning) | 0 | | 22 | 7 | 48 | 9 |
| | | In row before burning (soil) | 0 | | 110 | 41 | 30 | 10 |
| | | In row non burnt (straw removed from 5 m row - soil collected after burning) | 0 | | 32 | 18 | 9 | 3 |
| | | *% Reduction of seed in windrow by burning* | *0* | | *71%* | | *70%* | |
| | | *Final efficacy or overall % paddock seedbank reduction (concentration effect of windrowing)* | *0* | | *20%* | | *0* | |
| Salt Lake | Canola | Inter row (before burning) | 2.4 | 1.8 | 41 | 12 | 61 | 16 |
| | | In row before burning (soil) | 0 | | 94 | 25 | 54 | 12 |
| | | In row non burnt (straw removed from 5 m row - soil collected after burning) | 0 | | 18 | 6 | 26 | 8 |
| | | *% Reduction in windrow by burning* | *0* | | *81%* | | *52%* | |
| | | *Final efficacy or overall % paddock seedbank reduction (concentration effect of windrowing)* | *0* | | *9.3%* | | *0* | |
| N5 | Canola | Paddock sample | 0 | | 17 | 7 | 40 | 9 |
| Airstrip | Wheat | Paddock sample | 0 | | 14 | 6 | 129 | 58 |
| Shearing Shed | Barley | Paddock sample | 0 | | 2 | 1 | 96 | 30 |
| West well | Barley | Paddock sample | 0 | | 60 | 19 | 149 | 24 |

There was very little barley grass in windrows on LEP and ryegrass was the dominant grass weed. On LEP ryegrass weed seed capture was greater than upper EP (Table 2). The reduction in weed seed numbers by burning the windrow was similar on upper EP and lower EP.

## What does this mean?

Continuous cropping has resulted in paddock populations of barley grass which are germinating later in the cropping season compared to the oil mallee non-cropped area at Minnipa. Be aware of grass weed germination patterns in paddocks; monitor a crop free area during the growing season to see when grass weeds are germinating.

High temperatures during narrow windrow burning are being achieved, over 400°C for longer than 50 seconds, which should provide temperatures to sterilise most weed species. Burning temperatures required to sterilise or kill other weed seeds including barley grass will be determined as part of a SAGIT-funded project with the University of Adelaide.

There is good control of weed seed achieved by narrow windrow burning when it is captured at harvest and burnt, however the inter row weed seed numbers or background weed seed population is often as high as in the windrow, especially for barley grass. Ryegrass on lower EP showed a greater reduction in overall seed bank in paddock with narrow windrows. Narrow windrow burning also reduced snail numbers.

In 2017 paddock monitoring of alternative methods to manage grass weed numbers will continue, especially for barley grass. This will include early swathing of wheat with high barley grass numbers to capture barley grass seed within the windrow.

## Acknowledgements

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# Management of group A herbicide resistant barley grass in pasture phase

**Ben Fleet[1], Amanda Cook[2], Ian Richter[2], Wade Shepperd[2], Chris Preston[1] and Gurjeet Gill[1]**

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

RESEARCH

**Searching for answers**

**Location:**
Minnipa Agricultural Centre
paddock N1
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Actual: 2.9 t/ha, surrounding crop
**Paddock History**
2015: Pasture legume trial
2014: Mace wheat
2013: Mace wheat
**Soil Type**
Red loam
**Plot Size**
27 m x 9 m x 3 split plots (2015)
9 m x 9 m x 4 reps (2016)
**Yield Limiting Factors**
Barley grass
**Livestock**
Grazing simulated by mowing in pasture plots

## Key messages

- **At present, group A herbicide resistance in barley grass is relatively low at a district level on the EP. However, growers need to act now to integrate multiple control tactics to prolong the effectiveness of these cheap and effective herbicides.**
- **In the absence of group A herbicides, it is still possible to achieve large reductions in barley grass seed bank in a legume pasture phase.**
- **When using moderate efficacy-low cost herbicides (Treflan + Logran) for barley grass control in wheat, effective control of the weed in previous pasture phase was critical.**

## Why do the trial?

A field trial has been established at Minnipa Agricultural Centre (MAC) to investigate legume pasture options for controlling group A (ACCase inhibitors) resistant barley grass (GRDC project UA00149).

In 2012 the University of Adelaide (UA) conducted a GRDC-funded random resistance survey on barley grass from across EP and Upper North (UN) cropping districts (Shergill *et al*. 2015). The survey found 3% of the paddocks to be resistant to group A herbicides (≥ 20% survivors) and another 3% were developing resistance (1% ≤ 20% survivors). Resistance was much more prevalent in the UN than on EP (> 5 fold). These survey results are based on sampling barley grass from completely random locations around the survey districts; there could be individual farms in this area where resistance levels could be much higher.

While at a district level group A resistance is currently present at a relatively low level, it is likely to increase in prevalence in the future, which would reduce the effectiveness of the pasture phase in controlling barley grass. This trial was undertaken to investigate barley grass management options when group A herbicide resistance has evolved.

The trial also looked at the impact of these pasture treatments on a subsequent wheat crop and compared one vs. two consecutive years of legume pasture on barley grass management in the absence of group A herbicides.

## How was it done?

A trial site was established at MAC in a heavily barley grass-infested paddock (N1) before the 2015 growing season. Soil seedbank sampling was done to establish the initial barley grass seed bank. Soil cores were grown out in trays at Roseworthy Campus to assess the seed bank. Large (9 m x 27 m) replicated plots were set up under eight different pasture management options (Table 1).

Seed bank soil cores were again taken prior to the 2016 growing season. These samples were germinated in trays during 2016 at Roseworthy Campus to assess barley grass seed bank. Comparisons were then made for each plot to calculate the percent reduction in barley grass seed bank by pasture management treatments.

During the 2016 growing season plots were split into 3 sub plots (9 m x 9 m) where one sub plot repeated the pasture treatment of 2015 to provide two consecutive years of pasture treatment. The other two sub plots were sown to Scepter wheat (26 May) with the MAC air seeder. Two pre-emergent herbicide treatments were applied to the wheat sub plots: (a) moderate efficacy and cheaper option of trifluralin 1 L/ha + triasulfuron 30 g/ha (Tref + Log.) and (b) a high efficacy and expensive option of pyroxasulfone 118 g/ha (Sakura).

*Table 1 Pasture treatments in 2015*

| 2015 Pasture barley grass management treatments | |
|---|---|
| 1 | **Brown manure vetch** – vetch was sown and brown manured with glyphosate (570 g/L) @ 1.5 L/ha (4 September) |
| 2 | **Medic (regen.) pasture topped early** – topped with glyphosate (570 g/L) @ 0.5 L/ha when 10% barley grass seed was at soft dough stage (4 September) |
| 3 | **Medic (regen.) pasture topped mid** – topped with paraquat @ 1 L/ha when 50% barley grass seed was at soft dough stage (15 September) |
| 4 | **Medic (regen.) hay cut** – (29 September) |
| 5 | **Medic (regen.) glyphosate + hay cut** – topped with glyphosate (570 g/L) @ 2.4 L/ha (24 September) followed by hay cut (29 September) |
| 6 | **Medic (regen.) propyzamide** – applied at 1 L/ha EPE (8 May), note applied when medic had germinated but prior to significant barley grass germination |
| 7 | **Medic (regen.) propyzamide + spray topped mid** – propyzamide @ 1 L/ha EPE (8 May), paraquat @ 1 L/ha when 50% barley grass seed at soft dough stage (15 September) |
| 8 | **Medic (regen.) grazed (control**) – grazing simulated by mowing (20 August) |

During 2016 barley grass panicles were assessed in the wheat sub plots to indicate weed pressure in a subsequent wheat crop under the two pre-emergent herbicide options.

Soil cores will soon be taken to evaluate changes in barley grass seed bank. This approach will allow assessment of the impact of the original pasture treatments on the weed pressure in the subsequent wheat crop (under different herbicide options) and also the difference in barley grass seed bank between one and two consecutive years of legume pasture. These results will be available later in 2017.

## What happened?

Initial barley grass seed bank at the experimental site at the start of 2015 season was 1432 seeds/m$^2$. There was no statistical difference (P>0.05) between the replicates indicating the presence of a uniform weed population across the site.

Results from barley grass seed bank assessments at the start of 2016 were used to evaluate the reduction in barley grass by the pasture treatments applied in 2015 (Table 2).

Weeds

***Table 2 Summary of results 2015 pasture and 2016 wheat, letters within each column indicate statistical differences between the treatments; grain yield as percentage of the control treatment is shown in brackets***

| 2015 pasture treatments | 2016 wheat yield | 2015 reduction in barley grass | 2016 barley grass in wheat (panicles/m$^2$) | |
|---|---|---|---|---|
| | t/ha | % reduction | Tref + Log | Sakura |
| 1. Vetch brown manure | 2.10 ***bc*** *(101.8%)* | 69 ***a*** | 16.5 ***cd*** | 11.2 ***cd*** |
| 2. Medic early spray-top | 2.13 ***bc*** *(103.3%)* | 66 ***a*** | 18.3 ***c*** | 8.7 ***cd*** |
| 3. Medic mid spray-top | 2.29 ***ab*** *(110.9%)* | 60 ***a*** | 13.0 ***cd*** | 7.8 ***d*** |
| 4. Medic hay cut | 2.19 ***b*** *(106.3%)* | 62 ***a*** | 29.3 ***b*** | 17.5 ***cd*** |
| 5. Medic glypho. + hay | 2.20 ***ab*** *(106.8%)* | 49 ***ab*** | 25.8 ***bc*** | 9.2 ***cd*** |
| 6. Medic propyz. | 2.13 ***bc*** *(103.0%)* | 27 ***b*** | 50.0 ***a*** | 7.0 ***d*** |
| 7. Medic propyz. + spray-top | 2.32 ***a*** *(112.4%)* | 79 ***b*** | 16.7 ***cd*** | 8.0 ***cd*** |
| 8. Medic grazed (control) | 2.06 ***c*** *(100%)* | 23 ***b*** | 47.5 ***a*** | 12.0 ***cd*** |
| | *P<0.001, LSD=0.12* | *P<0.013 LSD=31.9 cv rep = 8.4%* | *Interaction P<0.001 LSD=10.48 cv rep = 10.8%* | |

All 2015 pasture treatments reduced barley grass density, ranging between 23% and 79% (Table 2). These results show that the barley grass population can be reduced significantly in pasture even in the absence of group A herbicides. However, when starting with such a high seedbank, it is likely there will still be significant weed pressure for subsequent crop or pasture after a single year pasture treatment. In this trial, the best pasture treatment reduced barley grass from approximately 1400 seeds/$m^2$ to about 300 seeds/$m^2$. This means that even the most effective pasture treatment would require an effective herbicide treatment to achieve high yield potential of subsequent wheat crops.

For the two hay based treatments (49% and 62% control), it is likely that that weed control could have been improved if hay was cut at an earlier growth stage of barley grass.

Pasture topping treatments reduced weed seedbank by 60 and 66% for early and mid-timings. Reducing the variability in maturity in barley grass population is critical for improving the effectiveness of pasture topping or hay cut operation. In a weed species with such variable maturity, synchronising plant development can be difficult. Historically group A herbicides have been used to synchronise plant development in barley grass populations to improve the performance of pasture topping. After group A resistance develops in barley grass, other tools such as crash grazing and soil applied herbicides will be needed to reduce variability of barley grass maturity.

Propyzamide was relatively ineffective in 2015, which may have been due to reduced herbicide uptake caused by the dry conditions early in the growing season. Visual observations (seed bank data still to be assessed) from 2016 indicate propyzamide was very successful in reducing barley grass under more favourable moisture conditions. Therefore, the use of propyzamide to control barley grass in legume pastures can be highly effective but highly dependent on the weather. It also has a significant grazing withholding period that needs to be carefully considered.

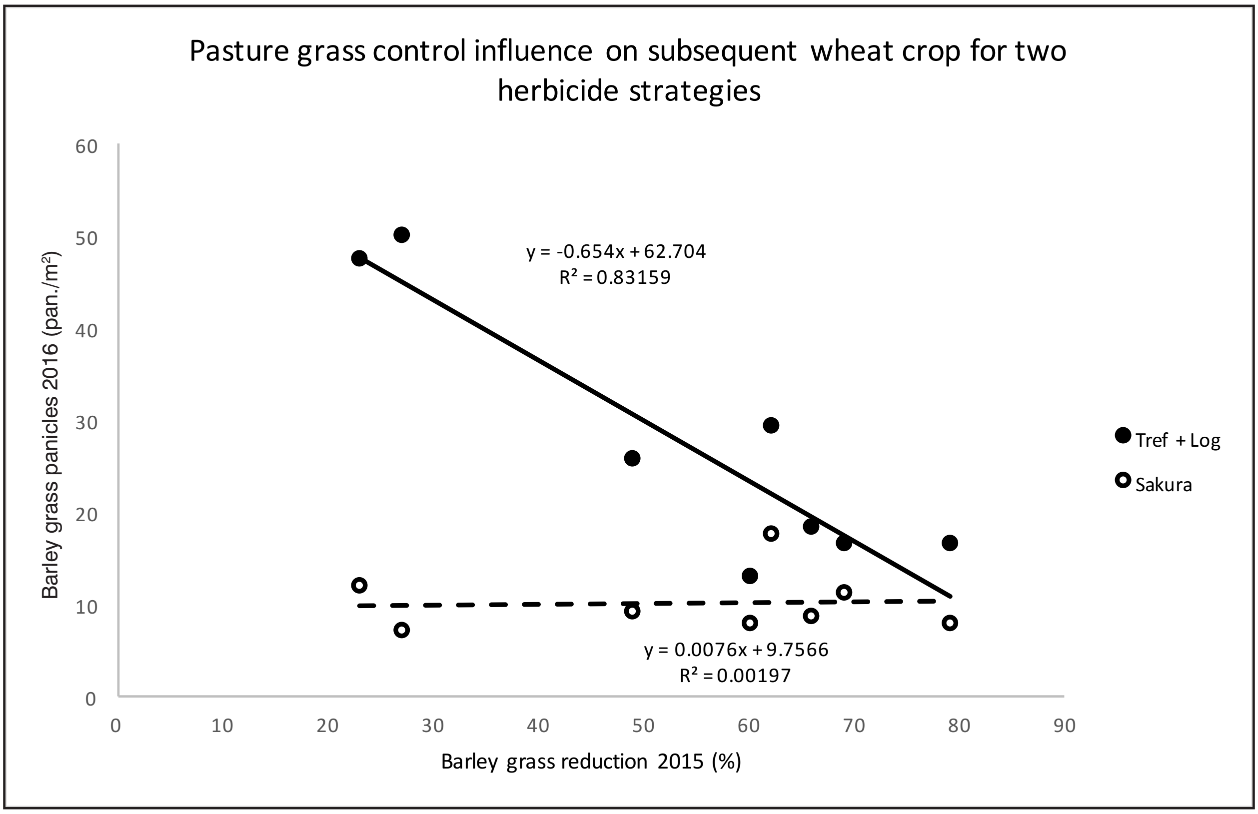


***Figure 1 Relationship between barley grass control in pasture (2015) and the amount of barley grass present in subsequent wheat crop (2016) for the two herbicide options investigated***

Barley grass infestation in wheat under the moderate efficacy-low cost (Treflan + Logran) treatment strongly reflected the level of barley grass control achieved in the previous year's pasture ($R^2$=0.83). However, barley grass numbers in wheat under the highly effective-high cost regime (Sakura) was unaffected by the previous year's pasture treatment ($R^2$=0.002), (Figure 1). Sakura in wheat was able to control barley grass effectively even in pasture treatments that provided poor barley grass control in 2015. Even though Sakura had high efficacy even in high weed density situations, using this herbicide repeatedly in such situations could accelerate resistance development. These results also show that the moderate efficacy-low cost (Treflan+ Logran) herbicide regime was adequate only under low weed pressure, but inadequate in situations of high barley grass pressure. These results are consistent with previous UA work on barley grass management in wheat on the EP.

Wheat yields in 2016 ranged from 2.06 to 2.32 t/ha; on initial investigation wheat yield was not closely related to previous pasture barley grass control ($R^2$=0.35, data not shown), but when treatment 1 (vetch brown manure) and treatment 2 (medic early pasture topped) were excluded the yields were strongly correlated to previous pasture weed control ($R^2$=0.86, data not shown).

The final barley grass seed bank assessment will be done in 2017 and is expected to show the differences between a single and consecutive years of each pasture treatment. It should also show seed bank changes for these pasture treatments following a wheat crop under both high and low efficacy weed control options.

## What does this mean?

- At present, group A herbicide resistance is low at a district level on the EP, but expected to increase resulting in the eventual loss of these highly effective and affordable herbicides.
- We need to be integrating multiple control tactics when controlling barley grass in a legume pasture phase to prolong the useful life of these affordable and effective group A herbicides.
- It is possible to greatly reduce barley grass seed bank in a legume pasture phase, but in the absence of group A herbicides, it is more difficult to synchronise plant development and results of seed set control tactics tend to be more variable.
- Despite being able to achieve large reductions in barley grass seedbank in a single year, sufficient weed infestations can occur to rapidly increase weed infestation unless they are managed effectively.
- When using moderate efficacy-low cost herbicides (Treflan + Logran) for barley grass control in wheat, effective control of the weed in previous pasture phase in critical.
- The high efficacy-high cost herbicide (Sakura) provided effective control of barley grass in wheat irrespective of the level of weed control achieved in previous pasture. However, repeated use of Sakura in a high weed pressure situation would speed up resistance development to this valuable herbicide.

## Acknowledgements

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# Overdependence on agrochemicals – UNFS barley grass trial

**Barry Mudge**
Barry Mudge Consulting for Upper North Farming Systems

**Searching for answers**

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

## Key messages

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

## Why do the trial?

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

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

This trial completed at Appila in the Upper North in 2016 represents a component of a coordinated approach across a number of low rainfall farming systems groups as part of a GRDC-funded 'Overdependence on Agrochemicals' project. The same trial was completed at Port Germein in 2015. This trial was reported in EPFS Summary 2016, p166-170. The key messages from the 2015 trial results were:

- In the presence of a mixed stand of barley grass and ryegrass, the doubling of seeding rates in a competitive barley variety like Fathom resulted in useful yield benefits, which was likely to be as a result of the increased crop competition.
- A less competitive barley variety like Hindmarsh and Mace wheat did not achieve significant yield benefits from a doubling of seeding rates.
- Increasing the seeding rate of both barley varieties had a significant impact on reducing weed biomass and potentially reducing weed seed carry-over. This same effect was not evident in wheat.
- At the high seeding rate, weed panicle counts at crop anthesis in barley were reduced significantly (56%) when compared with wheat.

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

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

## How was it done?

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

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

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

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

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

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

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

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

## What happened?

Crop establishment from seedbed moisture was reasonably good but was further consolidated by rainfall occurring 10 days after seeding. The remainder of the season saw above average rainfall culminating in a very wet September (Table 1).

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

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

***Seeding rate impact of Scepter wheat***

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

At tillering and at anthesis, there were no differences between high and low seeding rates on the density of grass and other weeds where herbicides were not applied. There was also no observed influence of seeding rate on total weed panicles measured at crop anthesis.

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

| | Treatment and sowing rate | | | |
|---|---|---|---|---|
| | **60 kg/ha (no herbicide)** | **120 kg/ha (no herbicide)** | **120 kg/ha (plus herbicide)** | ***LSD (P=0.05)*** |
| **Early crop establishment** | | | | |
| Crop (plants/m²) | 161 | 275 | 288 | *41* |
| Barley grass (plants/m²) | 118 | 142 | 21 | *45* |
| Broadleaved (plants/m²) | 14 | 10 | 10 | *ns* |
| **Tillering** | | | | |
| Crop biomass (g/m²) | 123 | 154 | 149 | *ns* |
| Weed biomass (g/m²) | 31.8 | 25.7 | 1.1 | *11.5* |
| Total weed tillers (number/m²) | 415 | 333 | 24 | *130* |
| **Anthesis** | | | | |
| Crop biomass (g/m²) | 695 | 701 | 919 | *115* |
| Grass biomass (g/m²) | 264 | 274 | 6 | *129* |
| Total grass panicles (number/m²) | 341 | 326 | 16 | *124* |
| **Harvest** | | | | |
| Crop yield (t/ha) | 1.21 | 1.24 | 1.50 | *0.26* |

The high seeding rate in Scepter wheat did not result in increased competition and did not influence weed density. At anthesis, there was no observed difference between the crop biomass in the high and low seeding rate plots, indicating that the wheat sown at low seeding rates had effectively compensated.

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

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

***Seeding rate impact of Fathom barley***

As with Scepter wheat, crop establishment of Fathom barley was good. As would be expected, barley plant numbers in the high seeding rate plots were about double that of the lower seeding rate ones (Table 3). There was no influence of seeding rate on early grass establishment. The pre-sowing herbicide treatment of 2.5 L/ha of TriflurX (incorporated by sowing) was moderately effective at controlling grass with grass establishment levels at about one quarter of levels in non-herbicide applied plots.

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

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

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

***Seeding rate impact of Hindmarsh barley***

As noted with earlier treatments, crop establishment in Hindmarsh barley was good and, as would be expected, differences in seeding rates (without herbicide) had no influence on the levels of early grass weed establishment (Table 4). The herbicide application reduced grass weed levels by about two thirds.

At crop tillering, there were no statistical differences showing in weed infestations at different seeding rates. However, by anthesis, weed biomass and total grass panicles were almost halved under the high seeding rates.

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

| | Treatment and sowing rate | | | |
|---|---|---|---|---|
| | **60 kg/ha (no herbicide)** | **120 kg/ha (no herbicide)** | **120 kg/ha (plus herbicide)** | ***LSD (P=0.05)*** |
| **Early crop establishment** | | | | |
| Crop (plants/m²) | 88 | 162 | 161 | *17* |
| Barley grass (plants/m²) | 149 | 136 | 59 | *37* |
| Broadleaved (plants/m²) | 14 | 15 | 11 | *ns* |
| **Tillering** | | | | |
| Crop biomass (g/m²) | 171.5 | 239.2 | 244.6 | *ns* |
| Weed biomass (g/m²) | 31.6 | 13.1 | 12.8 | *11.1* |
| Total weed tillers (number/m²) | 503 | 290 | 197 | *132* |
| **Anthesis** | | | | |
| Crop biomass (g/m²) | 920 | 1146 | 1029 | *ns* |
| Grass biomass (g/m²) | 198.1 | 78.2 | 44.6 | *86.7* |
| Total grass panicles (number/m²) | 246 | 115 | 68 | *85* |
| **Harvest** | | | | |
| Crop yield (t/ha) | 2.70 | 3.53 | 3.64 | *0.25* |

Crop biomass at both tillering and anthesis was significantly higher under the high seeding rates. It is reasonable to assume this extra competition eventually affected weed growth. Hindmarsh crop biomass at the high seeding rate with no herbicide applied was not significantly different to the treatment with herbicide.

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

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

At the higher seeding rate of 120 kg/ha, weed measurements taken at anthesis showed that both barley varieties had reduced grass weed panicles to well under half that observed in the wheat plots (Table 5). At the low seeding rate, this reduction in grass seed carry-over was still evident, but not to the same extent (Table 6). The analysis did not reveal any significant differences between the two barley varieties in terms of their impact on weed levels although the raw data tended to favour the more competitive variety, Fathom.



