# Eyre Peninsula Farming Systems Summary 2017


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# GRDC Foreword

On behalf of the Grains Research and Development Corporation, I have great pleasure in presenting the 2017 Eyre Peninsula (EP) Farming Systems Summary. This annual publication serves an important purpose in extending results and raising awareness regarding the outcomes and insights from the many agricultural research, development and extension (RD&E) activities conducted on the EP each year.

The 2017 season was a challenging one for many farmers in this region – an extremely dry start and variable conditions thereafter made for a trying year, and we can only hope that 2018 brings improved fortunes. The importance of targeted and regionally-relevant RD&E is often underlined during less than favourable seasons when access to knowledge and resources – pertinent to local farming systems – is critical for informed and timely decision-making.

The RD&E priorities of EP farmers are being addressed through a diverse and evolving range of investments and efforts by organisations including the GRDC, the South Australian Research and Development Institute, the University of Adelaide, the South Australian Grain Industry Trust, CSIRO, EP Agricultural Research Foundation, Lower Eyre Agricultural Development Association, EP Natural Resources Management Board and local farm advisers and agribusinesses who collaborate with great commitment and dedication to advance farming systems on the EP.

Whilst regional challenges remain around soil constraints; herbicide resistance; soil moisture conservation; seasonal climatic variability; disease, pest and nutrient management; mixed farming complexities and systems diversity; opportunities also continue to present.

It is therefore imperative that as new knowledge emerges from local RD&E activities, these learnings and advances are extended to growers and advisers as rapidly and effectively as possible to ensure on-farm practice change and adoption of recommendations and new technologies to deliver improved profitability. Much of the latest knowledge generated out of regionally-based research is captured and summarised in this publication and provides food for thought ahead of season 2018 and well beyond.

For the GRDC, the arrival of 2018 marks the beginning of what will perhaps be the most transformational period of grains RD&E investment in the corporation's history.

The GRDC has commenced development of the Strategic Research, Development and Extension Plan for 2018-23, with the plan's overarching objective supporting the GRDC's revised purpose of creating enduring profitability for Australian grain growers. Pivotal to the plan's development and future investment focus will be the feedback we receive from growers and other industry stakeholders. That feedback will be fed into the RD&E Plan to provide GRDC and broader industry with a sound and strategic framework for future investment - well beyond the next five years - geared to deliver profit-building outcomes for growers across the nation, including those on the EP.

To assist in capturing growers' priorities and in ensuring the objectives of the strategic plan are met, the GRDC has recognised the need for significantly greater regional presence and outreach to better engage and communicate with growers, the farm advisory sector, researchers, agribusiness and other important stakeholders. The skills, expertise, experience and knowledge of the regional staff we now have on board enables the GRDC to be more responsive and agile in identifying and responding to key issues affecting grower profitability. With regional staff in place, backed by the Southern Regional Panel and the Regional Cropping Solutions Network whose members are located on the EP and beyond, we now have a sound platform to deliver even greater impact from targeted GRDC investments in RD&E.

Maintaining an open dialogue is vital in ensuring issues of most concern to farmers on the EP are considered and appropriately addressed and so I encourage you to make contact with GRDC staff, Panel and RCSN members to raise any ideas or concerns you may have. In the meantime, I take this opportunity to thank everyone who has contributed to this summary, particularly the SARDI staff who have collated the publication. I encourage you take the time to review and digest the results presented and determine where they have applicability to your farming system and how they can be factored into your decision-making and future business management.

Craig Ruchs, GRDC Senior Regional Manager – South

# Eyre Peninsula Farming Systems Summary 2017


**Editorial Team**

| | |
|---|---|
| Naomi Scholz | SARDI, Minnipa Agricultural Centre, (MAC) |
| Amanda Cook | SARDI, MAC |
| Jessica Crettenden | SARDI, MAC |
| Fiona Tomney | SARDI, MAC |
| Nigel Wilhelm | SARDI, MAC/Waite |
| Andrew Ware | SARDI, Port Lincoln |
| Jacob Giles | SARDI, Port Lincoln |
| Fabio Arsego | 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.


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# Minnipa Agricultural Centre update

**Naomi Scholz**
SARDI, Minnipa Agricultural Centre

Welcome to the nineteenth Eyre Peninsula Farming Systems Summary. This summary of research results from 2017 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, GRDC and EPARF 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. Many of the trials are also catalogued in the GRDC Online Farm Trials Database, www.farmtrials.com.au, which is an excellent searchable resource for finding trials and research outcomes from across Australia.

Over the past four years SARDI and EPARF have been working on a project as part of the *Maintaining profitability in retained stubble systems program* (also known as the GRDC Stubble Initiative for short). As we near completion of the project this year, we have produced a series of locally relevant guidelines to overcome the barriers of retaining stubble. These guidelines are included in a supplementary booklet, and will also be available via the EPARF website, and at coming events.

2017 was the final year of trials for several larger projects, and we are currently working on new project submissions on topics such as crop competition for weed control, improving productivity on grey calcareous soils, soil amelioration in sandy soils, a new mixed farming extension program, EP farmer resilience, cover crops etc., with numerous collaborators and funding sources. Fingers crossed that we are successful on at least some of these!

MAC is also involved in a new major project, commencing in 2018, *"Boosting profit and reducing risk of mixed farms in low and medium rainfall areas with newly discovered legume pastures enabled by innovative management methods"*, or Dryland Legume Pasture Systems (DLPS) for short. This project is supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit program, the Grains Research and Development Corporation, Meat and Livestock Australia and Australian Wool Innovation. The research partners include SARDI, Murdoch University, CSIRO, the WA Department of Primary Industries and Regional Development, and Charles Sturt University, as well as grower groups. The aim of the project is to develop recently discovered pasture legumes together with innovative management techniques that benefit animal and crop production and farm logistics, and promote their adoption on mixed farms over one million hectares in the low and medium rainfall areas of WA, SA, Victoria and southern NSW.

## Staff

In 2017 we welcomed Fiona Tomney (Research Officer) who has replaced Brian Dzoma and is working on the SAGIT funded *Improving Medic Pastures* project, and Fabio Arsego (Senior Research Agronomist, based between Port Lincoln and Minnipa) who has replaced Mariano Cossani, and is working on assessing nitrogen and water co-limitations by remote sensing as a tool to improve wheat and canola profitability and risk management.

Both Brian and Mariano have moved to the Waite Campus in Adelaide to continue their work with SARDI under the GRDC-SARDI Bilateral project, with Brian focussing on nitrogen and soil improvements and Mariano developing risk management tools for managing nitrogen in legumes and wheat in extreme temperatures.

We also farewelled Brett Hay, Agricultural Officer, who has taken up a teaching position