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

| | Treatment and sowing rate | | | |
|---|---|---|---|---|
| | **60 kg/ha (no herbicide)** | **120 kg/ha (no herbicide)** | **120 kg/ha (plus herbicide)** | ***LSD (P=0.05)*** |
| **Early crop establishment** | | | | |
| Crop (plants/m²) | 106 | 204 | 199 | *24.1* |
| Barley grass (plants/m²) | 150 | 140 | 53 | *56* |
| Broadleaved (plants/m²) | 14 | 13 | 8 | *ns* |
| **Tillering** | | | | |
| Crop biomass (g/m²) | 146.3 | 226.0 | 221.9 | *67.4* |
| Weed biomass (g/m²) | 32.5 | 24.2 | 9.0 | *18.2* |
| Total weed tillers (number/m²) | 434 | 408 | 152 | *169* |
| **Anthesis** | | | | |
| Crop biomass (g/m²) | 780 | 1062 | 1079 | *167* |
| Grass biomass (g/m²) | 187.4 | 104.5 | 65.0 | *79.2* |
| Total grass panicles (number/m²) | 229 | 143 | 83 | *58* |
| **Harvest** | | | | |
| Crop yield (t/ha) | 2.75 | 3.28 | 3.38 | *0.41* |

*Table 5 Species and variety impact on weed infestation at 120 kg/ha seeding rate*

| | 120 kg/ha Seeding rate | | | |
|---|---|---|---|---|
| | Scepter | Fathom | Hindmarsh | *LSD (P=0.05)* |
| **Tillering** | | | | |
| Weed biomass (g/m$^2$) | 25.7 | 13.1 | 24.2 | *ns* |
| Total grass weed tillers (number/m$^2$) | 333 | 290 | 408 | *ns* |
| **Anthesis** | | | | |
| Weed biomass (g/m$^2$) | 274.3 | 78.2 | 104.5 | *104.9* |
| Total grass weed panicles (number/m$^2$) | 326 | 115 | 143 | *76* |

*Table 6 Species and variety impact on weed infestation at 60 kg/ha seeding rate.*

| | 60 kg/ha Seeding rate | | | |
|---|---|---|---|---|
| | Scepter | Fathom | Hindmarsh | *LSD (P=0.05)* |
| **Tillering** | | | | |
| Weed biomass (g/m$^2$) | 31.8 | 31.6 | 32.5 | *ns* |
| Total grass weed tillers (number/m$^2$) | 416 | 434 | 503 | *ns* |
| **Anthesis** | | | | |
| Weed biomass (g/m$^2$) | 264.3 | 198.1 | 187.4 | *ns* |
| Total grass weed panicles (number/m$^2$) | 341 | 246 | 229 | *69* |

## What does this mean?

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

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

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

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

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


## Acknowledgements

The Ritchie family from Appila for their enthusiasm in providing a suitable site and regular weather updates. Nigel Wilhelm and Peter Telfer (SARDI) for assisting with trial design and trial seeding and harvest. Rochelle Wheaton and Sarah Noack (Hart Field Site) for trial assessments. Amanda Cook (SARDI) for statistical analysis. GRDC for funding the trial under Project No CWF00020 'Overdependence on Agrochemicals'


## Products used in trial:

Scepter is protected by Plant Breeders Rights. Licencee AGT Seeds.

Fathom is protected by Plant Breeders Rights. Licencee Seednet.

Hindmarsh is protected by Plant Breeders Rights. Licencee Seednet.

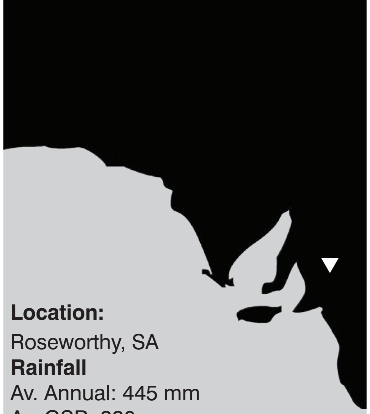
Sakura is a registered trademark of Kumiai Chemical Industry Co. Ltd.

TriflurX is a registered trademark of Nufarm Australia Limited.

# Effect of sowing time on ryegrass control in wheat

**Sam Kleemann, Gurjeet Gill & 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
2016 Total: 617 mm
2016 GSR: 455 mm
**Soil Type**
Sandy loam over medium calcareous clay - Red brown earth
**Plot Size**
1.5 m x 8 m x 4 reps

## Key messages

- **A growing number of farmers have now adopted earlier sowing times for cereals.**
- **Delayed sowing provided no advantage over the earlier sowing time in reducing ryegrass, moreover ryegrass flourished with the late spring under delayed sowing where crop competition was compromised.**
- **Sowing time had no effect on the performance of pre-emergent herbicides against ryegrass; herbicide mixtures of Sakura plus Avadex Xtra were highly effective (>90% control).**

## Why do the trial?

Delayed sowing has been considered a useful weed management tactic in order to maximise weed emergence and control prior to sowing the crop. However, delayed sowing often results in lower crop yield and the benefits for reduced crop weed competition are not well documented. The introduction of new residual herbicides has reduced the reliance on post-emergent herbicides and provided an opportunity for growers for dry sowing. Anecdotal grower evidence would suggest that dry or early sown crops sprayed with residual pre-emergent herbicides provide good annual ryegrass control and often higher grain yield.

Here we report the results from a field trial undertaken at Roseworthy in 2016 to investigate the effect of time of sowing (TOS) on the performance of pre-emergent herbicides and their mixtures on annual ryegrass control in wheat.

## How was it done?

A field trial was established at Roseworthy in 2016 to compare the effect of early and delayed sowing on annual ryegrass control with different pre-emergent herbicides. The trial was established in a split-plot design with one wheat variety (cv. Mace), two times of sowing (early May vs early June) and six pre-emergent herbicide treatments (Table 1).

Mace wheat was sown at 90 kg/ha on 6 May and 1 June, to represent early (TOS1) and late (TOS2) times of sowing respectively. The replicated trial was sown into a faba bean stubble using a standard knife-point press wheel system on 22.5 cm (9”) row spacing. Fertiliser rates were applied as per district practice with 100 kg/ha DAP (18:20:0:0) banded below the seed. Pre-sowing weed control (glyphosate 2.5 L/ha + oxyfluorfen 90 ml/ha) was undertaken on 20 April and immediately prior to each time of sowing (TOS1 and TOS2). Fungicide tebuconazole was applied on 23 September at 290 ml/ha. Pre-emergent herbicides were applied with a 2 m pressurised handboom and incorporated within a few hours of application. Boxer Gold was applied post-emergent (treatment 4) on 1 June (TOS1) and 25 June (TOS2) when the crop had reached the 2-leaf growth stage. Assessments included ryegrass control (reduction in plant and seed set), crop establishment, grain yield and quality.

*Table 1 Pre-emergent herbicide treatments evaluated in TOS trial at Roseworthy in 2016*

| Herbicide treatment | Herbicides applied |
|---|---|
| 1 | Nil |
| 2 | Sakura (118 g/ha) pre |
| 3 | Sakura (118 g/ha) + Avadex Xtra (2 L/ha) pre |
| 4 | Sakura (118 g/ha) pre + *Boxer Gold (2.5 L/ha) post |
| 5 | Boxer Gold (2.5 L/ha) pre |
| 6 | Boxer Gold (2.5 L/ha) + Avadex Xtra (2 L/ha) pre |

**POST Boxer Gold applied to crop at 2-leaf growth stage*

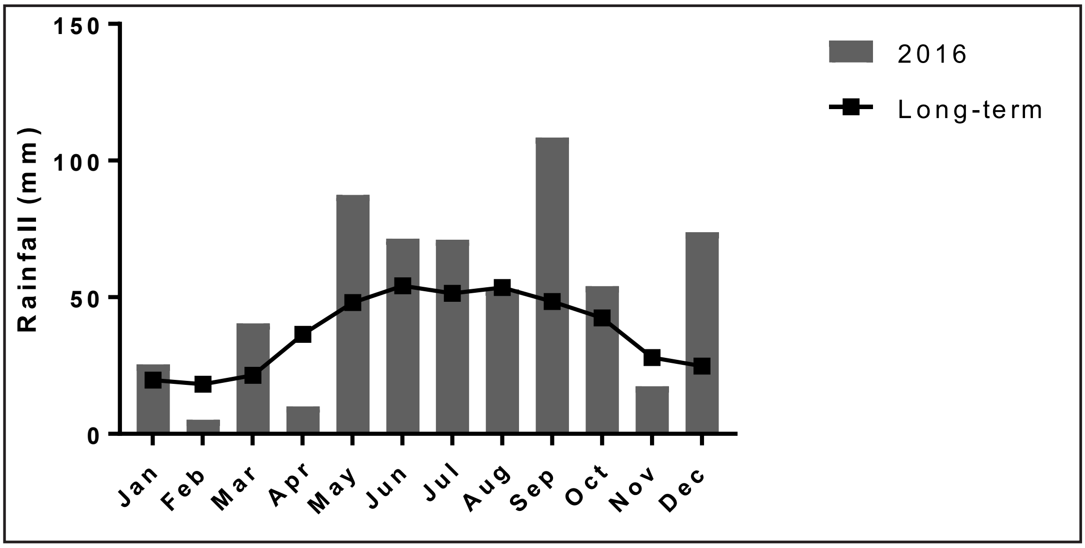



***Figure 1 Long-term and monthly total rainfall at Roseworthy in 2016***

## What happened?

The late break to the 2016 season meant soil moisture and rainfall conditions were very different between the two times of sowing; soil was dry prior to TOS1 (6 mm) relative to TOS2 (51 mm; Figure 1). There was a significant effect of herbicide ($P<0.001$), but not TOS or its interaction with herbicide on ryegrass numbers (Table 2). The dry conditions for TOS1 did not suit Boxer Gold which provided only 66% control as compared with 95% for Sakura + Avadex Xtra. Sakura + Avadex Xtra provided similar high level of control for TOS2 (96%), however Boxer Gold performed much better (84%). The improvement in control with Boxer Gold for TOS2 (84%) over TOS1 (66%) was entirely moisture driven with the damper conditions most likely improving incorporation and uptake of the herbicide.

The addition of Avadex Xtra to Sakura provided a 7 to 18% improvement in ryegrass control compared to Sakura alone. Absorption of Avadex primarily occurs through the base of the coleoptile (mesocotyl), whereas Sakura is predominately absorbed via the roots. Consequently Avadex may assist in the control of ryegrass emerging from deeper layers of soil. By contrast, addition of Avadex to Boxer Gold resulted in little or no improvement in control.

In this season delayed sowing appears to have provided no advantage over the earlier time of sowing in reducing ryegrass (Table 2). Control with knockdown herbicides was limited because of the late break, and most ryegrass germinated directly after sowing regardless of sowing time. Consequently ryegrass was found in wheat at similar densities in the control plots for both delayed (374 plants/m$^2$) and early time of sowing treatments (341 plants/m$^2$).

Even though some herbicide treatments had slightly higher weed density in TOS1, greater crop competition with the early sown wheat had a profound effect on suppressing weed seed production (Table 3). In response there was a significant effect ($P<0.05$) of both herbicide, TOS, and their interaction on ryegrass spike density. This was clearly evident in the untreated control where ryegrass spike density was nearly 2-fold higher for T0S2 (685 spikes/m$^2$) than TOS1 (347 spikes/m$^2$). Furthermore the combination of reduced crop competition coupled with the above average rainfall received in spring (Figure 1) allowed the ryegrass to flourish, resulting in significant seed production in TOS2.

***Table 2 Influence of TOS and herbicide treatment on annual ryegrass density in Mace wheat at Roseworthy in 2016***

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | Mean |
|---|---|---|---|---|---|---|---|
| | Ryegrass density (plants/m$^2$) | | | | | | |
| **TOS1** | 341 | 77 | 18 | 49 | 116 | 94 | 116 |
| **TOS2** | 374 | 40 | 13 | 12 | 60 | 89 | 98 |
| **Mean** | 357 | 58 | 15 | 31 | 88 | 92 | |
| ***Interaction*** | *0.97* | | | | | | |
| ***TOS*** | *0.60* | | | | | | |
| ***Herbicide treatment*** | *<0.001* | | | | | | |

***Table 3 Influence of TOS and herbicide treatment on annual ryegrass spike density in Mace wheat at Roseworthy in 2016***

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | Mean |
|---|---|---|---|---|---|---|---|
| | Ryegrass spikes (spikes/m²) | | | | | | |
| **TOS1** | 347 | 60 | 4 | 32 | 116 | 61 | 103 |
| **TOS2** | 685 | 71 | 21 | 23 | 112 | 167 | 180 |
| **Mean** | 516 | 65 | 13 | 28 | 114 | 114 | |
| ***Interaction*** | *<0.001* | | | | | | |
| ***TOS*** | *<0.05* | | | | | | |
| ***Herbicide treatment*** | *<0.001* | | | | | | |

Regardless of herbicide treatment there was a strong linear relationship between ryegrass plant and spike density for TOS1 ($r^2$=0.977) and TOS2 ($r^2$=0.999; Figure 2). The relationship provided further evidence of increased seed production with TOS2, with the slope of the relationship indicating that ryegrass on average produced two spikes per plant under TOS2, relative to a single spike per plant for TOS1. Ryegrass is well known for its ability to exploit favourable conditions during reproductive development, allowing it to produce large amounts of seed and rapidly build-up infestations from low levels. A significant increase in the size of the ryegrass seedbank would be expected following the delayed sowing treatment, making longer-term management more difficult and subsequent crop choices even more important.

There were significant differences (<0.001) between herbicide treatments, TOS and their interaction in wheat grain yield (Table 4), which was related to weed density and spring rainfall. Crop response to weed control is not surprising as ryegrass can be a highly competitive weed of wheat at high infestations. A strong linear relationship between ryegrass plant and spike density and the grain yield of wheat demonstrated the interference of ryegrass with wheat (Figure 3a & 3b). Grain yield was significantly (P<0.001) greater in early sown plots (TOS1) treated with herbicide mixtures of Sakura + Avadex Xtra (7.55 t/ha), Sakura + POST Boxer Gold (7.13 t/ha), and Boxer Gold + Avadex Xtra (7.47 t/ha) as compared to the untreated control (5.74 t/ha). Whilst Sakura + Avadex Xtra also provided highest grain yield for TOS2 (8.82 t/ha), Sakura (8.77 t/ha) and Boxer Gold (8.51 t/ha) treatments also performed well relative to the control (4.82 t/ha).

Even though weed interference appeared greater for the delayed time of sowing (TOS2), this treatment on average nearly outperformed TOS1 by as much as a tonne to the hectare (7.90 vs 7.03 t/ha; Table 4). This result is in response to above average rainfall in late spring (Figure 1), whereby the late sown wheat was able to capitalise on the longer growing season to produce much higher yield outcomes than the earlier maturing wheat under TOS1. The earlier sown wheat was also more vulnerable to frost events, which may have also negatively impacted yield.



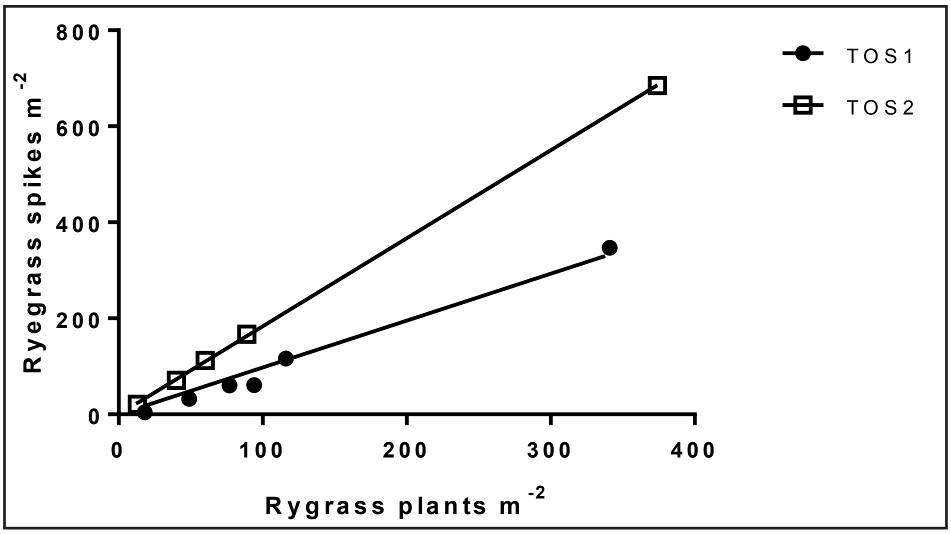



***Figure 2 Relationship between mean plant density and mean panicle density of ryegrass across herbicide treatments applied to early (TOS1; $r^2$=0.977) and delayed sown wheat (TOS2; $r^2$=0.999) at Roseworthy in 2016***

*Table 4 Influence of TOS and herbicide treatment on grain yield of Mace wheat at Roseworthy in 2016*

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | Mean |
|---|---|---|---|---|---|---|---|
| | Grain yield (t/ha) | | | | | | |
| TOS1 | 5.74 | 7.34 | 7.55 | 7.13 | 6.96 | 7.47 | 7.03 |
| TOS2 | 4.82 | 8.77 | 8.82 | 8.74 | 8.51 | 7.77 | 7.90 |
| Mean | 5.28 | 8.05 | 8.18 | 7.94 | 7.73 | 7.62 | |
| *Interaction* | *<0.001* | | | | | | |
| *TOS* | *<0.001* | | | | | | |
| *Herbicide treatment* | *<0.001* | | | | | | |

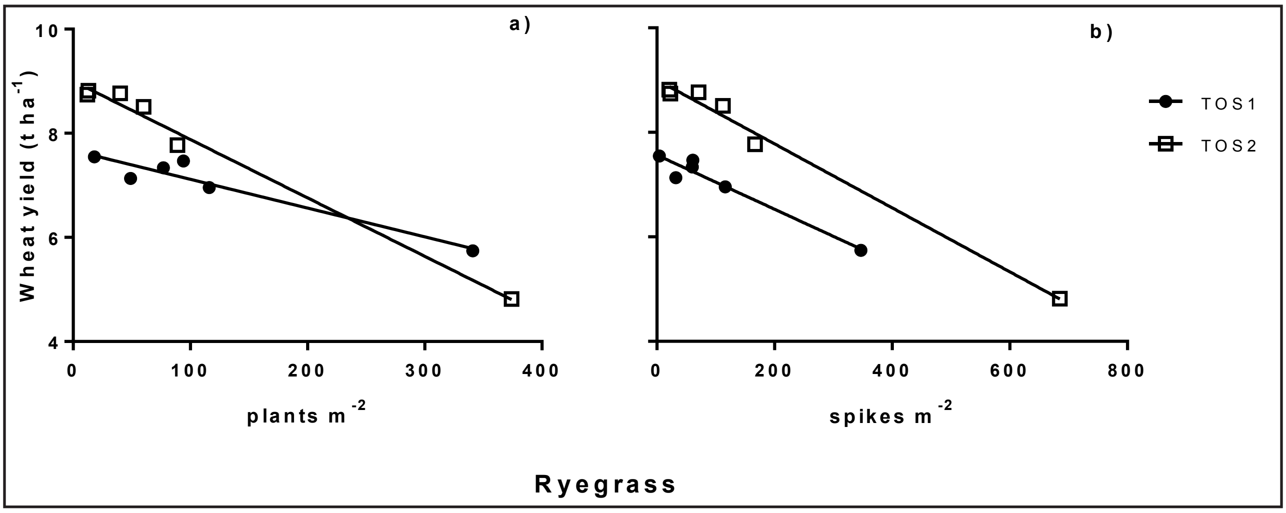



***Figure 3 Effect of plant (a) and spike (b) density of ryegrass on grain yield of early (TOS1) and delayed sown wheat (TOS2) at Roseworthy in 2016***
*Each data point represents the mean of 4 replicates*

The yield response could have been somewhat different had the finish to the season been early as in recent years, with the early sown wheat expected to outperform the delayed, in part from improved crop competition (i.e. reduced weed pressure) but also because the crop could flower during a more optimal period for yield.

## What does this mean?

The results from this study have shown that last season delayed sowing appears to have provided no advantage over the earlier sowing time in reducing ryegrass, moreover ryegrass seed production was two-fold higher for delayed compared to early sown wheat. A result in part because of reduced crop competition from the delayed sown wheat, but also due to the above average spring rainfall which ryegrass could exploit.

Importantly the performance of the different pre-emergent herbicides and their mixtures against ryegrass were not compromised by time of sowing with Sakura + Avadex Xtra providing >90% control.

Even though weed interference appeared greater for delayed sown wheat this was not entirely reflected in grain yield between the two times of sowing. The delayed sown wheat also appeared to capitalise on the protracted growing season to produce significantly more grain than the earlier sown crop.

## Acknowledgments


We are grateful to GRDC (Grains Research and Development Corporation) for project funding (project UCS00020) and Jerome Martin for providing technical assistance.

Avadex Xtra – registered trademark of Nufarm Technologies USA Pty. Ltd.

Boxer Gold – registered trademark of Syngenta Australia Pty. Ltd.

Sakura – registered trademark of Bayer Crop Science Australia Pty. Ltd.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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Section Editor:
**Brian Dzoma**
SARDI, Minnipa Agricultural Centre

# Livestock

## The impact of livestock on paddock health: nine-year enterprise summary

**Jessica Crettenden**
SARDI, Minnipa Agricultural Centre

RESEARCH

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**Location:** Minnipa Agricultural Centre, paddock S7
**Rainfall**
Av Annual: 325 mm
Av GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Paddock History**
2015: Medic pasture
2014: Wheat
2013: Wheat
**Soil Type**
Red sandy loam
**Soil Test**
Organic C%: 1.05
Phosphorous: 23 - 28 mg/kg
**Plot Size**
3.5ha
**Livestock**
Enterprise type: Self-replacing merinos
Stocking rate: Rotational grazing and district practice

### Key messages

- **Over nine seasons, incorporating livestock into the rotation improved overall system outcomes in this trial, including; increased nitrogen cycling and water use efficiency, reduction in weed and pest populations and no negative effects on cereal performance or soil health, while value adding to stubble and pastures by grazing.**
- **The high input grazed farming system had a gross margin of over $100/ha/year more than lower input and ungrazed treatments over the nine-year trial period.**

### Why do the trial?

Mixed livestock and cropping systems have an important role to play in the diversification, risk management and sustainability of farming in low rainfall areas. The majority of farms in these areas use livestock to provide enterprise diversity and risk management, however grazing also offers a range of other system benefits that are generally not accounted for in mixed farming enterprises. As a result of increasing cropping intensity in these systems, there is a perception of declining productivity of the pasture phase, with pastures remaining largely unimproved and most farming systems continuing to rely on self-regenerating medic for livestock feed and nitrogen (N). Pastures in these lower input mixed farming systems are generally set stocked and grazed at low stocking rates throughout the season with minimal effort to manage grazing for optimal production. Farmers are hesitant to increase grazing in the break phase of the rotation partly due to the perception that livestock can damage soil health, remove organic matter and induce weed germination, but also because their efforts are often concentrated on the cropping enterprise due to the income it brings into the business. With prices for livestock (both meat and wool) increasing over the past decade, and the valuable nutrition and disease break effect that the pasture phase provides to subsequent cereal crops, interest in the productivity and profitability of medic and livestock systems has increased.

A long-term study was established at the Minnipa Agricultural Centre from 2008 to 2016 (EPFS Summaries 2008 to 2015) to assess the systems impact of grazing on crop and pasture production, and soil health. The nine-year broad acre demonstration with a wheat-medic rotation (Table 1) also tested whether productivity could be improved under a higher input system (e.g. higher fertiliser and seeding rates, establishment of improved pasture) compared to a lower input and more traditional system (district practice seed and fertiliser inputs, volunteer pasture), and what effect this had on soil fertility.

*Table 1 Trial Treatments over the nine-year trial period (2008-2016) in paddock S7, Minnipa*

| Year | Low input (grazed) | Low input (ungrazed) | High input (grazed) | High input (ungrazed) |
|---|---|---|---|---|
| **2008** | Wheat sown @ 50 kg/ha + 45 kg/ha DAP<br>Paddock not yet grazed | | Wheat sown @ 70 kg/ha + 60 kg/ha DAP + 67.5 kg/ha ammonium sulphate | |
| **2009** | Wheat sown @ 50 kg/ha + 45 kg/ha DAP<br>Paddock not yet grazed | | Wheat sown @ 70 kg/ha + 60 kg/ha DAP + 67.5 kg/ha ammonium sulphate | |
| **2010** | **1070 DSE grazing days** | No treatment | Medic sown @ 5 kg/ha with 30 kg/ha DAP **2900 DSE grazing days** | Medic sown @ 5 kg/ha with 30 kg/ha DAP |
| **2011** | Wheat sown @ 50 kg/ha + 40 kg/ha DAP **30 DSE grazing days** | Wheat sown @ 50 kg/ha + 40 kg/ha DAP | Wheat sown @ 70 kg/ha + 60 kg/ha DAP **166 DSE grazing days** | Wheat sown @ 70 kg/ha + 60 kg/ha DAP |
| **2012** | **242 DSE grazing days** | No treatment | **521 DSE grazing days** | No treatment |
| **2013** | Wheat sown @ 50 kg/ha + 40 kg/ha DAP | | Wheat sown @ 70 kg/ha + 60 kg/ha DAP | |
| **2014** | Wheat sown @ 50 kg/ha + 40 kg/ha DAP **324 DSE grazing days** | Wheat sown @ 50 kg/ha + 40 kg/ha DAP | Wheat sown @ 70 kg/ha + 60 kg/ha DAP **312 DSE grazing days** | Wheat sown @ 70 kg/ha + 60 kg/ha DAP |
| **2015** | **637 DSE grazing days** | No treatment | 100 kg/ha DAP broadcast **1333 DSE grazing days** | 100 kg/ha DAP broadcast |
| **2016** | Wheat sown @ 50 kg/ha + 40 kg/ha DAP | | Wheat sown @ 70 kg/ha + 60 kg/ha DAP | |

**DSE grazing days describes the number of grazing days per dry sheep equivalent per treatment area*

## How was it done?

In 2008, a 14 ha red sandy loam portion of a paddock on Minnipa Agricultural Centre was divided into four 3.5 ha sections. Each section represented a system treatment: Low input - grazed, Low input – ungrazed, High input – grazed and High input – ungrazed. The pasture and grazing treatments were not imposed until 2010. Four sampling points were selected and marked as permanent sampling points in each section. Data presented for each treatment are a mean of the four selected permanent points in each section. Table 1 describes the treatments for each section over the period of the trial. More detailed treatment information can be found in EPFS Summaries 2008-2015.

A basic economic analysis was undertaken to assess gross margins of the four systems over the period of the trial, taking into account price and market differences from 2008 to 2016. The gross margin calculator tool is available on the Grain and Graze 3 website[1].

## What happened?

### *Production results*

Table 2 presents the averages of production and soil measurements over the nine-year duration of the trial. The higher input system produced 1.25 t DM/ha more medic biomass overall in the pasture phase of the rotation (2010, 2012 and 2015) and grazing reduced total biomass by 0.25 t DM/ha on average. The grazed systems carried a total of 2303 and 5232 DSE grazing days in the low input and high input systems respectively during the three years of medic pasture and grazing wheat stubbles over the summer/autumn period. The higher input systems had 0.5 t/ha greater wheat grain yield than the lower input system and the grazed systems had 0.1 t/ha more grain yield on average. Total mineral N was similar for high and low input systems, however the grazed systems had considerably more soil N on average (17 and 13 kg N/ha greater in the low and high input treatments respectively). There was an average of 11 mg/kg more extractable phosphorous in the low input system, compared to the high input treatments. Soil organic carbon remained steady throughout the lifetime of the trial, with similar results across all treatments.

***Table 2 Averages of production and soil measurements over the period of the trial (2008-2016)***

| Paddock treatment | Pasture biomass (t DM/ha) | Grain yield (t/ha) | WUE (kg/ha/mm) | Total mineral N 0-60 cm (kg/ha) | Colwell P (mg/kg) | Soil organic carbon (%) | DSE grazing days Total (average) |
|---|---|---|---|---|---|---|---|
| Low input (grazed) | 3.4 | 2.3 | 19.0 | 83 | 31 | 1.2 | 2303<br>(2.1 DSE/ha av.) |
| Low input (ungrazed) | 3.8 | 2.2 | 16.2 | 66 | 27 | 1.1 | |
| High input (grazed) | 4.8 | 2.8 | 22.3 | 81 | 21 | 1.1 | 5232<br>(4.9 DSE/ha av.) |
| High input (ungrazed) | 4.9 | 2.7 | 20.2 | 68 | 26 | 1.1 | |

There were several production influences in grazed treatments that may have had an effect on the overall farming system within each treatment, which were observed but not adequately measured over the period of the trial. Grazed treatments appeared to have lower snail and mice populations, increased ground cover outside of the growing season and reduced summer weed height and density.

### *Economic analysis*

A basic economic analysis of the study (Table 3) showed that over nine years, grazing contributed $328/ha to the low input treatment and $725/ha to the high input treatment. $274 and $651 of this was attributed to grazing medic in the pasture phases, with the remainder attributed to grazing the wheat stubbles over summer/autumn in the low and high input grazed systems respectively. The cost of improving pastures in the high input systems (seed and fertiliser application in 2010, and fertiliser application in 2015) was $99/ha in total. However the grazed high input system was able to offset these costs through the extra livestock production value, and achieved a total profit of $524/ha compared with the ungrazed high input system with a $127/ha loss for the pasture phase years. The low input system had minimal costs in the pasture phase years (only herbicide application) - the ungrazed low input system made a $66/ha loss in total, while the low input grazed system off-set these costs by grazing livestock, making a total profit of $208/ha.

***Table 3 Gross margin ($/ha) for the different input treatments in the nine-year trial[1]***

| | | Gross Margin ($/ha) – crop and sheep enterprises | | | |
|---|---|---|---|---|---|
| **Year** | **Crop/pasture** | **Low input (grazed)** | **Low input (ungrazed)** | **High input (grazed)** | **High input (ungrazed)** |
| **2008** | Wheat | -49 | -49 | -42 | -42 |
| **2009** | Wheat | 803 | 829 | 905 | 879 |
| **2010** | Medic | 96 | -23 | 284 | -39 |
| **2011** | Wheat | 362 | 284 | 465 | 366 |
| **2012** | Medic | 26 | -27 | 89 | -27 |
| **2013** | Wheat | 356 | 332 | 464 | 390 |
| **2014** | Wheat | 598 | 525 | 749 | 677 |
| **2015** | Medic | 86 | -15 | 151 | -60 |
| **2016** | Wheat | 372 | 339 | 490 | 490 |
| **Total** | **$/ha** | **2651** | **2194** | **3556** | **2635** |
| **Average** | **$/ha** | **295** | **244** | **395** | **293** |

Lower sowing rates and fertiliser inputs in the low input system meant that total costs for the cropping operations for the six wheat production years (2008, 2009, 2011, 2013, 2014 and 2016) were only $2451/ha, compared with the high input systems total costs of $2845/ha. The high input systems managed to compensate these costs through increased yield with a total $5719/ha profit compared to the low input system with $4647/ha profit in total over the six years.

Over the nine years, taking into account both the cropping and livestock systems, the average gross margin of each treatment was $295, $244, $395 and $293 in the low input (grazed), low input (ungrazed), high input (grazed) and high input (ungrazed) systems respectively. This means that running sheep added a $51/ha profit per annum to the conventional (low) input, ungrazed system, while adding higher inputs earnt an extra $49/ha. Including both sheep and higher inputs to the conventional system earnt an extra $155/ha.

## What does this mean?

The nine-year period of this study began with a severe drought in 2008, followed by 6 years of average to above average rainfall seasons (2009-2011 and 2014-2016) and the two seasons in 2012 and 2013 slightly below average growing season rainfall. The trial showed that over a range of seasons, integrating livestock grazing into a cropping system improved productivity and profitability, particularly in higher input farming systems, with no apparent negative effect on soil or system health.

Diversification into sheep can assist growers to better manage their risk, by reducing the effects caused by seasonal and grain market variability, and help reduce the levels of diseases and pests. Livestock are also a reliable source of income in years when yields or grain prices are low, and are recently proving they are as profitable as cropping gross margins even in average years.

The high input system carried over twice the stocking rate as the low input system over the trial period and was more productive in both the cropping and pasture rotations. This indicates that increased inputs into low rainfall mixed farming systems could be more productive and lucrative than they are currently on Eyre Peninsula. The decision to increase input rate and subsequent costs will however depend on the farmers attitude to risk and whether their business can cope with extra input costs if the season is unfavourable, and for how many seasons, versus having a system set up to capitalise better on a good year. Maintaining a degree of flexibility to respond to seasons (e.g. top-dress nitrogen, graze a crop) and markets (keep more ewe lambs, or feed grain to stock) is a strategy to reduce risk. Decisions must be made early to optimise the outcome, before prices change or an opportunity is missed.

## Acknowledgements

I gratefully acknowledge the help of Jake Hull, Wade Shepperd and John Kelsh for site management and Ian Richter, Sue Budarick and Brett Hay for data collection. I would also like to thank Barry Mudge with his assistance in the basic economic analysis of the trial. The Eyre Peninsula Grain and Graze 3 project is funded by GRDC (SFS00028).

[1]The basic economic analysis for cropping systems was undertaken using the *PIRSA Gross Margin Calculator* developed by Barry Mudge and funded by SAGIT in conjunction with Rural Solutions SA and GRDC. The livestock *Gross Margin Calculator* was partially funded by Grain and Graze 3. Both calculators will be available as free downloads from the PIRSA, GRDC and SAGIT websites, and the livestock calculator will be available on the Grain and Graze 3 website www.grainandgraze3.com.au

# The mechanisms that lead to yield loss after grazing across agro-ecological zones

RESEARCH

**Jessica Crettenden**
SARDI, Minnipa Agricultural Centre

**Searching for answers**

**Location:** Minnipa Agricultural Centre, paddock North 5 South
**Rainfall**
Av Annual: 325 mm
Av GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 3.6 t/ha (W)
Actual: 3.7 t/ha (W)
Potential: 4.0 t/ha (B)
Actual: 4.1 t/ha (B)
**Paddock History**
2015: Medic pasture
2014: Barley
2013: Wheat
**Soil Type**
Red sandy loam
**Soil Test**
Organic C%: 0.7
Phosphorous: 2 - 19 mg/kg
Nitrogen: 5 - 48 mg/kg
**Plot Size**
20 m x 24 m x 3 reps
**Livestock**
Simulated grazing

## Key messages

- **Ideal growing season conditions in 2016 provided an example of how grazing winter crops can be utilised as a tool, without significant consequence, as an early feed source for livestock in mixed farming systems of southern Australia.**
- **The value of grazing crops to the whole mixed farming system is important, as the combination of grazing and grain production may increase overall farm profitability through more productive use of farming land for both enterprises, however other flow on effects to the system can be challenging to quantify.**

## Why do the trial?

The practice of grazing winter crops is often used in mixed farming systems as an opportunistic feed source rather than a regular annual feed supply, thus suitable cereal varieties have habitually been referred to as 'dual purpose', signifying their fit for both grazing and grain uses. Varieties that have been bred to remain in a vegetative stage for a long period after sowing and that have a vernalization requirement (need for exposure to cold temperatures to trigger commencement of head development, described as having a 'winter habit'), are commonly labelled as dual purpose due to their longer growth habit, facilitating the successful recovery of the crop after grazing. Long season spring wheats, which do not have a vernalisation requirement, but mature later anyway, have also commonly been used for grazing.

However, because of the progress towards earlier sowing in our modern farming systems, with longer season wheat and barley varieties being bred to adjust to this expansion in the growing season, cultivars that have not traditionally been considered as dual purpose are proving their suitability for grazing over winter, and allowed to recover for hay, silage or grain production. This development is significant for growers in southern Australia, as research into the dual purpose fit of common grain varieties in the region's mixed farming systems is proving the potential. Just because a plant does not have winter habit does not mean it cannot be grazed and then recover successfully, though the opportunity to graze is usually reduced and the time when the plant changes from vegetative growth is less predictable depending on its innate 'earliness' and the presence of photoperiod or minor vernalisation genes.

Regardless of vernalisation requirement, wheat and barley varieties respond differently to stresses (such as grazing) due to genetic and phenological variances. Grazing has five main impacts on a growing crop being; a reduction in crop biomass, later phenological development, reduced photosynthetic area, changed leaf architecture and canopy development and changed root system. In addition, there can be impacts on foliar disease by ingesting leaf material. For this reason, a trial was undertaken at the Minnipa Agricultural Centre to determine the grain yield recovery potential of common wheat and barley varieties and if there are genetic differences in the way varieties respond after grazing, other than simple phenology. Whether nitrogen is able to assist in grazing recovery because it is highly correlated to biomass production will be investigated through yield and/or protein of grain as the determinants.

Similar trials, with some variations including irrigation and drought simulation treatments, have been undertaken as part of the Grain and Graze 3 project in 2015 (EPFS Summary 2015, p 43-45) and 2016 across three other sites in the mid-north region of South Australia, near Birchip in the mallee region of Victoria and in Southern Victoria to determine regional and seasonal differences.

## How was it done?

Soil was sampled for pre-sowing soil water content and chemical analysis on 4 May. The trial was sown on 16 May after 20 mm of rain with a pre-emergent herbicide mix of 1.5 L/ha DST + 60 ml/ha Hammer + 1.6 L/ha Avadex Xtra + 25 L/ha Boxer Gold + 800 g/100 L SOA + 500 ml/100 LI 700 sprayed prior to sowing. Wheat varieties Mace, Trojan and new AGT variety RAC2341, in addition to barley varieties Spartacus CL and Compass were sown @ 50 kg/ha with 57 kg/ha DAP (18:20:0:0). An insecticide and fungicide treatment of 350 ml/ha LeMat + 400 ml/ha Prosaro was applied for red-legged earth mite, aphids and leaf rust on 7 June and 1 L/ha Broadstrike was applied on 27 June to control broadleaved plants. Plant counts were recorded on 14 June. Biomass cuts were taken prior to a single simulated grazing (one mowing), which occurred on half of all plots on 15 July when plants were approaching GS30.

Nitrogen treatments were applied to the trial on the 9 August just prior to 8 mm of rain as 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 un-grazed sections of each plot. Flowering scores were recorded on 22 and 27 September. Yields and grain quality were recorded at harvest, which occurred on 18 and 23 November for the barley and wheat respectively.

## What happened?

Growing conditions were very favorable leading up to the simulated grazing with 113 mm of rainfall since sowing, producing 1.45 t/ha and 0.85 t/ha of biomass available for grazing in the barley and wheat respectively (Table 1).

***Barley (Compass and Spartacus comparison)***

The percentage of protein in the barley sample increased with the greater nitrogen (N) treatment with an average of 0.8% higher protein content in the 50 and 75 kg N/ha treatments compared to the lower N treatments ($P < 0.001$, LSD=0.43, results not presented). Spartacus CL had higher protein and test weight, while Compass recorded an average of 6.4% higher 1000 grain weight across all treatments (Table 1). Screenings were higher in the grazed compared to the un-grazed barley at 3.8% and 2.6% respectively ($P < 0.001$, LSD=0.6, results not presented). Figure 1 shows that Compass had 0.3 t/ha greater yield after grazing, compared to Spartacus CL, which lost 0.1 t/ha on average after grazing (P=0.004, LSD=0.21), with no yield differences between N treatments. All grazed and un-grazed grain from both barley varieties were classified as Feed 1 under the Viterra Classification system.

***Wheat (Mace, Trojan and RAC2341 comparison)***

There was a greater percentage of protein in un-grazed (12.0%) compared to grazed (11.8%) wheat across all varieties (P=0.008, LSD=0.11) and a trend of increasing protein with increasing rates of N applied after grazing, with an average of 11.7% (0, 10 and 25 kg/ha N), 11.9% (50 kg N/ha) and 12.2% (75 kg N/ha) ($P < 0.001$, LSD=0.18, results not presented). Grazing resulted in higher screenings compared to the un-grazed treatments with 1.9% and 1.7% respectively (P=0.004, LSD=0.1). Trojan wheat recovered best after grazing, yielding 0.15 t/ha higher than the un-grazed treatment, followed by RAC2341 yielding 0.05 t/ha higher and Mace lost 0.29 t/ha on average due to grazing (P=0.004, LSD=0.19). Figure 1 shows yields for Trojan and Mace were higher than that of RAC2341, regardless of grazing or N treatment.

***Table 1 Biomass, yield and grain quality results for the wheat and barley varieties***

| | Biomass (t/ha) | Yield (t/ha) | Protein (%) | Screenings (%) | Test weight (kg/hL) | 1000 grain weight (g) |
|---|---|---|---|---|---|---|
| Compass | 1.6 | 4.2 | 12.5 | 2.7 | 66 | 32.1 |
| Spartacus CL | 1.3 | 4.1 | 13.3 | 3.6 | 68 | 25.7 |
| *LSD (P<0.05)* | *0.14* | *ns* | *0.27* | *0.60* | *0.72* | *4.02* |
| Mace | 0.9 | 3.8 | 11.2 | 1.9 | 79 | 35.7 |
| Trojan | 0.9 | 4.0 | 11.8 | 1.9 | 81 | 38.5 |
| RAC2341 | 0.7 | 3.3 | 12.8 | 1.6 | 76 | 35.2 |
| *LSD (P<0.05)* | *0.08* | *0.13* | *0.14* | *0.13* | *0.52* | *1.11* |

**LSDs presented are for varietal comparisons between barley cultivars and wheat cultivars as displayed*

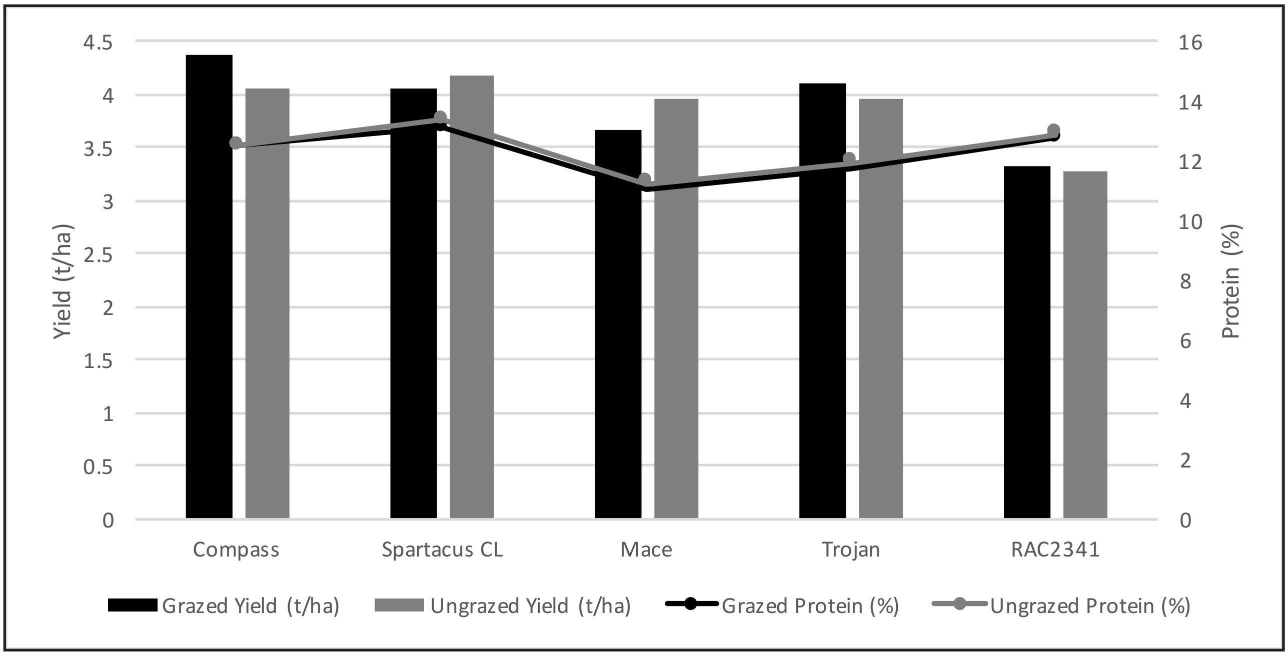


***Figure 1 Yield (t/ha) and protein (%) response to grazing across two barley and three wheat varieties in 2016***

## What does this mean?

Ideal growing season conditions in 2016 proved that grazing winter cereal crops can be utilised as an early feed source for livestock in mixed farming systems of southern Australia, without significant grain yield loss. Good seasonal conditions meant yield penalties were minimal or that yield actually increased due to grazing and there was no significant downgrading of grain quality in this trial.

In a highly productive year such as 2016, grazing crops can have a multitude of benefits to the cropping system that may not be realised until harvest. Benefits to the cropping system can include; enabling excessive crop canopies to be managed, reducing possible lodging, incidence of disease and future stubble loads, conserving soil moisture to be utilized by the crop later in the year and delaying maturity which may avoid frosts. Winter crops can offer high quality feed which is equivalent or higher than typical pastures at the same time of year, in particular, the early vegetative stage of crop growth offers superior digestibility, metabolisable energy and protein when compared to grazing cereals later in the season. Autumn sown cereals produce high quantities of dry matter very soon after establishment when compared to many other pasture species.

There are also potential downsides and risks of grazing crops, including; the possibility of reducing grain yield and grain quality, uneven grazing which may lead to variable crop maturity, possibility of increased weed populations, delayed maturity which may expose the crop to heat stress and reduction of stubble remaining after harvest.

Reducing crop canopy can manipulate cereal production by changing the phenology and physiology of the crop, in particular delaying flowering, which may reduce the risk of the cropping program to the threat of frost. Newer varieties such as Trojan and RAC2341 that have been bred to remain in a vegetative stage for a longer period after sowing, have opened up an opportunity for growers to sow earlier with the possibility of an early graze if conditions are favourable. Understanding crop development, and how different varieties respond to stress plays a key role in the success or failure of utilising cereal crops as a dual purpose option. Unfortunately for ease of analysis in replicated trials across regions and across years, recommended sowing and grazing times are not always achievable for every variety in a trial. Knowing that grazing is planned provides the opportunity to sow commercial varieties earlier than would otherwise be normal practice.

The practice of grazing crops should be utilised as another tool for farmers to manage risk in mixed farming systems, as good growing seasons cannot be predicted. The combination of large amounts of early biomass production and the ability to fill feed gaps and still leave an opportunity to harvest grain can increase whole farm profit. Our limited research has shown that a moderate application of nitrogen after grazing should assist in crop recovery after grazing, however more investigation is required to determine the optimal amount due to variable responses in grain yield and quality across regions, seasons, cereal varieties and treatments. We aim to undertake an across-site and across-year analysis of the Grain and Graze 3 project data in order to gain a clearer understanding of varietal response to grazing and the impact of nitrogen in crop recovery.

The value of grazing crops to the whole mixed farming system is important, as the combination of grazing and grain production may increase overall farm profitability. Flow on effects or system impacts can be challenging to quantify, as they are not immediate, enterprise specific or necessarily measureable from either a production or economic perspective. Often system benefits, and downsides, need to be considered for individual farms to help calculate the financial implications to the whole system. Previous articles about grazing crops have highlighted the outcomes of grazing at a time of year when there may be a feed gap and have shown how this strategically benefits the livestock enterprise. It is important to note that grain yield loss doesn't always occur, and that the value of grazing should be valued, both economically and in a systems context in the cropping portion of a 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. I appreciate AGT for allowing the use of their new wheat variety RAC2341 in the trial before official release. 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).

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# Keeping livestock productive on crop stubbles

RESEARCH

**Alison Frischke[1] and Jessica Crettenden[2]**

[1]Birchip Cropping Group, Victoria, [2]SARDI, Minnipa Agricultural Centre


**Location:**
Southern Australia
Grain & Graze

## Key messages

- **Feed value will vary across a paddock and is difficult to measure.**
- **Feed quality is determined by the amount of residual grain and green plant growth.**
- **A guide for a productive stubble is one with at least 40 kg/ha of grain or green shoots, but condition scoring or weighing animals is most accurate.**

## Why do the trial?

Crop stubbles are an important feed source for livestock over the summer/autumn months in mixed farming enterprises. They are available when green pasture is scarce and are used to reduce high stubble loads for better establishment of subsequent crops.

Numerous studies across Australia have shown that lightly grazing stubbles will not compromise a cropping system, with no negative impacts to soil health or subsequent crop yields, so long as sufficient stubble (50-70% ground cover) is retained to prevent wind erosion and maintain water infiltration.

## How was it done?

The GRDC-funded ‘Grain & Graze 3’ program included a project monitoring cereal and pulse stubbles across south east Australia, including at Minnipa, and measured the feed quality of a range of crops.

***What is the grazing value of stubble?***

Stubble quality can vary between crops and seasons and can change quickly across a paddock, particularly once grazing commences or after summer rain. The value of feed is determined by the amount of residual grain and green plant growth present, including summer weeds and shot grain. The efficiency of modern harvesting methods and better weed control means there is now less grain and fewer weeds left in stubbles than 25 years ago.

Digestibility is the main factor that determines feed intake and the energy of that feed. Sheep and cattle will eat the most digestible feed first (grain and green) and leave the least digestible (straw) until last. Grains such as barley or lupins are 80-90% digestible and provide a high energy diet, whereas straw and trash have generally lower digestibility (35-55%) and provide less energy.

Protein is also very important with higher requirements during late pregnancy and lactation, and is necessary for good liveweight and wool growth rates. Cereal grains generally contain between 8-15% protein, and legume grains 20-36% protein. However, straw contains less than 5% protein which is too low to sustain sufficient microbial growth in the rumen and may restrict fibre digestion, so an additional source of protein is generally needed.

A feed test will accurately measure the nutrient level of your grain and stubble components. Research carried out as part of the Grain & Graze initiative measured the feed quality of a range of crops across south eastern Australia to determine the average value of crop components (Table 1).

Using feed tests, you can deduce whether stock are getting the nutrients they need according to their respective class (Table 2).

## What happened?

***Estimating feed value***

Monitoring of stock and the paddock condition will prevent a setback in production, which takes time and resources to recover. However, the feed value of stubbles is variable and can be difficult to measure accurately. Recording liveweight and condition score will give you the best measure of livestock wellbeing, where stock must be maintaining or increasing weight. The logistics of collecting liveweight is currently labour intensive for most people, particularly on extensive properties, but innovations are developing such as walk-over-weighing and the use of GPS tracking technology to monitor livestock behaviour which could indicate a change in weight and available feed.

Livestock may begin to lose weight on a stubble paddock by, if not before, six weeks of grazing, depending on type of stubble, season, paddock size and the stocking pressure (number and class of animal).

*Table 1 Average feed value of crop components*

| Feed Value | Wheat & Barley stubble | | | | Oats | Lentils | |
|---|---|---|---|---|---|---|---|
| | *Grain* | *Green* | *Straw* | *Loose trash* | *Grain* | *Grain* | *Straw* |
| **Digestibility DMD (%DM)** | 82-87 | 59-73 | 38-40 | 40-41 | | 92 | 36 |
| **Metabolisable energy (MJ/kg DM)** | 12.7-13.2 | 8.5-11.0 | 5.0-5.3 | 5.3 | 9.0-11.0 | 13.1 | 4.6 |
| **Crude protein (%)** | 9.5-13.5 | 15.9-18.7 | 1.2-2.8 | 2.0-4.0 | 6.0-12.0 | 27.5 | 6.7 |

*Source: Grain & Graze, (2004-2007, 2016)*

*Table 2 Nutrient requirements of different sheep classes*

| | Maintenance of 70 kg dry ewe | Lactating 70 kg ewe | | 40 kg weaner lamb | |
|---|---|---|---|---|---|
| | | # of lambs | | Growth rate | |
| | | Single | Twin | 250 g/day | 300 g/day |
| **Daily DM intake (% of liveweight)** | 1.9 | 2.8 | 2.8 | 3.3 | 3.8 |
| **Feed intake (kg/animal/day)** | 1.3 | 2 | 2 | 1.3 | 1.5 |
| **Metabolisable energy (MJ/day)** | 10.3 | 15.7 | 19.8 | 10.6 | 12.3 |
| **Protein (g/day)** | 104 | 229 | 306 | 171 | 199 |

*Source: Adapted from NRC (2007)*

Previous Grain & Graze research in southern Victoria found that cattle lost weight once the grain or green shoots available fell below 40 kg/ha of grain, or 40 kg/ha of green shoots (shot grain and weeds)[1].

To estimate the quantity of useful feed, count the number of grains and green shoots in a 0.1 $m^2$ (32 cm x 32 cm square) quadrat. The approximate calculation for grains is to multiply this number by a factor of 3.2 to get the quantity of grain in kg/ha (e.g. 26 grains/$m^2$ equates to 83 kg/ha) and similarly for green shoots, multiply this number by a factor of 2.9 to get the quantity of dry matter in kg/ha (e.g. 21 shoots/$m^2$ equates to 61 kg/ha).

At Minnipa, a barley, wheat and canola stubble were sampled prior to grazing then regularly over a four-month period. Table 3 shows the quantity and quality measurements of whole stubble samples from the first monitoring on 14 December immediately after harvest. It shows what influence the low quality straw and trash has on overall nutrition. The value of the grain fell within the ranges presented in Table 2, with much higher digestibility, protein and energy. The feed value of the stubbles after 14 December fluctuated, however a common outcome for all stubble types was that quality deteriorated rapidly following summer rainfall. Stubble quantity remained high throughout the sampling period due to low stocking rate and conservative grazing practices.

***How does weather affect the feed value of my stubble?***

Rain during summer and autumn can reduce the digestibility of the stubble, mainly through leaching out the soluble/digestible components of the straw. Over 55 mm of rain in early January 2016 on a barley stubble at Birchip reduced digestibility from 47.5 to 32.6%, and ME from 6.6 to 4.2 MJ/kg of DM. However more importantly, germination of grain and weeds after rain can create very useful feed. For the same barley stubble, while grain on the surface had been eaten, buried grain germinated and provided 70 kg green shoots/ha, which are highly digestible and have high energy value (>11 MJ ME/kg DM) and protein (>25% protein).

Stubbles following a drought, that have hayed off or suffered frost or heat damage, often contain more nutrients than usual. If a crop dies quickly after flowering, less energy and protein can be deposited into grain, so it remains in the stem and leaves, providing more nutrition.

Stubbles after a good season can vary in feed value depending on weather events. If harvest is uneventful weatherwise, crops have less feed value as tall heads are efficiently harvested and less grain is left in the paddock. Stock will quickly graze off any grain in the crop stubble before moving to fence lines searching for other weed seeds. On the other hand, spring rains can induce late tillers that are lower in height and not collected by harvest that will contain feed value. Crops, particularly high yielding crops, may also suffer from windy weather from lodging, cereal head loss or loss of grains such as faba beans, dropping grain to the ground that cannot be picked up at harvest. Take note at harvest to get an indication of how weather has affected the value of your stubbles.

***Managing grazing behaviour on stubbles***

Grazing behaviour on stubbles can be different to that on green feed and depend on the animals. For example, lambs can be hesitant to graze tall stubbles and will circulate the paddock due to inexperience, whereas ewes may want to graze with heads facing into the breeze, or hang around scrub lines, hills and troughs in warmer weather.

*Table 3 Quantity and quality of stubble feed components sampled at Minnipa on 14 December 2015 prior to grazing over 2015/16 summer*

| | Quantity | | | | | Feed quality of whole stubble sample | | | |
|---|---|---|---|---|---|---|---|---|---|
| Stubble type | Trash (t/ha) | Straw (t/ha) | Grain (kg/ha) | Shoots (kg/ha) | Ground cover (%) | Dry matter (%) | Crude protein (%DM) | Digestibility DMD (%DM) | Metabolisable energy (MJ/kg DM) |
| Barley | 1.4 | 2.4 | 65.4 | 7.4 | 82.2 | 89.2 | 2.2 | 47.5 | 6.6 |
| Wheat | 2.8 | 1.6 | 149.5 | 4.6 | 78.3 | 88.3 | 2.6 | 41.0 | 5.4 |
| Canola | 1.8 | 1.8 | 11.8 | 22.9 | 77.8 | 89.5 | 2.7 | 28.3 | 4.1 |

To encourage more even grazing, place water points in central locations as best you can. To reduce selective grazing, trampling and camping, use temporary fencing to create smaller grazing areas, to control stocking pressure and protect erosion-prone areas.

## What does this mean?

***When should stock be supplemented or put into containment?***

Knowing when to move animals from a paddock will depend on ground cover and animal condition. When stubbles are grazed in summer, ewes need to be about condition score 3 for joining, and lambs will be about six months old. It's commonly thought that older sheep will use low quality feed more efficiently than young lambs, but this is not the case – it's because dry, older sheep will have seven to eight times more body fat (energy reserves) than young sheep. A 25 kg weaner has only one kilogram of body fat as an energy store, and can survive less than 10 days on this energy.

Unless sheep are bare shorn, there are no shortcuts to monitoring animal condition. It is best to either condition score sheep or weigh them to accurately know whether they are getting enough nutrition and achieving adequate growth rates.

It is recommended that a minimum of 50-70% ground cover (about 1-1.5 tonne dry matter/ha) remains on paddocks to prevent wind erosion. Note that over time it may appear that groundcover is increasing, as sheep knock the standing stubble down as they graze. However, it's preferable to have some standing stubble, with research indicating that standing, anchored stubble 10 cm high is twice as effective at reducing wind erosion compared with loose flat stubble.

When cover in a paddock is reduced below 50% and the paddock is exposed to winds of 30 km/h or more, loosened soil starts to move. To reduce the likelihood of overgrazing, decisions should be made early to either sell stock, hold stock on less erosion-prone paddocks, or place stock into containment.

***What are my other options for grazing stubbles?***

**Grazing chaff heaps:** The chaff fraction from a crop harvest is collected by a chaff cart and heaped to concentrate resistant weed seeds. These heaps have been burnt in the past, but now some growers are grazing them first, and may not burn at all. There is mounting evidence that sheep grazing chaff heaps are performing better than those who are not, achieving better growth rates and lifting lambing percentages. Sheep help to knock down the heaps making the next sowing pass easier, and if burnt they burn faster which avoids having smouldering heaps for days. Barley chaff heaps may thatch and may need burning, preferably in winter to avoid the risk of a fire spreading. In terms of viability, research has shown that less than 3% of ryegrass seeds survive the rumen, whereas up to 30% of ryegrass seeds ingested by cattle remain viable in faeces[2].

**Summer pastures:** May include pastures such as lucerne and forage brassicas, or native grasses. These will be sown in spring if there's stored soil moisture.

**Lick and stock feeders:** Provide a small supplement of grain. If energy is lacking, open the lick feeder up or use a normal feeder so that stock can get the ration needed.

**Trailing-out grain:** A cheap and effective way of delivering a grain supplement. Can be along the ground, on old tin, or in a raised feeding system made from tin or shadecloth, that allows water to drain in the event of summer storms.

**Grazing ripe standing crops such as oats:** A crop that is left to mature and then grazed, saving the harvest, storage and feeding-out costs of grain.

Containment or feedlot: Removal of sheep from the paddock to a smaller holding area, designed and managed for either animal maintenance or finishing.


## Acknowledgements

The Grain & Graze 3 project is funded by GRDC, project code SFS00028. Southern Farming Systems (SFS), Birchip Cropping Group (BCG), SARDI Minnipa Agricultural Centre and Ag Ex Alliance (AEA).


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Livestock

**Section Editor:**
**Jessica Crettenden**
SARDI, Port Lincoln

# Section 7

# Pastures

## Identifying the causes of unreliable N fixation by medic based pastures: 2016 results

**Brian Dzoma[1], Ross Ballard[2], Nigel Wilhelm[1,2] and Ian Richter[1]**
[1]SARDI, Minnipa Agricultural Centre; [2]SARDI, Waite

RESEARCH

**Searching for answers**

**Location:**
Piednippie - Brent Cronin & Family
**Rainfall**
Av. Annual: 379 mm
Av. GSR: 304 mm
2016 Total: 485 mm
2016 GSR: 323 mm
**Paddock History**
2016: Mace wheat
2015: Mace wheat
2014: Pasture - oats
2013: Mace wheat
**Soil Type**
Calcareous grey sand
**Plot Size**
6 m x 1.5 m x 3 reps

**Location:**
Pinbong - Greg Scholz & Family
**Rainfall**
Av. Annual: 321 mm
Av. GSR: 227 mm
2016 Total: 378 mm
2016 GSR: 261 mm
**Paddock History**
2016: Medic
2015: Barley
2014: Mace wheat
2013: Mace wheat
**Soil Type**
Red sandy loam
**Plot Size**
6 m x 1.5 m x 3 reps

### Key messages

- **Growers should be aware that the application of certain broad-leaved herbicides can result in a reduction in shoot dry matter of medic pastures.**
- **Application of a full label rate of Agritone 750 (late) resulted in the largest reduction of shoot dry matter.**
- **Applying P to a soil with low P reserves when establishing a medic pasture boosts shoot and root dry matter, improves root health and improves N fixation.**
- **Growers should also be aware that the use of herbicides can reduce nodulation and $N_2$-fixation in medic pastures.**

### Why do the trial?

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 nitrogen (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 N fixation by medics under field conditions typical of the upper Eyre Peninsula. This article reports on the second year of field trials in this three year SAGIT funded project. First year results are available in the Eyre Peninsula Farming Systems Summary 2015 p 209-213.

### How was it done?

Two replicated field trials were established on Eyre Peninsula in 2016; one representative of typical mallee environments in SE Australia (Greg Scholz - Pinbong) and the other on a grey highly calcareous sandy soil (Brent Cronin - Piednippie). Background rhizobia populations, soil moisture and soil fertility were determined prior to seeding. Treatments (Table 1), to simulate herbicide residues were imposed on 27 January and the trials were later sown on 11 May (Piednippie) and 12 May (Pinbong) with all nutrition treatments applied at sowing. Both trials were sown as a split plot design with the main plots comprising the strand medic varieties Angel and Herald, and management options as subplots (nutrition, herbicides and inoculants) applied to both varieties.

*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 |
| Agritone 750 (2) | 750 g/L MCPA (as dimethylamine salt) | I | 330 ml |
| Agritone 750 - Late | 750 g/L MCPA (as dimethylamine salt) | I | 330 ml |
| Broadstrike | 800 g/kg Flumetsulam | B | 25 g + Uptake oil |
| Tigrex | 250 g/L MCPA as the ethyl hexyl ester; 25 g/L Diflufenican | F<br>I | 100 ml + 200 ml *wetter |
| Tigrex + Verdict | 250 g/L MCPA as the ethyl hexyl ester; 25 g/L Diflufenican<br>520 g/L Haloxyfop | F<br>I<br>A | 75 ml + 200 ml *wetter<br>100 ml |
| LVE Agritone | 570 g/L MCPA as the 2-ethylhexyl ester | I | 250 ml + 200 ml *wetter |
| LVE Agritone + Verdict | 570 g/L MCPA as the 2-ethylhexyl ester<br>520 g/L Haloxyfop | I<br>A | 250 ml + 200 ml *wetter<br>100 ml |
| Rustler | 500 g/L Propyzamide | K | 1 L |
| Verdict | 520 g/L Haloxyfop | A | 75 ml + uptake oil |
| **Herbicide residues** | | | |
| Intervix | 33 g/L Imazamox; 15 g/L Imazapyr | B | 50 ml |
| Logran | 750 g/kg Triasulfuron | B | 1.25 g |
| 2,4-D Amine | 625 g/L 2,4-D (as dimethylamine salt) | I | 1 L |
| **Nutrition** | **Delivered as** | | |
| Nitrogen | Urea | | 100 kg |
| Phosphorous | Phosphoric acid | | 10 kg |
| Phosphorous | Phosphoric acid | | 5 kg |
| Zinc | Zinc sulphate | | 2 kg |
| **Control 1** | Inoculated | | |
| **Control 2** | Not Inoculated | | |

**Wetter = BS1000*

Post emergent herbicide treatments were applied after the third trifoliate leaf stage on 5 July 2016 at a water rate of 100 L/ha, with the exception of the Agritone 750 (2) and Agritone 750 - late treatments that were later imposed when medic plants were 5-7 cm in diameter on 19 July and 16 August 2016 respectively. Two rates of phosphorus (P) were applied to determine the lower limit of P response. The Pinbong site had mostly broad-leaved weeds (turnip), while the Piednippie site had grassy weed problems (ryegrass). Plots were kept free of weeds as much as possible to avoid competition effects from the herbicide treatments, with plots hand weeded if necessary.

Plots were sampled on 17 August to determine the number of viable nodules, early dry matter and root health and weight. Sampling was also done on 6 September to estimate medic productivity (late DM) and $N_2$-fixation by the *$^{15}N$ natural abundance technique*. Contribution to N reserves in the soil will also be measured by sampling for mineral N in the root zone in autumn 2017.

## What happened?

Pasture emergence and establishment was more rapid when compared to the 2015 trials because the medic was sown into wet and warm soil. Plant density after emergence was not affected by the herbicide residue treatments but was reduced ($P<0.05$) by urea applied below the seed at sowing. At Pinbong, mean site plant density was 97 plants/m$^2$ but urea reduced this to 74 plants/m$^2$; and at Piednippie mean site plant density was 110 plants/m$^2$ and with urea only 93 plants/m$^2$. A positive growth response to both rates of P (5 and 10 kg P/ha) was evident during the early stages of the season at Piednippie, and stunted growth was observed in the Tigrex and Agritone 750–late treatments at both trial sites.

*Table 2 Effect of variety on nodulation, dry matter and root health*

| Site | Variety | Total nodules/ plant | Effective nodules/ plant | Ineffective nodules/ plant | Root damage score (0 Good - 15 Bad) | Root DM (mg plant) | Shoot DM (mg/plant) | Biomass (t/ha) |
|---|---|---|---|---|---|---|---|---|
| Pinbong | Angel | 9.4 | 2.8 | 6.7 | 4.1 | 24.6 | 281.8 | 0.7 |
| | Herald | 9.1 | 3.1 | 6.0 | 4.0 | 26.0 | 311.7 | 0.7 |
| | *LSD (P=0.05)* | *ns* | *ns* | *0.6* | *ns* | *ns* | *ns* | *ns* |
| Piednippie | Angel | 7.9 | 5.8 | 2.1 | 3.3 | 13.3 | 146.4 | 1.0 |
| | Herald | 6.8 | 5.1 | 1.7 | 3.1 | 13.5 | 154.7 | 1.0 |
| | *LSD (P=0.05)* | *0.5* | *0.5* | *0.3* | *ns* | *ns* | *ns* | *ns* |

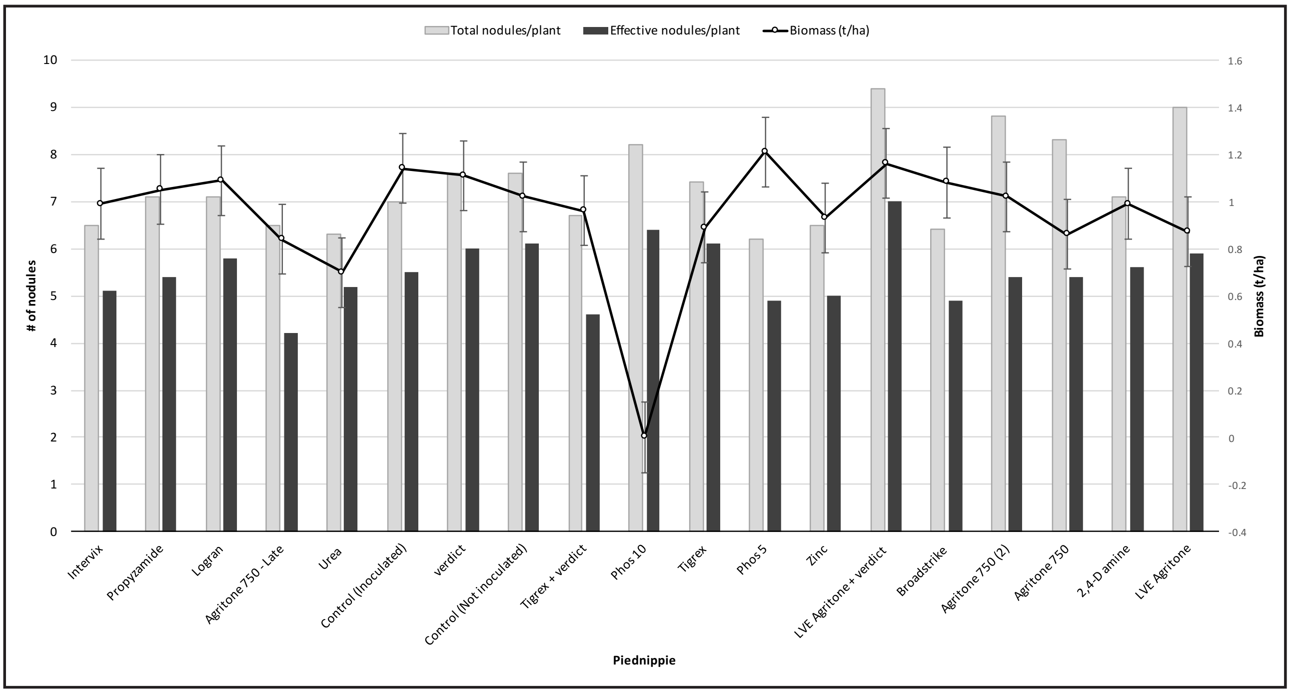


***Figure 1 Total and effective nodule numbers per plant and biomass (t/ha) at Piednippie 2016***

Differences in the performance of Herald strand medic and its successor Angel, which has tolerance to sulfonylurea herbicide residues, were measured (Table 2). There were no differences in variety responses to treatments imposed at both sites for biomass, shoot DM, root DM and root health. At Piednippie, Angel nodulated better than Herald with more total nodules per plant, and total effective nodules per plant.

Average shoot biomass in late August at Piednippie was 1.03 t/ha but some treatments had large effects on dry matter production. Phos 10 was the only treatment that increased biomass compared to the inoculated control, with no response at 5 units of P (Phos 5). Biomass production (t/ha) was reduced by Tigrex (0.89), urea (0.7), LVE Agritone (0.87), Agritone 750 (0.86) and Agritone 750 – Late (0.84) (Figure 1).

Total number of nodules per plant, which averaged 7.4 at Piednippie, increased from the inoculated control with Phos 10, LVE Agritone+Verdict, LVE Agritone, Agritone 750-2 and Agritone 750. However, apart from the Phos 10 treatment, these increases were associated with an increase in the number of ineffective nodules per plant, possibly indicating the plant response to the herbicide stress was to produce more nodules to compensate for those that were not working.

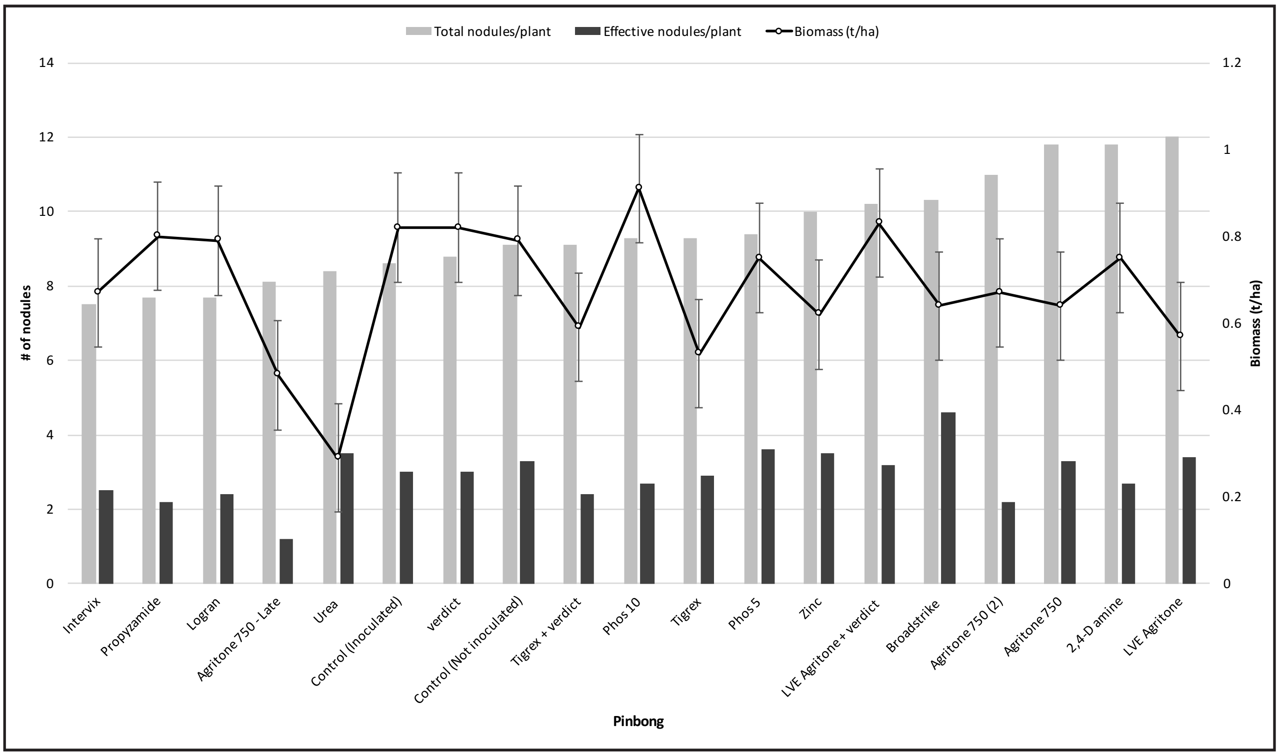


***Figure 2 Total and effective nodule numbers per plant and biomass (t/ha) at Pinbong 2016***

At Pinbong, shoot biomass was very poor and averaged only 0.7 t/ha in late August. There was no growth response to the nutrition treatments (P and zinc), and no other treatment performed better than both the inoculated and uninoculated controls. However, urea, Tigrex, Tigrex+verdict, LVE Agritone and Agritone 750-Late all resulted in large reductions in biomass (Figure 2). There was an increase in the total number of nodules (site mean 9.3/plant) for Agritone 750, Agritone 750-2 and LVE Agritone, however, no treatment had lower total nodules than the inoculated control. Total number of effective nodules per plant was not affected by any of the treatments imposed, however total number of ineffective nodules per plant (site mean 6.3) was increased by LVE Agritone, Agritone 750 and Agritone 750-2. Root damage score, which is a measure of root health (0 = good – 15 = bad), was decreased by only Agritone 750-Late.

***Plant and soil nitrogen (2015 results)***

At Pinbong, measures of plant N from the *$^{15}$N natural abundance* analysis showed that both medic varieties and all treatments resulted in similar total N (kg/ha) and fixed N (kg/ha and kg/t DM). The percentage of N fixed at this site was more than 90% and N fixed per tonne of dry matter was about 24 kg N/t DM (Table 3). These amounts were higher than at Piednippie (65% Nfix and 19 kg N/t DM) (Table 3). At Pinbong, the amount of N fixed (kg/ha) ranged from 15 (Agritone 750 treatment) to 26 kg/ha (plus P treatment).

At Piednippie there were treatment effects on fixed N (kg/ha); fixed N (kg/tDM) and total N (kg/ha). Phosphorous addition was the only treatment that increased the amount of fixed N (23 kgN/ha) compared to the control (9 kgN/ha), whereas late Agritone (5 kgN/ha) was the only treatment to fix less N than the control.

Soil mineral N levels in the autumn after the trials were conducted was not affected by treatments at both sites. Total mineral N (0-60 cm) was higher, on average, at Pinbong (101 kg N/ha) than at Piednippie (78 kg N/ha).

*Table 3 Fixed N (kg/ha) and N fixed per tonne of dry matter (kg/tDM) at Piednippie and Pinbong in 2015*

| Site | | Fixed N (kg/ha) | Fixed N (kg N/t DM) | Total N (kg/ha) |
|---|---|---|---|---|
| Pinbong | Average | 20.5 | 23.8 | 22.1 |
| | Range | 15-26 | 22-25 | 16-28 |
| Piednippie | Average | 10.9 | 18.8 | 16.1 |
| | Range | 5-23 | 17–25 | 9-33 |

## What does this mean?

The amounts of N fixed per hectare by legumes are usually related to plant growth with around 20 kg of N reported to be fixed for every tonne of above-ground dry matter produced. Our results show substantial variation about this level associated with impacts of nutrition and herbicide use. However, 30-60% of the legume's total plant N may be below-ground associated with roots and nodules (Peoples and Baldock, 2001). Herbage production for the 2016 trials was only increased (28%) by applying 10 units of P at Piednippie, and this can be attributed to the low starting P reserves (Colwell P, 0-10 cm of 14 mg/kg) prior to sowing.

Our trials show that there can be a shoot DM penalty when certain herbicides are used to control broad-leaved weeds during the pasture phase. There was a reduction in shoot DM by applying Agritone 750 (25%), Agritone LVE (23%) and Tigrex (22%) at Piednippie, and by applying Tigrex (35%), Agritone LVE (30%) and Tigrex + Verdict (28%) at Pinbong. The biggest reduction in shoot DM at both trial sites was from the application of Agritone 750 late (when plants were greater than 7 cm in diameter), with a reduction of 26% at Piednippie and 41% at Pinbong. Therefore, the timing of application is crucial in order to achieve maximum potential DM production by medic pastures. These reductions in shoot DM were associated with increased numbers of ineffective nodules and so we expect less total shoot N to be fixed and available for the next cereal crop. However, it should not be assumed that all of the shoot N fixed by legume pastures will immediately be available to crops, because the breakdown of shoot and root residues is dependent upon the rate of mineralisation, which is also dependant on various factors but mainly summer and autumn rainfall.

The 2016 findings are consistent with the trends measured in previous trials (2015), that pasture DM production is improved with the application of P when establishing new medic pastures, even on paddocks with moderate P reserves. The effects of herbicide application were also consistent, with the application of MCPA amine based (Agritone) herbicides increasing the proportion of ineffective nodules and reducing herbage production, especially when applied late in the season. Herbicides are essential in intensive farming systems, particularly in reduced tillage 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.

It should also be noted that some of the chemicals used in this trial (Tigrex and LVE Agritone) are considered off label chemicals for use in medic pastures but have been included to make growers aware of the impact that they may have on medic nodulation, N-fixation and herbage production.

The $^{15}$*N natural abundance* analysis from the 2016 season was not available at time of publication.

## References

Peoples M, Baldock J (2001). Nitrogen dynamics of pastures: nitrogen fixation inputs, the impact of legumes on soil nitrogen to Australian farming systems. Australian Journal of Experimental Agriculture 41, 327-346.

## 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).

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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Improving regenerating medic pastures in low rainfall mixed farming systems

**Brian Dzoma**
SARDI, Minnipa Agricultural Centre

RESEARCH

**Searching for Answers**

**Location:**
Piednippie
**Rainfall**
Av. Annual: 379 mm
Av. GSR: 304 mm
2016 Total: 485 mm
2016 GSR: 323 mm
**Paddock History**
2016: Parabinga medic
2015: Mace wheat
2014: Mace wheat
**Soil Type**
Calcareous grey sand
**Plot Size**
3 m x 1.5 m x 3 reps

## Key messages

- **The paddock contained a population of effective rhizobia and so the number of nodules on lateral and taproots was not affected by the addition of different rhizobial inoculants.**
- **Improved soil nutrition did not affect dry matter production and nodulation.**
- **Grazing (simulated) reduced the total dry matter produced by the medic pasture, however the use of sheep would provide a more realistic assessment of grazing on DM production, nodulation and $N_2$-fixation.**

## Why do the trial?

The use of pasture legume species such as annual medics *(Medicago spp.)* has long been considered to be a sustainable and profitable means of maintaining soil nitrogen (N), fertility, forage quality and productivity in both permanently grazed pastures and ley-farming systems. However, due to current farming methods there has been a decline in the level of management inputs routinely supplied to pastures for wool and meat production, and a trend towards shorter pasture phases in pasture-crop rotations in low rainfall mixed farming systems. This general neglect of pastures and increased grazing pressure has resulted in poor seedbank persistence and pasture regeneration, and poor nodulation and N-fixation in some cases. The aim of this trial was to investigate the impact of grazing, soil nutrition and rhizobial inoculants on dry matter production, nodulation and $N_2$-fixation of a regenerating medic pasture under field conditions.

## How was it done?

A replicated field trial was established on 7 April 2016 on a regenerating barrel medic pasture *(var. parabinga)* at Piednippie on a grey sandy soil with 1.5% organic carbon, 24 mg/kg Colwell P and 20 kg N/ha in the 0-10 cm root zone. Before sowing, the soil contained 823 medic rhizobia per gram (0-10 cm) and they were 76% as effective as the commercial inoculant (WSM 1115) in combination with Parabinga. All treatments (Table 1) were imposed on 24 May, which was followed by 26 mm of rain over three days. ALOSCA rhizobia granules (containing approx. 23,000 rhizobia/g) were spread over the plots by hand. Peat inoculant was dissolved in water overnight and sprayed onto plots using a backpack sprayer at 250 L/ha of water. Parabinga seed was spread by hand (over the treatments with added seed) and raked in to simulate prickle-chaining in order to improve seed-soil contact and the inoculated Parabinga seed had 26,000 rhizobia/seed. The trial site was sprayed with Broadstrike @ 25 g/ha, Verdict @ 75 ml/ha and uptake oil @ 500 ml/ha on 22 June to control broad-leaved and grass weeds, and simulated grazing (only on 'grazed' main plots) was imposed by mechanical mowing on 21 July after sampling for early dry matter (DM). Sampling for nodulation was done on 17 August, late dry matter (DM) on 29 August and $N_2$-fixation 9 September.

## What happened?

Initial crop establishment counts indicated a satisfactory plant density for a regenerating medic pasture with 188 plants/m$^2$. Dry conditions at the start of the season resulted in slow dry matter production. There were no differences in early DM (Figure 1) prior to the imposition of the simulated grazing treatment. However, there was a significant ($P<0.001$) response to the main plot grazing effect, with the un-grazed treatment averaging 4.2 t DM/ha and grazed 2.2 t DM/ha. An average of 0.9 t DM/ha was removed from the 'grazed' plots through simulated grazing, and reduced total medic DM production for the season (3.2 t DM/ha compared to 4.2 t DM/ha).

*Table 1 Treatment details*

| Treatments | Formulation/application | Application rate/ha |
|---|---|---|
| Peat | Dissolved | 250 g/250 L water |
| *ALOSCA gran 10 | Granular | 10 kg |
| *ALOSCA gran 5 | Granular | 5 kg |
| Phosphorous | Triple super phosphate | 10 kg |
| Phosphorous | Triple super phosphate | 5 kg |
| Zinc | Zinc sulphate | 2 kg |
| Sulphur | Gypsum | 20 kg |
| Manganese | Manganese sulphate | 3 kg |
| Nitrogen | Urea | 100 kg |
| Peat inoculated seed | Broadcast | 4 kg |
| Non-inoculated seed | Broadcast | 4 kg |
| Control ^ | Nil | Nil |

**Alosca granules*
*^ Control – regenerated medic with no added nutrition or inoculant*

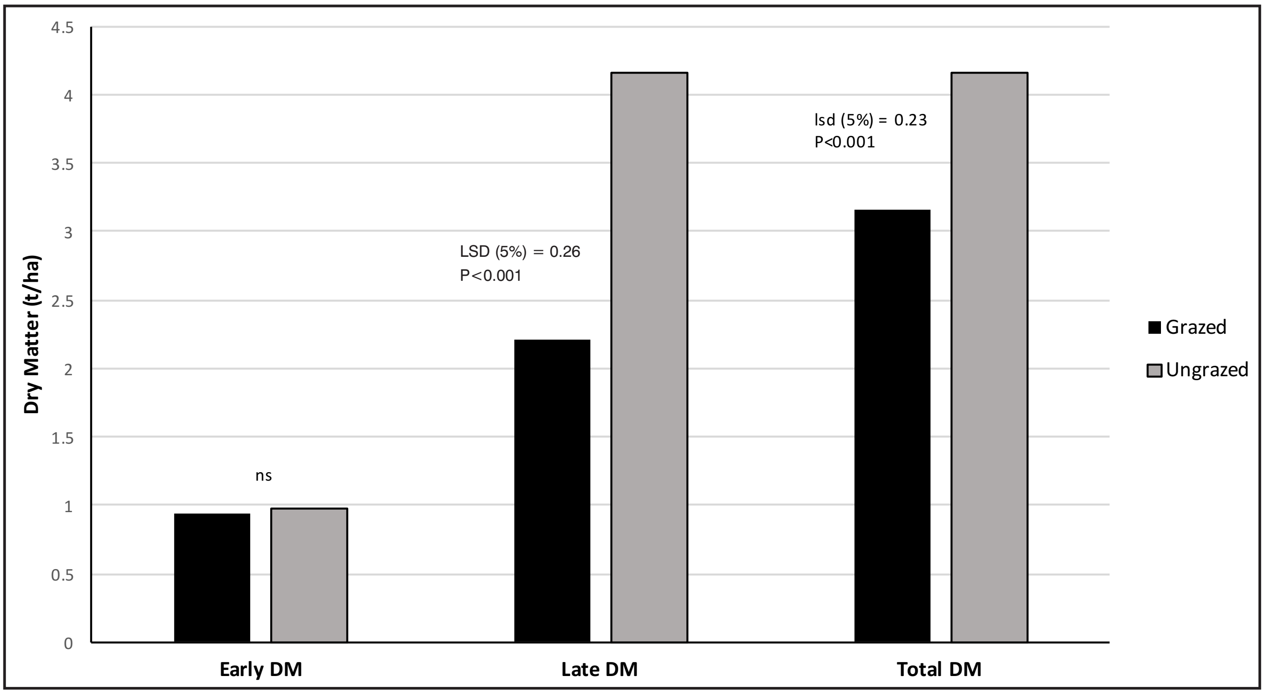


***Figure 1 Dry matter (t/ha) for grazed vs un-grazed medic***

There were no visible or significant measured effects of the nutrition or rhizobia treatments on above ground DM production irrespective of grazing at any of the 3 sampling times. For total DM (Figure 2), the un-grazed plots produced more DM than the grazed plots with peat (4.8), urea (4.7), and ALOSCA gran 5 (4.7) having the biggest effect on DM (t/ha).

The medic plants at the time of sampling for nodulation and $N_2$-fixation were large and mature (some had pods). Because of their maturity, it was not possible to distinguish between ineffective and effective nodules and so nodule numbers on the tap and lateral roots was determined. Using a split plot analysis (grazed/un-grazed) there were no significant treatment effects on total nodules per plant (Figure 3). These results are consistent with the presence of reasonably effective background population of rhizobia at the site. That said, the site mean of 6.4 nodules per plant was below the optimum of 10-20 nodules per plant after eight weeks of growth

The peat inoculant treatment did have the highest mean nodule number (7.8) and the $N_2$ fixation data (pending) may provide support to this trend. There were no significant treatment effects on root DM and root damage score.

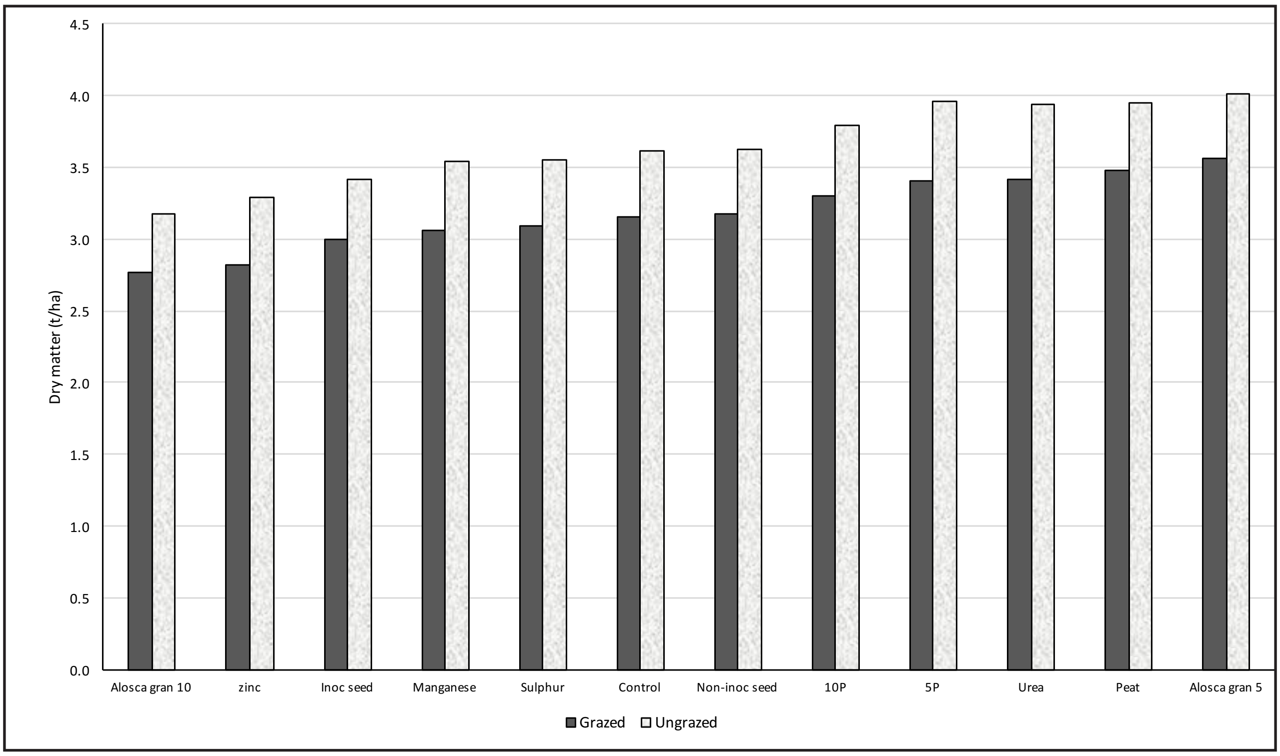


*Figure 2 Total dry matter (t/ha) with the grazing effect*

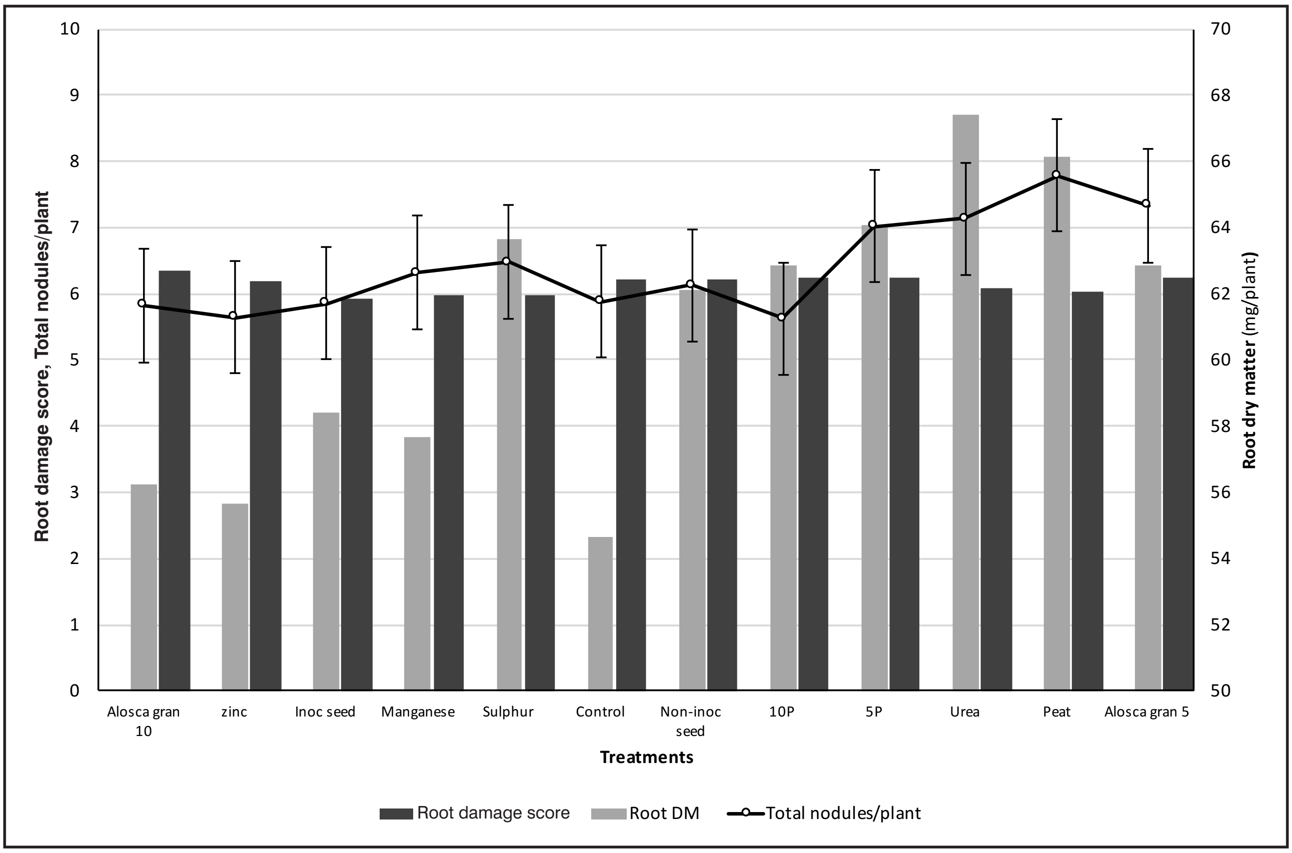


*Figure 3 Root damage score, root dry matter and total nodules per plant*

## What does this mean?

Factors that influence the quantity of N fixed are the level of soil N, the number and $N_2$ fixation capacity of rhizobia that nodulate the legume, and the amount of legume plant growth which is affected by how the legume is managed and the length of growing season. The 2016 growing season was above average and medic growth was good, averaging 3.6 t DM/ha across the site. The lack of any inoculation response was likely the result of the paddock already supporting a satisfactory number (823/g soil) of effective rhizobia. Sowing seed to increase plant numbers did not have a positive effect on plant density and DM production because of the good starting plant population (site mean = 188 plants/$m^2$). This management strategy is likely to have a positive effect if the background seed for regeneration is low. Good starting levels of macronutrients i.e. 24 mg/kg Colwell P, 20 kg N/ha, 664 mg/kg K and 6.7 mg/kg S; and trace elements 1.2 mg/kg DTPA zinc and 8.8 mg/kg DTPA manganese in the 0-10 cm root zone also confirmed the lack of a DM and nodulation response by the medic pasture.

Total medic DM production was reduced by simulated grazing (3.2 t DM/ha vs 4.2 t DM/ha). The 0.9 t DM/ha removed through grazing (early DM) can support 10 DSE/ha with a DM intake of 1.5 kg DM/ha/day for approximately two months, therefore if we factor in the value of DM removed by grazing, then the overall benefit of grazing would increase. The difference in total DM can also be attributed to the fact that simulating grazing through the use of a mechanical mower is not ideal as sheep are usually selective when they graze and also they put back into the system some nitrogen, particularly in urine, while the mowing is non-selective and provides no nutrients. The use of sheep would provide a more realistic assessment of grazing on DM production, nodulation and $N_2$-fixation.

While there are general concerns about medic nodulation and $N_2$ fixation, the paddock in this study provides an example of what is possible where there are adequate numbers of effective rhizobia and reasonable nutrition. Future studies should target paddocks with less nutrition, where poor medic growth has been observed and the rhizobia background has been confirmed as poor so that the importance of re-inoculating low rhizobia paddocks and improving soil nutrition can be demonstrated. $N_2$ fixation data are still pending, but if 20 kg/t shoot DM is achieved then the 4.2 t/ha of un-grazed regenerating medic pasture will have contributed about 100 kg/ha of fixed N (including a contribution from roots).

## Acknowledgements

Thanks to Brent Cronin and family for allowing us to have the trial on his property, Ian Richter for technical support, Ross Ballard and Nigel Wilhelm for their continued input in this project. The Eyre Peninsula Grain and Graze project is funded by GRDC (SFS00028).

# Modelling methane emissions from Merino lambs on improved forages in low rainfall mixed farming systems

**Brian Dzoma**
SARDI, Minnipa Agricultural Centre

RESEARCH

**Searching for Answers**

**Location:**
Minnipa Agricultural Centre, competition paddocks
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Livestock**
Enterprise type: Mixed cropping and livestock
Type of stock/breed: Merino sheep

## Key messages

- **Grazing vetch and lucerne can be used as a management strategy to improve lamb dry matter intake and growth rates during the late spring and early winter feed gaps.**
- **The Grazfeed decision support tool has predicted that while both legume forages (vetch and lucerne) will increase methane output ($gCH_4$/day), there is a reduction in methane output per unit of animal product ($gCH_4$/day/100gADWG).**
- **Moisture limitations can affect herbage production of lucerne, which in turn reduces the chances of growing lambs to achieve the full potential dry matter intake in low rainfall mixed farming systems.**

## Why do the trial?

The issue of enteric (from intestines) methane ($CH_4$) emissions produced by ruminant livestock is gaining local and global interest due to methane being a powerful greenhouse gas and ruminants being a significant source of emissions. In the absence of measurements, prediction models can facilitate the estimation of enteric methane emissions from ruminant livestock and aid investigation of mitigation options. In Southern Australia, the management of the feedbase in low rainfall mixed farming systems through addressing 'feed gaps' – times of year during which the supply of forage is insufficient to meet livestock demand; is a key practice change which has the potential to mitigate methane emissions, particularly from sheep.

The aim of this trial was to evaluate pasture/forage options with a potential to fill the late-spring and early winter feed gaps and to measure comparative animal production and feed quality in response to current and improved forages. Methane output ($gCH_4$/day) was simulated using the GrazFeed model.

The GrazFeed decision support tool is a component of the GRAZPLAN decision support project for Australian grazing enterprises developed by CSIRO to help graziers improve the profitability of livestock production through more efficient use of pastures and supplementary feeds. It does this by predicting the intake of energy and protein and their use for maintenance and production (Freer *et al.,* 1997).

## How was it done?

Replicated field trials were established at Minnipa Agricultural Centre, Minnipa, EP, SA (Lat: 32° 50'11" S; Long: 135°09'05" E) in June (winter trial) and October (spring trial) 2016. The winter grazing trial commenced on 1 June with 100 Merino wether lambs (July/August 2015 drop) at an average liveweight (LW) of 37 kg, split equally into two treatment groups of 50 animals. The lambs were weighed on 1 June following an overnight fast and treatment 1 lambs were placed on 3 ha of lucerne and treatment 2 lambs on 1.5 ha of self-sown oats. The lambs were taken off treatments for shearing and fat and eye muscle scanning on 14 June and taken back to treatments on 17 June. Final LW measurements were done on 5 July 2016 following an overnight fast.

The spring grazing trial commenced on 28 September with 60 Merino wether lambs (July/August 2016 drop) at an average LW of 28 kg, split equally into two treatment groups of 30 animals. Lambs were weighed on 28 September and treatment 1 lambs placed on 1 ha of green vetch at podding stage, supplemented by oaten hay; and treatment 2 lambs on 1.5 ha of a mature self-sown oats crop, supplemented by lupins in a lick feeder. Lambs were taken off treatments on 27 October and final LW measurements were done the following day. For both grazing trials, forages were tested for dry matter (DM) availability and forage quality (FEEDTEST analysis) (Table 1).

*Table 1 Treatment details and fodder/pasture quality*

| Phase | Stock type/age | Grazing days | Treatment | Diet supplement | Dry matter (%) | Crude protein (% DM) | Digestibility (%) | ME (Mj/kgDM) |
|---|---|---|---|---|---|---|---|---|
| Winter 2016 | Merino lambs (~12 months) | 31 | Lucerne | | 92.6 | 27.8 | 70.1 | 11.1 |
| | | | Self-sown oats (green) | | 93.5 | 23.4 | 73.9 | 11.3 |
| Spring 2016 | Merino lambs (~5 months) | 30 | Vetch | Vetch | 23.4 | 17.2 | 74.1 | 11.1 |
| | | | | Oaten hay | 86.8 | 9.6 | 66.4 | 9.8 |
| | | | Mature self-sown oats | Self-sown oats | 44.5 | 7.1 | 64.1 | 9.4 |
| | | | | Lupins (grain) | 92.8 | 29.8 | 82.5 | 13.3 |

In previous grazing trials (EPFS Summary 2013, 2014, 2015), methane output was measured using a polytunnel supplied by CSIRO (WA), however for the winter and spring 2016 grazing trials, GrazFeed was used to estimate LW gain and DM intake (DMI), then simulate methane output (g$CH_4$/head/day) in relation to DMI, DM digestibility and protein percentage.

## What happened?

There was a high response ($P<0.001$) in LW gain and animal growth rate, to the forages offered in both grazing trials. For winter 2016, the lambs grazing lucerne consumed an estimated 1.69 kg DM/lamb/day and achieved an Average Daily Weight Gain (ADWG) 20% higher (204.7 g/head/day) than the lambs grazing self-sown oats (163.4 g), shown in Table 2. DMI for the lambs on lucerne was lower because intake was being limited by the quantity of herbage on offer, which was too low (average of 1.4 t DM/ha) for the potential intake to be achieved. The 20% difference in growth rate can be attributed to the fact that the self-sown oats crop, which was lower in protein (no fertiliser inputs), deteriorated in quality as the crop matured, and resulted in a slower gut passage time due to poor digestibility of the fodder. For spring 2016, the lambs grazing vetch at podding stage had a higher DMI (1.39 kg DM/head/day) than the ones on the mature self-sown oats (1.08 kg DM/head/day), and achieved higher ADWG (154.2 g/head/day) because of higher digestibility (%), crude protein (%) and metabolisable energy (ME, MJ/kgDM).

GrazFeed predictions (Table 3) were close to the actual calculated estimates for DMI and LW gain. However, there were bigger differences in predicted LW gains for spring 2016 with GrazFeed estimating mean LW gain (g/head/day) of 24 g and 199 g for lambs on the mature self-sown oats and vetch respectively, as compared to actual calculated estimates of 8 g and 154 g for the same forages.

For both grazing trials, winter and spring 2016, LW gain for these lambs was not being limited by the concentration of protein in their diet. This is indicated in Table 3 by the surplus in the intake of rumen degradable protein and undegradable protein. Lambs on lucerne had the highest surplus rumen undegradable (202 g) and degraded protein (69 g). For winter 2016, gain efficiency was higher for lambs on lucerne (47%) than lambs on self-sown oats; and for spring 2016 it was higher for lambs grazing vetch (56%).

*Table 2 Forage intake and liveweight gain*

| Phase | Fodder | Fodder intake (kg DM/head/day) | Average LW gain (kg/head) | Ave Daily Weight gain (g/head/day) |
|---|---|---|---|---|
| Winter 2016 | Lucerne | 1.69 | 6.6 | 204.7 |
| | Self-sown oats (green) | 1.78 | 5.2 | 163.4 |
| | *LSD (P<0.001)* | | *0.8* | *23.5* |
| Spring 2016 | Vetch | 1.39 | 4.6 | 154.2 |
| | Mature self-sown oats | 1.08 | 0.2 | 7.6 |
| | *LSD (P<0.001)* | | *1.1* | *36.2* |

***Table 3 GrazFeed simulations for DMI (kgDM/head/day), ADWG (g/head/day), degradable protein (g) and maintenance and gain efficiency (%)***

| | Parameters | Winter 2016 | | Spring 2016 | |
|---|---|---|---|---|---|
| | | Lucerne | Self-sown oats (green) | Vetch | Mature self-sown oats |
| **DM Intake** *(kgDM/head/day)* | Actual calculated estimate | 1.69 | 1.78 | 1.39 | 1.08 |
| | GrazFeed estimate | 1.70 | 1.71 | 1.34 | 0.90 |
| **Mean LW gain** *(g/head/day)* | Actual calculated estimate | 205 | 163 | 154 | 8 |
| | GrazFeed estimate | 213 | 176 | 199 | 24 |
| **GrazFeed outputs** | Maintenance efficiency (%) | 71 | 72 | 72 | 68 |
| | Gain efficiency (%) | 47 | 37 | 56 | 34 |
| | Surplus rumen degradable protein (g) | 202 | 138 | 184 | 37 |
| | Surplus undegradable protein (g) | 69 | 65 | 62 | 20 |

***Simulated methane output***

The GrazFeed model was used to simulate the changes in methane output ($gCH_4$/day) in response to the improved pastures that have the potential to fill early winter and late spring feed gaps. 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 to 100 g ADWG over the grazing period.

There were no differences in total methane output between lambs on lucerne or self-sown oats (winter 2016), but for spring 2016, the lambs on vetch were producing 13% more methane than the ones grazing a mature self-sown oats crop. Methane emission intensities ($gCH_4$/day/100gADWG) were higher on the legume forages than cereals for both grazing trials. For every 100 g of ADWG the lambs on vetch were producing 0.78 $gCH_4$/hr, compared to 11.46 $gCH_4$/hr for the lambs grazing mature self-sown oats (Figure 1).

## What does this mean?

Feed gaps are key limitations for improving livestock productivity in most regions of Australia's mixed farming systems. Management practices that can reduce the frequency or intensity of a major feed gap can greatly improve the profitability of a livestock enterprise by reducing the amount of supplementary feeding and/or increasing the livestock numbers without the risk of overgrazing. Assuming lamb prices (cents/kgLW) for Merino wethers averaging 40 kg and 29 kg are 279 cents and 334 cents respectively (Auctionplus, 2017), the LW gain would represent a dollar benefit of $18 for lambs grazing on lucerne, $15 on green self-sown oats, $15 on vetch and only $1 for lambs grazing mature self-sown oats for the 30-day grazing period. For this trial, filling the spring feed-gap with a better quality green feed (vetch) resulted in a $14 difference in dollar benefit between green vetch and mature self-sown oats. While improving the availability and digestibility of forages offered to lambs during critical feed gaps can increase growth rates and enteric methane output (g/day) produced by growing sheep, it can also bring significant reductions in methane emissions per unit of animal product. Alcock and Hegarty (2011) showed that if farmers use sheep with 10% higher growth rates, methane emissions are reduced by about 3%. For the two grazing trials, lucerne and vetch proved to be better options to fill the winter and spring feed gaps by maximizing animal productivity with lower methane emission intensities.

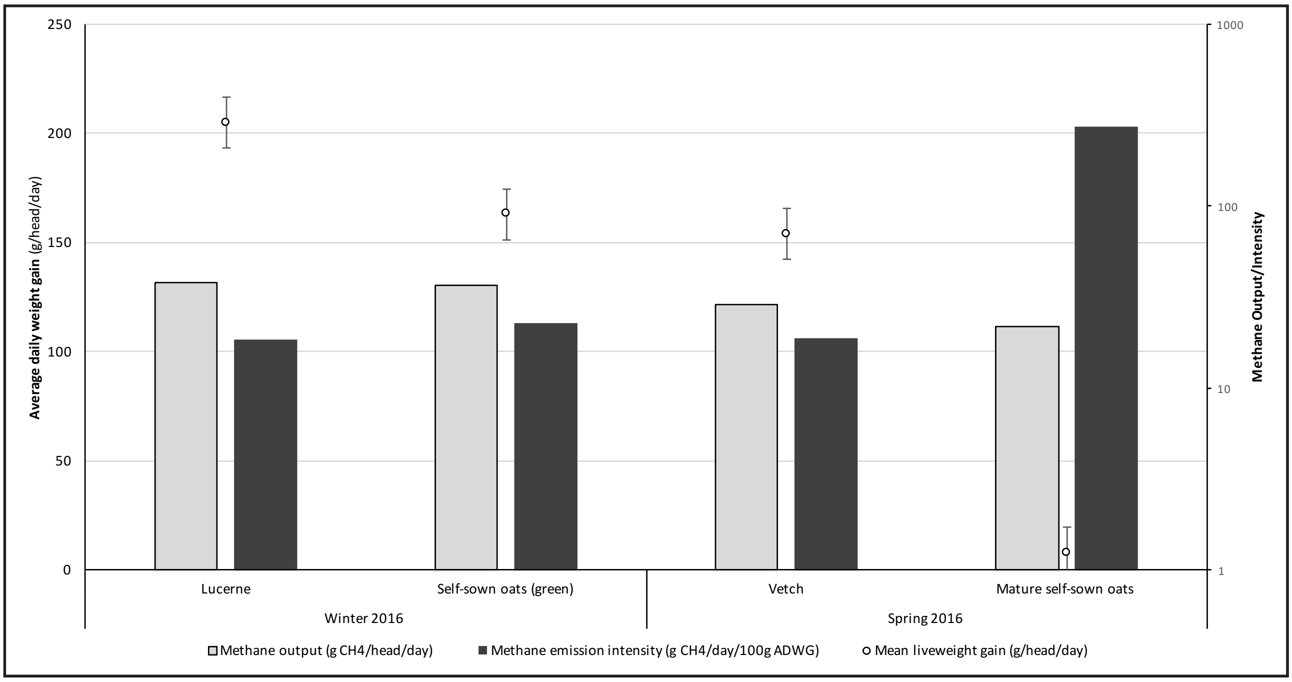


***Figure 1 Mean liveweight gain (g/head/day), methane output ($gCH_4$/head/day) and methane emission intensity ($gCH_4$/day/100gADWG)***

The GrazFeed decision support tool has proved that in the absence of real-time polytunnel methane measurements it can be used to identify critical relationships between lamb productivity and methane output relative to the availability and quality of the different forages offered.


## Acknowledgements

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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Low cost annual pasture legumes for sandy soils

RESEARCH

**Roy Latta**

Dodgshun, Medlin, Ouyen VIC

**Location:**
Mallee, Northwest Victoria
Walpeup Centre, Department of Environment, Land, Water & Planning

**Rainfall**
Av. Annual: 333 mm
Av. GSR: 200 mm
2015 Total: 235 mm
2015 GSR: 143 mm
2016 Total: 390 mm
2016 GSR: 308 mm

**Paddock History**
2015: Barley/Pasture

**Soil Type**
Mildly acid to neutral surface soil to alkaline subsoil 6.5 to 8 pH (CaCl) sand and sandy loam

**Plot Size**
10 m x 1.5 m x 3 reps

## Key messages

- **Undersowing forage legumes in a barley crop was as reliable and at a lower cost than sowing as monocultures in the following year.**
- **In 2016 vetch was more productive than all other tested forage legumes on a sandy soil and as productive as annual medics on a loam.**
- **The aerial seeded serradella was as productive as the annual medics on the sandier soil type.**

## Why do the trial?

A progressive shift in the Mallee from cereal dominance to more diverse rotations has increased interest in the re-inclusion of legume pastures in the farming systems. Current returns from the livestock industries support this opportunity as an alternative to growing legume field crops.

To improve the viability of the pasture option, the trial set out to compare the establishment and production of both traditional and alternative pasture legumes through undersowing into a cereal in the year prior to the pasture phase, as opposed to sowing as monocultures in the following year. Benefits which would accrue from successful undersowing would include a lower seeding rate and no requirement to seed the pasture area in the pasture year.

## How was it done?

Replicated trials at two sites (a sand and a loam soil type) compared establishment, production and regeneration of four groups of pasture legume; annual medic, serradella, clover and vetch. They were established by seed pod or seed undersown to barley in year 1 (2015) or sown as a monoculture in year 2 (2016).

Establishment method;

1. A mixture of Charano, Eliza and Margurita serradella pods, unprocessed Bartolo bladder clover seed and Harbinger annual medic pod undersown to 25 kg/ha of barley in April 2015.
2. Annual medic varieties (listed in Table 1 and Table 2) and Volga vetch seed undersown to 25 kg/ha of barley in April 2015.
3. The mixture of serradella pods (listed in 1), unprocessed Bartolo bladder clover seed and Jaguar annual medic pod spread on barley stubble in February 2016.
4. Annual medic varieties (listed in Table 1 and Table 2) and Volga vetch seed sown as monocultures in barley stubble in April 2016.

2015 pasture plant establishment and seed yields were collected from three 0.2 m$^2$ quadrats taken within the 15 m$^2$ plots. Barley grain yields were estimated from harvesting the plots with a plot harvester in November 2015. 2016 pasture plant regeneration and establishment, biomass and seed yield measurements were collected from three 0.1 m$^2$ quadrats taken within each of the 15 m$^2$ plots. Plots were harvested with a grain plot harvester in December 2016 to assess potential on farm seed yields. Analysis of variance (ANOVA) using Genstat 5 was carried out on plant establishment, pasture biomass and seed yields on 2016 collected data.

## What happened?

In 2015 on the sandy soil type, the barley undersown with pastures yielded 2.4 t/ha. Harbinger medic undersown as pods (establishment method 1) resulted in fewer plants (2 plants/m$^2$) than all other entries (>10 plants/m$^2$, data not presented). The undersown annual medic cultivars shown in Table 1 (establishment method 2), produced more seed than the undersown Harbinger medic pods, Bartolo and Volga vetch and serradella produced no seed.

The undersown vetch contaminated the header harvested barley grain sample at more than 3%, with contamination by the plant pod retention medic Jaguar at 0.8%.

In 2016 the 2015 undersown PM250 and Jaguar medics established more plants than their 2016 monoculture sown namesakes (Table 1).

The 2015 undersown Volga and 2016 sown serradella and Bartolo established fewer plants than all other entries. The vetch had higher October biomass and seed yields than the medics, 2015 undersown serradella and bladder clover, which were higher than the 2016 sown bladder clover and serradella. Vetch yielded more than a tonne of harvested seed, serradella 120 kg/ha and the bladder clover and annual medic less than 20 kg/ha.

In 2015 on the loam trial site, the barley undersown with pastures yielded 2.7 t/ha. Plant establishment varied from 5 plants/m$^2$ for the Harbinger medic undersown as pods (establishment method 1) to 19 plants/m$^2$ for Sultan (establishment method 2) (data not presented).

The undersown annual medic cultivars Sultan and Parabinga and Volga vetch produced more seed than the undersown Harbinger medic pods and Bartolo. Serradella produced no seed (Table 2).

In 2016 plant establishment on the loam site was generally lower for the 2015 undersown serradella and vetch and the 2016 sown bladder clover and serradella than all other treatments (Table 2). The 2016 sown vetch and the 2015 and 2016 sown Sultan and Parabinga produced similar October biomass. The 2016 sown vetch produced more seed than all other treatments. Vetch yielded more than 1.5 t/ha of harvested seed, serradella 70 kg/ha, bladder clover 90 kg/ha, and the annual medics all less than 10 kg/ha.

## What does this mean?

Harbinger medic pods and seed of current medic cultivars undersown in 2015 at 10 and 2 kg/ha respectively produced adequate seed to regenerate at higher or comparable levels and were at least as productive as similar treatments sown in 2016 at 4.5 and 2.5 times the seeding rate.

The serradella mixture of cultivars undersown to barley in 2015 was as productive in 2016 as the other 2015 undersown treatments on the sand site. However it was less productive on the loam site as a result of low plant numbers. The total lack of seed production in 2015 meant 2016 establishment was from 2015 sown seed, which was 70% hard at time of sowing. The reason for the failure of the February 2016 surface spread serradella and Bartolo, with at least 30% soft seed, to establish at populations at least comparable with 2015 establishment of the same lines and seed supply is uncertain. However, insect collection is certainly a possibility as the seed was left uncovered until shallow tillage was carried out in late April.

These results suggest that undersowing provides a reliable and lower cost method, due to lower seeding rates and less farm operations, of establishing forage legumes than sowing as a monoculture. However, undersowing as a pasture establishment technique was abandoned in the 1970's due to a number of reasons, including the widespread use of selective broad-leaved and residual in-crop herbicides. Current extended cropping phases reduces the likelihood of broad-leaved herbicide use in the final crop before the pasture phase.

In recent times Western Australia has promoted spreading unprocessed seed or seed pods of site suitable aerial seeded lines, bladder clover, serradella etc. over the summer immediately prior to the pasture phase.

***Table 1 2015 and 2016 seeding rates (kg/ha), 2015 seed yield (kg/ha), 2016 plant regeneration and establishment (plants/m$^2$) and biomass (tDM/ha) and seed yields (t/ha) of forage legumes undersown as pods or seed to barley in 2015 or as monocultures in 2016 on the sandy soil site***

| Establish. Method (sandy soil type) | Pasture cultivar | 2015/16 Seeding rate (kg/ha) | 2015 Seed yield (kg/ha) | 2016 Regen Establish (plants/m$^2$) | 2016 Biomass (tDM/ha) | 2016 Seed yield (t/ha) |
|---|---|---|---|---|---|---|
| 1 (2015) | Harbinger medic pods | 10 | 23 | 55 | 2.9 | 1.19 |
| 1 (2015) | Serradella pods | 9 | 0 | 42 | 3.5 | 1.45 |
| 2 (2015) | PM250*medic | 2 | 72 | 160 | 3.4 | 1.28 |
| 2 (2015) | Jaguar medic | 2 | 50 | 145 | 2.7 | 1.15 |
| 1 (2015) | Bartolo bladder clover | 4 | 38 | 24 | 1.7 | 1.88 |
| 2 (2015) | Volga vetch | 10 | 17 | 6 | 2.3 | 1.86 |
| 3 (2016) | Jaguar medic pods | 45 | | 53 | 2.3 | 1.02 |
| 3 (2016) | Serradella pods | 15 | | 1 | 0.6 | 0.48 |
| 4 (2016) | PM250*medic | 5 | | 111 | 3 | 1.43 |
| 4 (2016) | Jaguar medic | 5 | | 77 | 3.1 | 1.20 |
| 3 (2016) | Bartolo bladder clover | 8 | | 2 | 0.3 | 0.12 |
| 4 (2016) | Volga vetch | 20 | | 37 | 4.7 | 3.75 |
| | *LSD (P=0.05)* | | | *38.1* | *0.67* | *0.55* |

**PM 250 is a powdery mildew tolerant Harbinger type strand medic*

*Table 2 2015 and 2016 seeding rates (kg/ha), 2015 seed yield (kg/ha), 2016 plant regeneration and establishment (plants/m²) biomass (tDM/ha) and seed yields (t/ha) of forage legumes undersown as pods or seed to barley in 2015 or as monocultures in 2016 on the loam soil type*

| Establish. Method (loam soil type) | Pasture cultivar | 2015/16 Seeding rate (kg/ha) | 2015 Seed yield (kg/ha) | 2016 Establish (plants/m²) | 2016 Biomass (tDM/ha) | 2016 Seed yield (t/ha) |
|---|---|---|---|---|---|---|
| 1 (2015) | Harbinger medic pods | 10 | 28 | 59 | 4.2 | 1.35 |
| 1 (2015) | Serradella pods | 9 | 0 | 12 | 4 | 2.08 |
| 2 (2015) | Sultan*medic | 2 | 46 | 34 | 4.8 | 1.65 |
| 2 (2015) | Parabinga medic | 2 | 46 | 55 | 5.1 | 1.7 |
| 1 (2015) | Bartolo bladder clover | 4 | 18 | 23 | 3.5 | 2.0 |
| 2 (2015) | Volga vetch | 10 | 44 | 3 | 2 | 1.84 |
| 3 (2016) | Jaguar medic pods | 45 | | 47 | 4.2 | 1.46 |
| 3 (2016) | Serradella pods | 15 | | 1 | 0.5 | 0.39 |
| 4 (2016) | Sultan*medic | 5 | | 66 | 4.8 | 1.61 |
| 4 (2016) | Parabinga medic | 5 | | 56 | 5 | 1.59 |
| 3 (2016) | Bartolo bladder clover | 8 | | 1 | 0.6 | 0.14 |
| 4 (2016) | Volga vetch | 20 | | 47 | 5.5 | 3.74 |
| | *LSD (P=0.05)* | | | *20.2* | *0.82* | *0.51* |

** Sultan is a sulfonylurea tolerant barrel medic.*

For the seed to further soften over the summer autumn period, and when coupled with burial by livestock or mechanically by late autumn, high establishment numbers should result. This method was not successful in this study, maybe due to insect seed collection or possibly soft seed imbibition following 4.5 mm of rainfall on 18 March.

Further support for expanding the use of forage legumes is the opportunity to harvest an on-farm seed supply. The vetch yielded more than 1 t/ha in Year 2. However vetch contaminated the oversown barley crop above acceptable grain receival levels and did not regenerate successfully in 2016. This probably restricts its use to being a sown as a monoculture.

Potential alternatives to vetch for on-farm seed supply include Jaguar annual medic pods. It was initially promoted for its inherent plant pod retention capability and the opportunity to harvest pods with a normal header. However, it did not yield adequate commercially harvested seed pods at the trial site in 2016, making the use of the medic seedpod sowing strategy problematic, though previous research has reported useful Jaguar plant pod harvest yields. One possibility of the issues encountered during the harvesting process is that the supplied trial seed was inadvertently Herald or Angel strand medics, which are very similar in appearance.

The aerial seeded serradella mixture and bladder clover, seedpod and seed yield respectively, were limited to approximately 100 kg/ha. These sites received above average growing season rainfall in 2016, so these yields may cast doubt on the capacity of these species to produce economic on farm seed yields in this environment. However, based on the serradella and bladder clover yields collected from the soil surface, 1.5 to 2 t/ha, there would seem to have been loss issues with the harvesting process as the pods and seed heads were retained on the plant.

In terms of the performance of the pasture types the vetch sown as a monoculture in 2016 was as, or even more productive than, all other entries. The serradella was shown to be well adapted to the deeper sandy soils with production comparable to the medics from only 30% the plant population. These soils are currently being sown to lupins, and serradella may provide an alternative lower cost option for mixed farmers if the seed can be harvested economically on farm. The Bartolo was comparable in performance to the serradella on the loam site and less productive on the sand site, which indicates the relative adaptation traits of the two pastures with serradella suited to sands and bladder clover to loams.

The medic species either undersown or sown as monocultures performed similarly, the barrel medics Sultan and Parabinga on the loam, and the strand medics Jaguar and PM250 on the deeper sand. Their individual advantages are based on their specific attributes; sulfonylurea tolerance of Sultan, powdery mildew tolerance of PM250, which was clearly evident in the high rainfall September 2016, and the pod retention of Jaguar, although not evident in 2016 it has been previously reported.

## Acknowledgements

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Pastures

Section Editor:
**Mariano Cossani**
SARDI, Minnipa Agricultural Centre

# Section 8

# Soils

## Heavy trafficking gives Rhizoctonia a headache

**Nigel Wilhelm**
SARDI, Minnipa Agricultural Centre

RESEARCH

**Searching for answers**

**Location:**
Minnipa Agricultural Centre, paddock S3S
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
**Yield**
Potential: 4.0 t/ha (B)
Actual: 3.7 t/ha
**Paddock History**
2015: Scepter wheat
2014: Medic pasture
2013: Medic pasture
**Soil Type**
Calcareous red sandy loam
**Plot Size**
50 m x 3 m x 4 reps

### Key messages

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

### Why do the trial?

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

This article summarises the first two years of crop performance after trafficking was imposed on a red calcareous sandy loam at Minnipa Agricultural Centre (a detailed summary of 2015 results can be found in the EPFS Summary 2015, p197). Three other trials similar in design and monitoring have also been implemented across the LRZ – on a deep sand at Loxton (SA), a brown loam near Swan Hill (Vic) and on a deep red earth at Lake Cargellico (NSW). All these trials will be maintained for at least the five year life of the project.

### How was it done?

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

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

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

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

At Minnipa, trafficking treatments were imposed in April 2015, the wet passes and deep ripping following 30 mm of rainfall. Scepter wheat was grown in 2015.

In 2016, Fathom barley was sown on 19 May at 65 kg/ha and with 60 kg/ha of DAP 18:20:0:0 without prior cultivation into good seeding conditions. The farm's Horwood Bagshaw precision seeder (knife points) was used and 40 kg/ha of urea was top-dressed on all plots mid-season.

Crop performance was monitored at establishment, for early and late dry matter production and at maturity (grain yield, quality and yield components). Grain harvest was conducted by hand to avoid trafficking from a header on treated plots.

## What happened?

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

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

Establishment of barley was much more even and consistent across all treatments in 2016. Ripping caused seed to be placed a little deeper than the control (56 mm vs 42 mm) and multi trafficking wet a little shallower at 34 mm (Table 1). Plant populations were the same in all treatments and averaged 99 plants/m$^2$.

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

Trafficking on wet soil in the previous year substantially increased the yield of barley in 2016 by more than 0.7 t/ha (Table 1). Ripping and trafficking on dry soil resulted in grain yields similar to the control of 2.9 t/ha. Barley produced more grain after trafficking due to more fertile heads in the crop. The number of grains per head and 1000 grain weight were similar for all treatments. Grain proteins in 2016 were all high in the trial and similar to the control except for deep ripping which was more than 2% higher than the control (13.2%), suggesting that the crop after ripping had accessed N reserves which the control had not.

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

Soils

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

| | Grain yield (kg/ha) | Depth of seeding (mm) | Rhizoctonia severity (0: none, 5: severe) | Heads per m$^2$ | No of grains per head | 1000 grain weight (g) | Grain protein (%) |
|---|---|---|---|---|---|---|---|
| Control | 2923 | 42 | 3.8 | 353 | 21 | 39 | 13.2 |
| Single trafficking on dry soil | 3366 | 45 | 4.0 | 438 | 20 | 39 | 12.9 |
| Single trafficking on wet soil | 3773 | 42 | 1.8 | 458 | 21 | 39 | 12.8 |
| Multi trafficking on wet soil | 3696 | 34 | 1.3 | 459 | 21 | 39 | 13.1 |
| Ripping | 3284 | 56 | 2.3 | 449 | 19 | 39 | 15.4 |
| *LSD (P=0.05)* | *562* | *9* | *1.7* | *51* | *ns* | *ns* | *1.0* |

## What does this mean?

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

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

In the second crop after trafficking had been imposed, growth of barley was poorest in the control and Rhizoctonia the most severe. Both forms of soil “conditioning”, trafficking on wet soil and ripping, improved growth during the season and reduced Rhizoctonia. The exception was trafficking on dry soil which has been very similar to the control throughout the two years of the trial so far. Wet trafficking finished very well in 2016, producing 30% more heads than the control and more than 0.7 t/ha of extra grain. Only part of this yield increase with wet trafficking was due to reduced rhizoctonia. Ripping and dry trafficking produced grain yields similar to the control but protein levels in ripping were substantially higher than in any other treatment.

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

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

## Acknowledgements

Thanks to MAC farm staff for the implementation and management of the R site and to Ian Richter and Naomi Scholz for undertaking the monitoring of crop performance and soil condition. GRDC is the major funder of this project, which is managed by the Australian Controlled project code: ACT00004. Traffic Farming Assocation.

Australian Controlled Traffic Farming Association Inc

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

# ‘Farming Acid Soils Champions’ for cost effective management of low soil pH on lower Eyre Peninsula

**Brett Masters**
PIRSA Rural Solutions SA, Port Lincoln

**Searching for answers**

**Location:**
Lower Eyre Peninsula
LEADA, Cockaleechie Landcare group
**Soil Type**
Ironstone loamy soils, coarse sandy soils, red brown earths

## Key messages

- **There are a lot of benefits in farmers gathering to share their experiences and discuss new research/tools for managing production and sustainability constraints.**
- **Soil pH mapping revealed large variations in pH within paddocks on many lower Eyre Peninsula paddocks.**
- **Mapping pH variation can offer large potential savings on the cost of liming compared to uniform application rates, even when the cost of mapping is taken into account.**
- **Microsoft Excel based tools (or computer models) such as the “Lime maintenance calculator” and “Lime cheque”, can be useful in determining the impact of management decisions on soil acidification rates and calculating the most cost effective means of addressing this.**

## Why do the trial?

Soil acidification is a major soil health issue on an estimated 178, 000 ha of agricultural land on lower and eastern Eyre Peninsula. The Natural Resources Eyre Peninsula ‘Farming Acid Soils Champions’ was a pilot project supported by LEADA and the Cockaleechie Landcare Group and funded by DEWNR’s ‘Healthy Soils for Premium Food’ program and the Australian Government’s National Landcare Program which aimed to:

- Build on the knowledge gained through other Natural Resources Eyre Peninsula projects regarding soil acidification rates under agricultural production systems in the region,
- Provide landholders with the knowledge and skills to identify areas of their farm which may be prone to soil acidification,
- Use innovative tools and technologies to develop an action plan for cost effective management of soil acidity on these areas, and
- Encourage landholders to champion effective management of soil acidity by sharing their experiences with other participants and the wider community.

## How was it done?

The project aims were achieved through a series of activities including two workshops and paddock mapping exercises. A total of sixteen landholders, eight from the Cockaleechie Landcare Group and eight from the broader lower Eyre Peninsula district, participated in the program. The first workshop held on 30 March at Cummins gave the participants an overview of the causes and impacts of soil acidity, the influence of soil type and farming system on acidification rates and lime quality and rates. During this workshop participants shared their experiences of treating soil acidity. Participants also undertook a mapping exercise designed to give them the skills to map spatial variability of pH within a paddock using a basic field pH kit and an aerial photograph.

After Workshop 1 each participant identified a case study paddock of around 40 ha, where soil pH was mapped using a Veris pH manager ‘on-the-go’ mapper. The total mapping area for this exercise was 1,080 ha. A second workshop gave participants the opportunity to discuss the mapping results and to trial a number of new excel based tools for managing soil acidity.

## What happened?

The Veris soil pH Manager was used. This machine takes a soil sample every 25 metres with a swath width of 36 metres resulting in 10 to 12 samples per hectare. The machine takes a soil sample at about 8 cm deep which is then raised up to the pH electrodes. Validation has shown that the pH machine readings are about 0.3 to 0.4 higher than pH ($CaCl_2$).

Soil samples were taken from each of the case study paddocks and sent for laboratory analysis to validate the Veris pH readings. Comparison of pH values from the Veris machine against laboratory analysis of soil pH ($CaCl_2$) had a strong correlation (Figure 1).

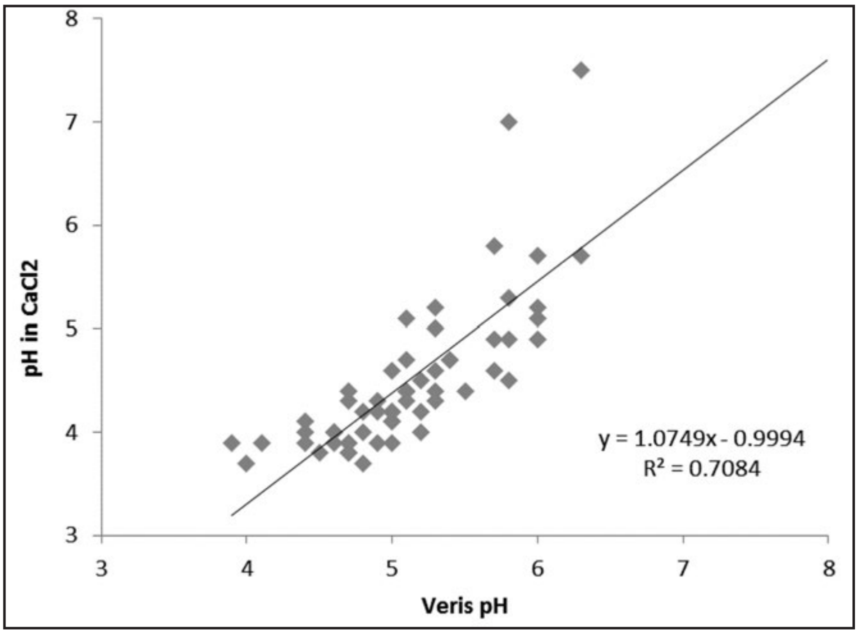


*Figure 1 Regression analysis Veris machine pH readings against pH ($CaCl_2$)*

A detailed map of pH zones was generated from the results. Mapping revealed a high degree of pH variation within and between paddocks with the pH within each paddock differing by an average of 3.5 pH units for the 16 sites. The amount of mapped land falling into different pH ranges is detailed in Table 1.

The mapping revealed that 64% of the area mapped was below the target pH of 5.5 ($CaCl_2$) with 33% (366 ha) below pH 5.0 ($CaCl_2$).

The lowest pH value, adjusted to pH ($CaCl_2$) was 3.5, but many paddocks also contained alkaline areas (97 ha or 9% of the total area mapped). The pH maps allowed a prescription lime map to be generated for different pH zones in the paddock.

From this exercise, the potential savings on the cost of lime application when following the prescription map could be compared to the costs of applying a uniform rate of lime over the whole paddock. A lime rate of 2.5 t/ha was chosen as the uniform application rate for this analysis. This rate was chosen as;

- It is a rate commonly used by farmers in the district when spreading lime.
- It accords with the 10 year replacement lime requirement modelled for typical farming systems and soil types in the district.

On average the forecast potential cost saving, even when the cost of mapping, lime, freight and application was accounted for, was $2,242 per paddock (41% of the cost of lime applications). The lowest cost savings were on those paddocks with a higher proportion of acid soils, as the calculated lime required from pH mapping was not much different to a uniform application rate on these paddocks. The highest potential savings were on those paddocks with a high degree of variability, particularly those with a significant proportion of alkaline soils within them.

Three Microsoft Excel based tools (Lime Cheque, Maintenance Lime Calculator and Acid$Cost) developed by PIRSA consultants were demonstrated during the second workshop. These tools provide ways to compare the cost of liming using different lime sources, calculate the rate of lime required to counteract acidification resulting from agricultural practices on a paddock, and estimate the cost of lost production in a paddock over time as a result of soil acidity. These tools can be downloaded from the Ag Excellence Alliance website (http://agex.org.au/project/soil-acidity/).

*Table 1 Paddock area for different pH ranges*

| pH Range ($CaCl_2$) | Area (ha) | Area (%) |
|---|---|---|
| <4.4 | 90 | 8 |
| 4.5 – 4.9 | 276 | 25 |
| 5.0 – 5.4 | 323 | 30 |
| 5.5 – 5.9 | 160 | 15 |
| 6.0 – 6.4 | 96 | 9 |
| 6.5 – 6.9 | 44 | 4 |
| >7.0 | 97 | 9 |
| Total area | 1080 | 100 |

Landholder paddock information was entered into the 'Maintenance Lime Rate Calculator' with the estimated annual lime replacement to offset acidification ranging from 175 to 340 kg lime/ha/year and an average of 264 kg lime/ha/year depending on soil type, crop type and yield and nitrogen inputs. Modelling showed that the biggest contributor to soil acidification on these paddocks was nitrogen fertiliser (up to 95% of the total lime replacement lime requirement), with those sites that included a grain legume/legume pasture having lower acidification rates than cereal/oilseeds rotations, which require almost all of the crop nitrogen to be applied as fertiliser.

## What does this mean?

- The field mapping exercise with farmers indicated that mapping does not need to be complicated or cost-prohibitive. Using a simple field pH kit and marking results on an aerial photograph of the paddock can provide a useful guide to pH variation within a paddock.
- However, an 'on-the-go' machine as the Veris pH mapper can cost effectively improve mapping resolution for target prescription variable rate applications with potential to improve the cost effectiveness of liming operations by 41% on the case study paddocks.
- With appropriate calibration, there was a good correlation ($R^2$=0.71) between pH values between laboratory analysis of soil samples and the Veris machine on acidic soils on lower Eyre Peninsula. This provides landholders confidence to use the results in their decision making.
- Although paddocks mapped with a high proportion of acidic soils have low cost-savings from prescription lime applications compared to a uniform rate of 2.5 t/ha, additional benefits could be gained from pH mapping as the effectiveness of lime applications is improved by targeting lime applications to different pH zones.
- In paddocks with a high proportion of alkaline soils, analysis indicated very large (up to 75%) potential cost-savings of liming according to prescription maps compared to uniform application rates. However, this may not reflect the true cost-savings as it is likely that some farmers would recognise that some areas of the paddock would not require as high a lime rate as others and may not have applied a uniform 2.5 t/ha rate of lime over the whole paddock.
- The findings from this project accord with earlier surveillance sampling and modelling results suggesting that the lime requirement to offset acidification caused by agricultural production on the acid prone soils of lower Eyre Peninsula is in the order of 264 kg of replacement lime/ha/year.

## Acknowledgements

The author wishes to acknowledge funding from DEWNR 'Premium food from resilient soils', the Australian Government's National Landcare project, and Natural Resources Eyre Peninsula, LEADA and the Cockaleechie Landcare Group for supporting this pilot program. Thanks to Kym I'Anson (I'Anson Farms, Saddleworth) for mapping the case study paddocks, Andrew Harding (PIRSA Rural Solutions, Clare) and Mary Crawford (Natural Resources Eyre Peninsula) for their input into the workshops and landholder participants for their commitment and enthusiastic participation in the program.



LEADA Lower Eyre Agricultural Development Association

Government of South Australia Eyre Peninsula Natural Resources Management Board

Australian Government

Government of South Australia Department of Environment, Water and Natural Resources

Government of South Australia Primary Industries and Regions SA

# Overcoming subsoil constraints to increase soil carbon in Eyre Peninsula soils

RESEARCH

**Brett Masters and David Davenport**
PIRSA Rural Solutions SA, Port Lincoln

**Searching for answers**

**Location:**
Crossville, Ungarra & Cockaleechie. Francis Beinke, Jamie Phillis, Terry Young, Geoff & Jim Holman
**Plot Size**
Large plot trial 20 m x 8 m x 3 reps
**Yield Limiting Factors**
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 appropriate soil modification and ameliorant applications, but the response depends on site and treatment.**
- **Knowledge of the characteristics of the soil profile at depth is vital for determining an appropriate and effective management strategy.**
- **Whilst surface application of lime and gypsum can have impact on addressing soil constraints, better results are achieved through the incorporation of these ameliorants and organic matter into the constrained soil layer.**
- **The development of appropriate and affordable machinery to effectively deliver soil ameliorative tools into constrained soil layers on a broadacre scale is required.**

## Why do the trial?

Around 40% of soils under agricultural production on Eyre Peninsula have subsoil constraints, including bleached A2 horizons and sodic layers that limit crop and pasture production. These soils also have low soil organic carbon (SOC) levels that negatively affect soil physical and biological function and impact on crop production. Deep ripping of poorly structured soils and the addition of clay to sandy soils can improve productivity, but results have been inconsistent (EPFS Summary 1999 p72, EPFS Summary 2000 p105, EPFS Summary 2005 p129, EPFS Summary 2010 p154, EPFS Summary 2011 p166, EPFS Summary 2014 p207, EPFS Summary 2015 p205). These trials were funded through the Australian Government Action on Ground program and aim to find more efficient methods to address the constraints to production and to increase SOC, thereby offsetting carbon dioxide emissions.

## How was it done?

A set of trials with different sites, soils, treatments were established in 2014 (Table 1).

Trials were monitored throughout the 2014 and 2015 season with data collected for plant emergence, spring dry matter and crop yield (EPFS Summary 2014 p201 and EPFS Summary 2015 p205). Results from 2014 and 2015 delivered different responses. In 2014, significant yield benefits from the addition and deep incorporation of clay and organic matter to the sandy soil profile were recorded at Young's Ungarra site. The addition of organic matter also provided a biomass response on the sodic soil at the Phillis site. However, there was no significant yield benefit at this location. Results obtained in 2015 also differed between locations and treatments, with no yield benefit from treatments at the Holman and Beinke sites, but with higher yields on all the spaded treatments at Young's, and for the rip+gypsum treatment at the Phillis site. Apart from treatment induced differences, the variability in responses may be due to a number of factors associated with each environment such as seasonal rainfall, hot and windy days at flowering and conditions at grain fill.

## What happened in 2016?

Rains during March 2016 resulted in good stored soil moisture levels at all sites. Further rain in April and May provided ideal conditions for sowing and crop germination at all sites except the Beinke site that was in a ley pasture.

Plant density was evaluated in early June. Significant difference in crop germination between treatments was only observed on the Young site, where the shallow clay treatment had significantly higher plant density at emergence than the control (Figure 1).

*Table 1 Summary of replicated trial sites*

| Co-operator / Location | Soil type | 2016 crop | Measurement | Treatments (applied prior to seeding 2014) |
|---|---|---|---|---|
| **Beinke, FB Crossville** | Alkaline red brown earth | Grazed pasture | No measurements taken in 2015 as grazed medic pasture | 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 | Wheat | Plant emergence, dry matter, 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 | Vetch | Plant emergence, dry matter, crop yield | Untreated, spaded, clay spreading (250 t/ha) with shallow incorporation, 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 | Wheat | 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) |

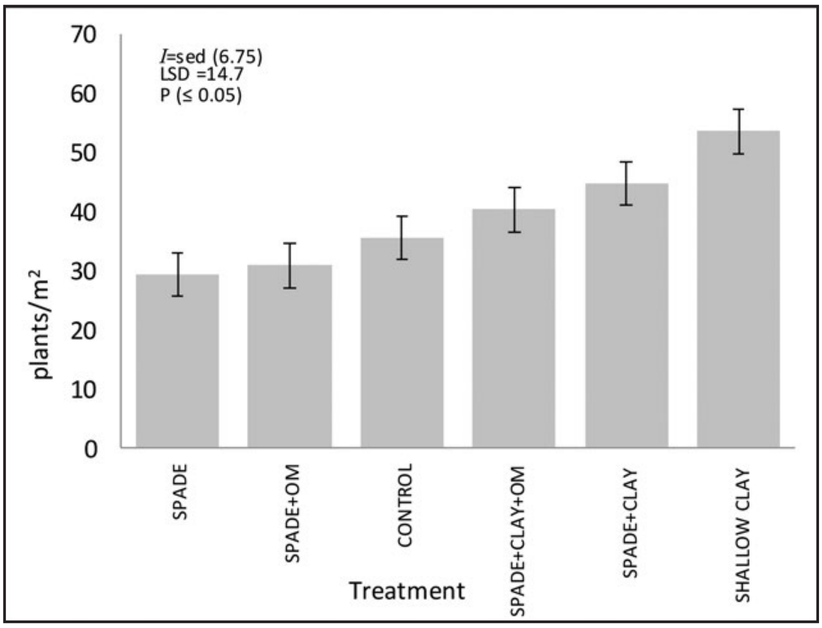


***Figure 1 Plant densities at crop establishment at Young's in 2016 (OM = organic matter)(error bars indicate standard error difference of two means)***

Soils

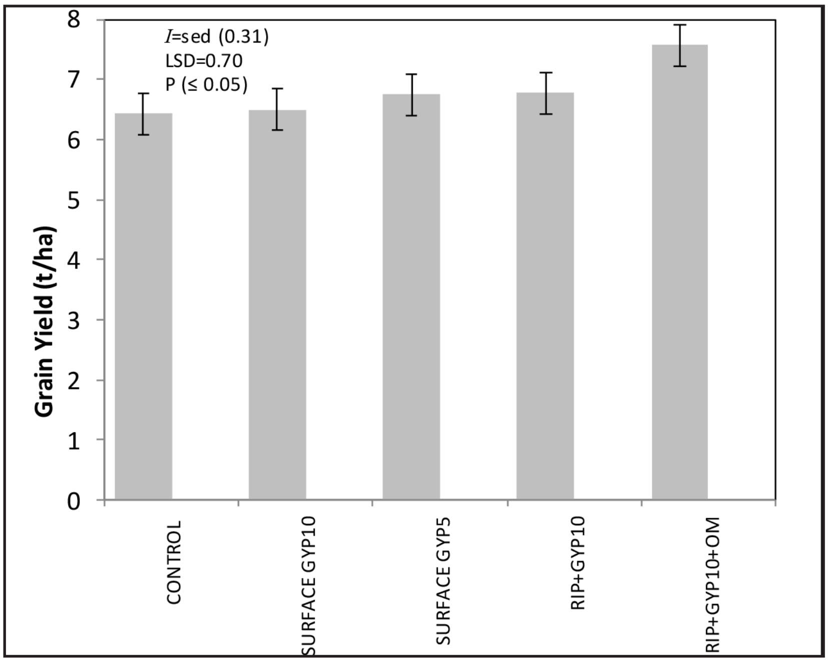


***Figure 2 Wheat yield at Phillis site, Ungarra in 2016 (OM = organic matter) (error bars indicate standard error difference of two means)***

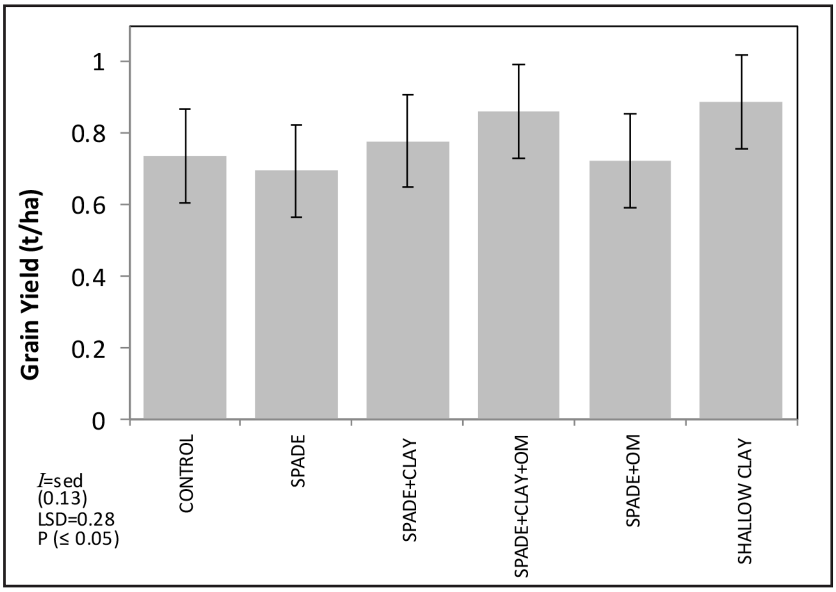


***Figure 3 Vetch yield at Young's site, Ungarra in 2016 (OM = organic matter)(error bars indicate standard error difference of two means)***

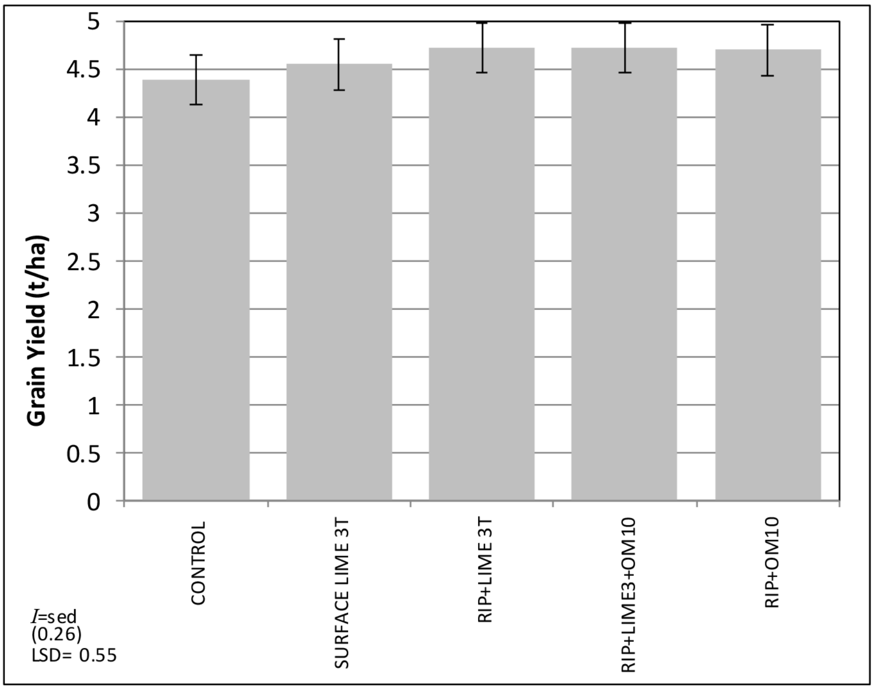


***Figure 4 Wheat yield at Holman site, Cockaleechie in 2016 (OM = organic matter)(error bars indicate standard standard error difference of two means)***

Regular rainfall events kept the soil profile damp but not waterlogged and all trials had a high yield potential at the end of winter.

Biomass at flowering time did not show significant differences between treatments at any location.

At the Phillis site only the ripping+gypsum+organic matter treatment provided significantly higher yields than the other treatments and the control (Figure 2).

Treatments at Young and Holman site did not show significant differences (Figure 3 and 4).

## What does this mean?

Results from this experiemental year have shown no significant difference in biomass and yield.

A major influence increasing yields on soils with subsoil constraints is considered to be improved access to soil water. Above average rainfall in 2016 ensured that water was not limiting crop growth and may explain the evenness of the treatments and control.

Also the improvements to soil physical properties as a result of treatments may take time to develop and may not yet be realised. Soil analyses yet to be finalised may provide some data to answer these questions. This soil analysis will also determine the impact of soil modification treatments and soil amerliorants on soil bulk density and soil organic carbon.

These trials support earlier work which suggests that that whilst modification of soils with severe production constraints can increase biomass and grain yield, results are highly variable and it can take some time following modification to see benefits.

Key questions that remain unanswered include;

- 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 and benefits of these treatment options?

It is hoped that detailed analysis of soil samples taken in January 2017 will provide information on the implications of treatments on soil carbon stocks. A cost benefit analysis of crop response to the treatments over the three years of the project will be undertaken.

## Acknowledgements

The authors would like to thank the landholders involved in this project; Francis Beinke, Jamie Phillis, Terry Young and Geoff and Jim Holman. This project is supported by Natural Resources Eyre Peninsula with funding from the Australian Government.

Soils

Government of South Australia
Department of Environment, Water and Natural Resources

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Section Editor:
Mariano Cossani
SARDI, Minnipa Agricultural Centre

# Section 9

# Nutrition

## Effectiveness of in-season soil sampling and testing for optimising nitrogen inputs – make every drop count

**Sean Mason[1], Andy Bates[2] and Sam Holmes[3]**
[1]Agronomy Solutions; [2]Bates Ag Consulting; [3]Holmes Farm Consulting

**Searching for answers**

**Location:**
Lock
Jeffery and Caroline Longmire
**Rainfall**
Av. Annual: 391 mm
Av. GSR: 296 mm
2016 Total: 371 mm
2016 GSR: 288 mm
**Yield**
Potential: French/Schultz model, assuming no stored summer moisture, potential was 3.56 t/ha.
Actual: Best treatment in N Trial was 3.78 t/ha or 106% of potential without including any stored summer moisture
**Paddock History**
2016: Mace wheat
2015: Cobra wheat
2014: Stingray canola
2013: Fleet barley
**Soil Type**
Sandy loam over clay
**Plot Size**
18 m x 18 m x 3 reps

### Key messages

- **In season N testing using existing lab techniques (mineral N) was well correlated with yield responses to N applications applied both at sowing and at GS30.**
- **Sampling and testing in the crop row is more accurate than between rows and could be more widely utilised to assist nitrogen input decisions mid-season.**
- **Incorporating the root zone (0-60 cm) ammonium levels may improve the accuracy of the correlation between in season soil N levels and yield.**
- **In season application of nitrogen was more efficient at producing wheat grain responses compared to inputs at sowing.**

### Why do the trial?

To improve the accuracy of nitrogen (N) decision making, advisors are increasingly acknowledging the potential benefits of testing for soil N status in crop, and close to the period of peak demand for the target crop. This is an attempt to better account for in season mineral N dynamics that are difficult to predict, and can vary significantly depending on season, soil type, and previous crop rotations. Unfortunately, the current turnaround times from initial sampling to receiving results, and the infrequent and unpredictable conditions suitable for post emergent N application, leave little room for flexibility in N management.

A portable N unit using ion selective electrodes (ISE) has been recently developed which offers the prospect of rapid, real time, on site testing. This new technology may potentially overcome the delays and costs involved in traditional standard laboratory soil nitrate measurements. This project assessed the accuracy and reliability of a portable ISE in field nitrate testing unit under Southern Australian field conditions. In addition to correlating an in-field assessment of soil nitrate with laboratory nitrate measurements, the project investigated spatial differences in nitrate readings from sampling soil (in crop) either at the inter-row or in-row, to establish a basic protocol for sampling. The results were compared with crop performance (grain yield) from two N response trials at Lock and Maitland for their relative ability to estimate in crop N status.

## How was it done?

Two nitrogen response trials were performed at Lock (Eyre Peninsula) and Maitland (Yorke Peninsula) in order to test the different procedures for measuring soil N. The Lock trial was sown with Mace wheat on 26 May 2016 at a seeding rate of 180 seeds/m$^2$ which equates to 72 kg/ha. Triple superphosphate was applied to supply adequate phosphorus levels to the wheat @ 100 kg/ha which was banded below the seed at sowing. Different nitrogen rates were applied as urea and replicated three times. The urea was applied at either sowing or at GS30 which occurred on 8 August, as the following treatments:

1. Nil (P only)
2. 15 kg N/ha as urea below seed
3. 25 kg N/ha as urea below seed
4. 35 kg N/ha as urea below seed
5. 70 kg N/ha as urea below seed
6. 15 kg N/ha as urea spread at GS30
7. 25 kg N/ha as urea spread at GS30
8. 35 kg N/ha as urea spread at GS30
9. 70 kg N/ha as urea spread at GS30

Six soil samples (0-60 cm) were taken from each plot in season approximately two weeks after the N application at GS30, combined and analysed for soil nitrate through ISE and Mineral N (nitrate + ammonium) at the laboratory. Two sampling strategies were implemented with soil samples taken from in-between the crop rows and analysed separately from soil samples taken within the crop row. Soil N measurements were correlated with increases in crop growth (expressed as % relative yield) using a Mitscherlich function to assess the accuracy of the two different soil testing techniques and two different soil sampling strategies.

The Maitland trial was performed in accordance with the Lock trial, the only difference was the N rates were higher (0, 25, 50, 75 and 140 kg N/ha).

## What happened?

The Lock trial was moderately responsive to N applications (Figure 1) typical of a relatively favourable climatic season for growth responses to N fertiliser. In season (GS30) applications were significantly ($P < 0.05$) more effective at promoting a growth response compared to the same rates applied at sowing (Figure 1). In season applications of N were highly effective resulting in an optimal N rate 27 kg N/ha to produce 90% of the yield response (yield (0N) – 2.13 t/ha, yield (maximum) – 3.79 t/ha).

Significant ($P < 0.05$) correlations were obtained for both methods of measuring soil nitrate and both sampling regimes with crop response (expressed as relative yield %) incorporating results from both trials (Table 1). Moderate improvement in accuracy compared to the ISE method occurred when the samples were tested for nitrate in the laboratory using the mineral N procedure and another additional improvement was obtained when samples were concentrated within the root zone compared to focusing samples between crop row (apart from soil ammonium). In-season testing also accurately reflected available N generated by both application strategies. As the mineral N lab method also measures soil ammonium levels this provided an opportunity to assess the importance of including ammonium levels when making fertiliser N decisions. Significant ($P < 0.05$) correlations were obtained between soil ammonium and crop response potentially due to the climatic conditions experienced during sampling. Overall, the best indicator of available nitrogen levels in the soil after recent applications of N fertiliser was when both nitrate and ammonium were included in the result (Table 1, Figure 2). Currently, the in-field testing method of N is unable to measure ammonium which appears to be an important consideration when measuring soil N levels after recent applications of fertiliser. Higher ammonium levels compared to nitrate levels were found for the most recent N application timing (GS30), in which sampling was potentially still capturing the conversion of ammonium to nitrate even after two weeks' post application.

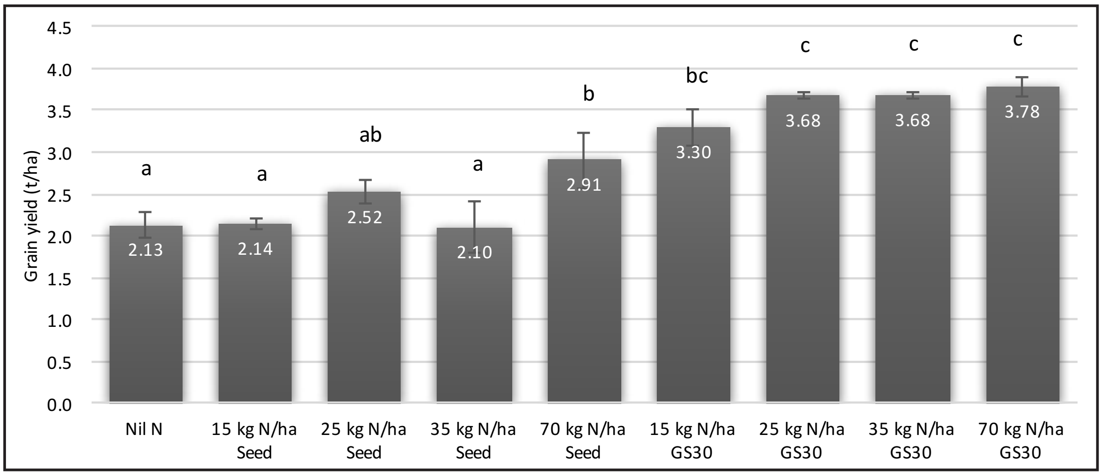


***Figure 1 Yield responses in association with 4 different rates of nitrogen application (as urea) at two different timings (sowing and GS30) at Lock. Trial stats: Relative yield = 56%, Optimal N = 27 kg/ha, P < 0.01, LSD = 0.553***

Nutrition

*Table 1 Relationships (presented as $R^2$) between relative yield and the different soil sampling strategies, and soil nitrogen testing parameters. Critical values were determined at the intercept of 90% relative yield*

| | Sampling area | Coefficient of determination ($R^2$) | Critical value (mg/kg) |
|---|---|---|---|
| **Ion Selective Electrode** | Inter-row | 0.53 | 8.6 |
| | Row | 0.62 | 7.8 |
| **Mineral N - Nitrate** | Inter-row | 0.56 | 7.7 |
| | Row | 0.75 | 7.0 |
| **Mineral N – Ammonium** | Inter-row | 0.25 | 5.0 |
| | Row | 0.47 | 8.1 |
| **Mineral N – Nitrate + Ammonium** | Inter-row | 0.75 | 10.2 |
| | Row | 0.86 | 12.0 |

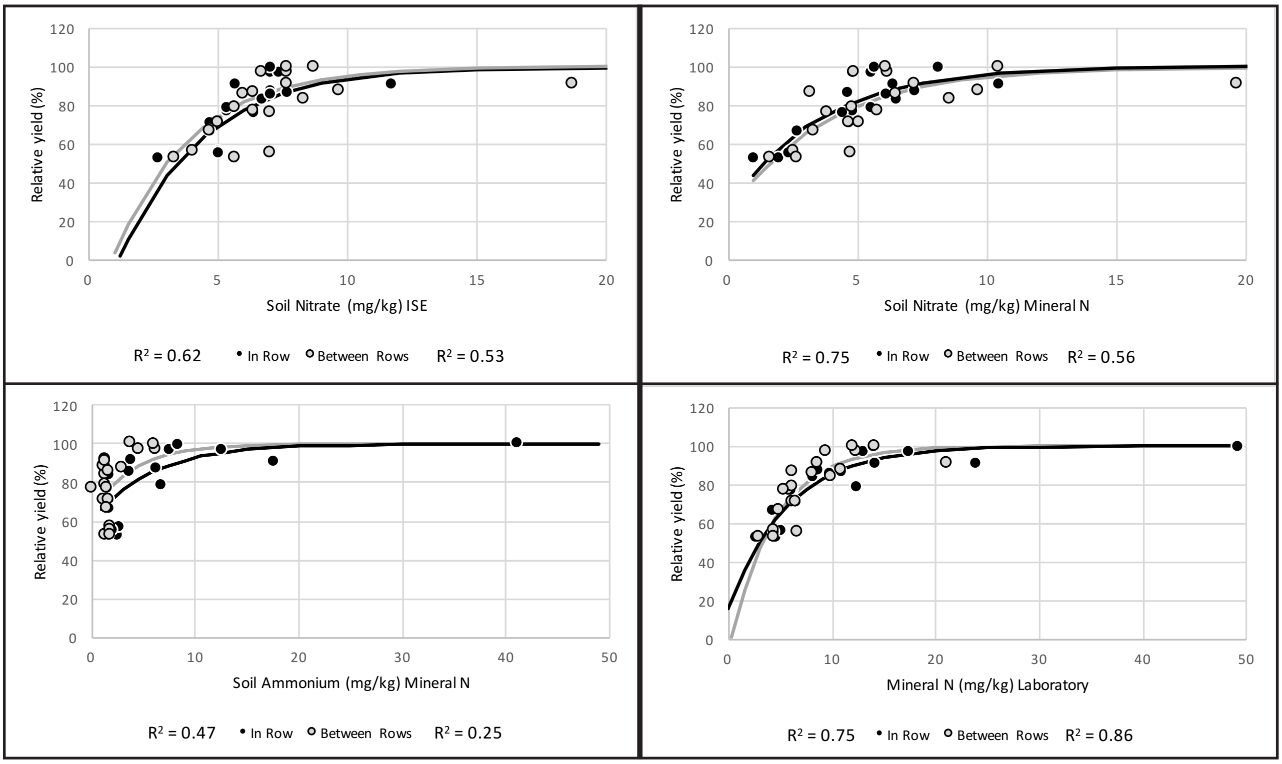


*Figure 2 Relationship between soil nitrate ISE (top left), soil nitrate lab (top right), soil ammonium lab (bottom left) and mineral N lab (bottom right) and yield response to N applications for two N response trials. Closed symbols represent in row sampling while open symbols represent between-row sampling within the crop canopy*

## What does this mean?

In season deep soil N testing using existing lab techniques (mineral N) was well correlated with wheat grain responses to N applications both at sowing and in-season (GS30) in a relatively favourable climatic season. Incorporating the root zone (0-60 cm) ammonium levels may improve the accuracy of the correlation between in season soil N levels and yield, especially after recent applications of N fertiliser. Sampling and testing in the crop row is more representative than between rows and could be more widely utilised to assist nitrogen input decisions mid-season. Conventional methods (mineral N) for assessment of soil available N are currently more accurate than the portable nitrate ion specific electrodes. However, ISE methods were able to determine available N within the first 60 cm in a less costly and fastest option while explaining at least 53% of the variability in yield response to N. To build strength in determining the accuracy of in-season sampling, further field studies like this across different climatic seasons are needed.


## Acknowledgements

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

# Manganese applications did not improve cereal yields in 2015 and 2016

**Sjaan Davey[1], Nigel Wilhelm[1], Terry Blacker[2], Amanda Cook[3] and Ian Richter[3]**

[1]SARDI, Waite; [2]SARDI, Port Lincoln; [3]SARDI, Minnipa Agricultural Centre

RESEARCH


## Key messages

- **There was no increase in wheat (2015) or barley (2016) performance with application of manganese on highly calcareous sands, even though these environments have regularly produced severe Mn deficiency in the past.**
- **Current industry guidelines still appear to be relevant for diagnosing trace element deficiencies in cereal crops and how they are best managed.**

## Why do the trial?

There has been concern raised across the grains industry that:

1. strategies for managing trace element deficiencies are less well known than those for managing nitrogen and phosphorous deficiencies, and
2. trace element supplies in soils may not be adequate for current, more productive and more intensive cropping systems.

The reality is that trace element management packages for manganese (Mn), zinc (Zn) and copper (Cu) were developed 20-40 years ago in substantially different cropping systems. Speculation that these packages need to be reviewed and adapted to current farming systems, economic climate and the new cropping areas has driven two GRDC funded projects to investigate trace element deficiencies in the Australian cropping zones – one for Western Australia and one for the rest of the cropping zone. These two projects are assessing the current extent and severity of trace element deficiencies in typical cropping situations and also reviewing management guidelines for their effectiveness.

Trials investigating Zn, Mn, Cu and boron deficiencies have been conducted across the cropping zone of Australia over the last three years, including many on Eyre Peninsula. This article summarises the outcomes of several Mn trials conducted on upper Eyre Peninsula over the last two years.

## How was it done?

Trial sites at Streaky Bay and Tooligie on highly calcareous sands with a known history of Mn deficiency were selected in 2015 and 2016. These sands have traditionally produced severe Mn deficiency in crops and pastures in most years. These small plot replicated trials were to evaluate Mn fertiliser rates and application strategies in a current variety of wheat or barley and had from 6 to 22 different Mn fertiliser strategies applied.

Each site was sampled for its soil Mn status prior to seeding. In season sampling included establishment counts, plant dry weights, and two timings of leaf samplings (youngest emerged blades, YEBs) for nutrient analysis. Grain yield data was assessed at maturity.

Data were analysed using Analysis of Variance in GENSTAT.

## What happened?

None of the trials conducted in 2015 or 2016 recorded a response in grain yield to the addition of Mn in any form or timing (which also occurred for several trials conducted in the Coffin Bay area on the same soil type, another traditional area for severe Mn deficiency). Seeding applications of Mn did not affect establishment in any trials.

In 2015 YEBs of wheat at late tillering had an average of 27 mg Mn/kg at Streaky Bay, which is above deficiency levels in the existing guidelines and in a later sampling were still 29 mg Mn/kg. Grain yield averaged 1.2 t/ha, regardless of treatment.

In 2016 for barley at Streaky Bay, YEBs had an average of 19 mg Mn/kg and 13 mg Mn/kg, respectively for similar growth stages to the wheat trial. These levels are also above current thresholds for deficiency (10-15 mg Mn/kg at late tillering). None of the manganese treatments had an effect on yield, the site mean was 2.7 t/ha.

The barley trial at Tooligie in 2016 had slightly lower YEB values taken at similar stages to the Streaky Bay trials, 14.5 and 11.8 mg/kg respectively. These levels are considered marginal for barley so the outcome that all treatments yielded about 2.7 t/ha (i.e. no response) is not inconsistent with the plant testing guidelines.

## What does this mean?

The outcomes from these Mn trials do not contradict the current guidelines where YEB values of greater than 15 mg Mn/kg at tillering (the first tissue sampling) indicate adequate manganese status and thus are unlikely to respond to additional Mn fertiliser.

For other trials in this project targeting Zn or Cu, similar findings have been made; existing guidelines for interpreting soil and plant tests appear to be still relevant to current cropping systems.

In the absence of crop responses to fertiliser strategies it is not possible to evaluate the effectiveness of management options so this component of the project could not be completed with these Mn trials.

This project has highlighted the difficulty in finding trace element deficient sites in current cropping systems and that tissue testing continues to be the best form of monitoring for trace element deficiencies. The most extreme example has been our experiences on the highly calcareous sands along the west coast of Eyre Peninsula. This environment was the “go to” region for field-based Mn deficiency research conducted in the 1980s and 1990s and many trials over those decades recorded frequent and extreme deficiencies in crops.

We have not found any Mn responses in our attempts over the last 3 years which raises questions whether systems have changed sufficiently that Mn deficiency is no longer as severe or prevalent as it once was. Better weed control, improved disease management, more adapted varieties, and in particular earlier seeding, all encourage better early growth and root development. With improved root systems, crops would scavenge more effectively for Mn in the soil and potentially avoid Mn deficiency. Or perhaps we were just unlucky!

## Acknowledgements

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# 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
Amicide625 - 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

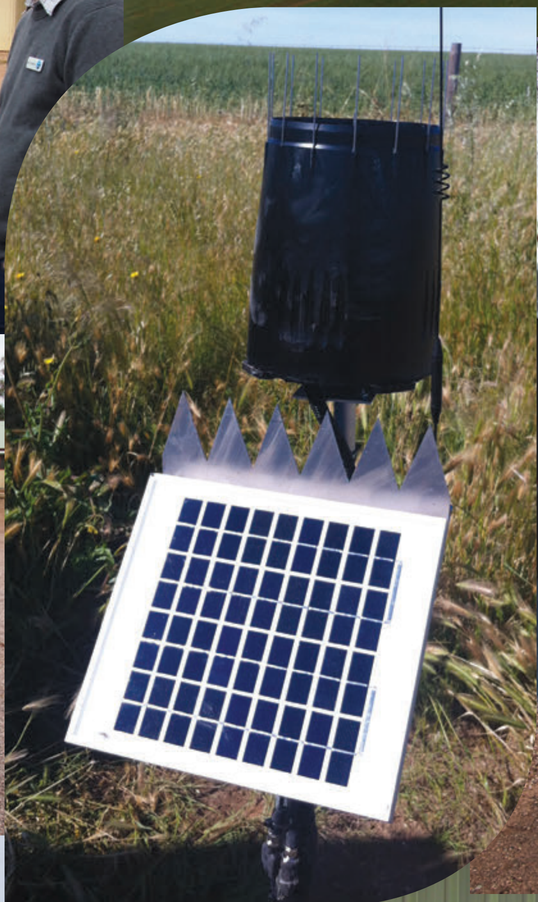
| Name | Position | Location | Address | Phone Number | E-mail |
|---|---|---|---|---|---|
| **Bates, Andy** | Principal Consultant | Bates Agricultural Consulting | PO Box 137<br>Streaky Bay SA 5680 | Mob 0427 261 709 | batesag@bigpond.net.au |
| **Brace, Dot** | Executive Officer | EPARF | PO Box 31<br>MInnipa SA 5654 | Ph (08) 8680 6202 | dot.brace@sa.gov.au |
| **Cook, Amanda** | Research Officer | SARDI<br>Minnipa Agricultural Centre | PO Box 31<br>Minnipa SA 5654 | Ph (08) 8680 6217 | amanda.cook@sa.gov.au |
| **Crettenden, Jessica** | Research Officer | SARDI<br>Minnipa Agricultural Centre | PO Box 31<br>Minnipa SA 5654 | Ph (08) 8680 6227 | jessica.crettenden@sa.gov.au |
| **Cossani, Mariano** | Research Scientist | SARDI<br>Minnipa Agricultural Centre | PO Box 31<br>Minnipa SA 5654 | Mob 0437 828 185 | mariano.cossani@sa.gov.au |
| **Davis, Leigh** | Accounts Manager Agronomy | Landmark, Wudinna | PO Box 32<br>Wudinna SA 5652 | Mob 0438 679 267 | megsy.davis@landmark.com.au |
| **Day, Sarah** | Research Officer | SARDI<br>Field Crop Improvement Centre | PO Box 822<br>Clare SA 5453 | Ph (08) 8842 6264 | sarah.day@sa.gov.au |
| **Dzoma, Brian** | Research Officer | SARDI<br>Minnipa Agricultural Centre | PO Box 31<br>Minnipa SA 5654 | Ph (08) 8680 6205 | brian.dzoma@sa.gov.au |
| **Fleet, Ben** | Research Officer<br>Soil & Land Systems | University of Adelaide | PMB 1<br>Glen Osmond SA 5064 | Ph (08) 8313 7950<br>Mob 0417 976 019 | benjamin.fleet@adelaide.edu.au |
| **Frischke, Alison** | Grain & Graze Systems Officer | BCG | PO Box 167<br>Eaglehawk VIC 3556 | Ph (03) 5437 5352<br>Mob 0429 922 787 | alison@bcg.org.au |
| **Guerin, Simon** | Chair | EPARF | Post Office<br>Port Kenny SA 5671 | Ph (08) 8625 5143<br>Mob 0427 255 144 | simonlizguerin@bigpond.com |
| **Hull, Jake** | Farm Manager | SARDI<br>Minnipa Agricultural Centre | PO Box 31<br>Minnipa SA 5654 | Ph (08) 8680 6200<br>Fax (08) 8680 5020 | mark.klante@sa.gov.au |
| **Kleemann, Sam** | Research Officer | University of Adelaide | PMB 1<br>Waite Campus<br>Glen Osmond SA 5065 | Ph (08) 8303 7908 | samuel.kleemann@adelaide.edu.au |
| **Latta, Roy** | Specialist - Research & Development | Dogshun Medlin | 348 Campbell Street<br>Swan Hill VIC 3585 | Mob 0428 948 983 | roy.latta1@bigpond.com |
| **Loss, Stephen** | General Manager - Farming Systems, Soils & Agronomy (South) | GRDC<br>National Wine Centre | Hackney Rd & Botanic Rd, Adelaide SA | Mob 0408 412 453 | stephen.loss@grdc.com.au |
| **Low, Megan** | Executive Officer | LEADA | | Mob 0408 412 453 | LEADAEXEC@gmail.com |
| **Mason, Dr Sean** | Research Fellow | University of Adelaide | PMB 1<br>Glen Osmond SA 5064 | Ph (08) 8303 8107<br>Mob 0422 066 635 | sean.mason@adelaide.edu.au |
| **Masters, Brett** | Soil & Land Management Consultant | Rural Solutions SA | PO Box 1783<br>Port Lincoln SA 5606 | Ph (08) 8688 3460<br>Mob 0428 105 184 | brett.masters@sa.gov.au |
| **McMurray, Larn** | Senior Research Agronomist | SARDI - Field Crop Improvement Centre | PO Box 822<br>Clare SA 5453 | Ph (08) 8842 6265 | larn.mcmurray@sa.gov.au |
| **Mudge, Barry** | Principal Consultant | Barry Mudge Consulting | | Mob 0417 826 790 | theoaks5@bigpond.com |
| **Nagel, Stuart** | Research Officer | SARDI Crop Improvement | PO Box 397<br>Adelaide SA 5001 | Ph (08) 8303 9377<br>Mob 0407 720 729 | stuart.nagel@sa.gov.au |
| **Scholz, Naomi** | Project Manager | SARDI<br>Minnipa Agricultural Centre | PO Box 31<br>Minnipa SA 5654 | Ph (08) 8680 6233<br>Mob 0428 540 670 | naomi.scholz@sa.gov.au |
| **Vadakattu, Dr Gupta** | Research Scientist | CSIRO Entomology | PMB 2<br>Glen Osmond SA 5064 | Ph (08) 8303 8579 | gupta.vadakattu@csiro.au |
| **Walela, Christine** | Research Officer | SARDI<br>Field Crop Improvement Centre | PO Box 822<br>Clare SA 5453 | Ph (08) 8842 6264 | christine.walela@sa.gov.au |
| **Wallwork, Hugh** | Principal Cereal Pathologist | SARDI Plant Research Centre | GPO Box 397<br>Adelaide SA 5001 | Ph (08) 8303 9382<br>Mob 0427 001 568 | hugh.wallwork@sa.gov.au |
| **Ware, Andrew** | Research Scientist | SARDI, Port Lincoln | PO Box 1783<br>Port Lincoln SA 5606 | Ph (08) 8688 3417 | andrew.ware@sa.gov.au |
| **Wilhelm, Nigel** | Farming System Leader<br>Scientific Consultant | SARDI<br>Minnipa Agricultural Centre<br>Waite | PO Box 31<br>Minnipa SA 5654<br>GPO Box 397<br>Adelaide SA 5001 | Mob 0407 185 501<br>Ph (08) 8303 9353 (Adel)<br>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 |
| **MED** | Molar Ethanol Droplet |
| **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:



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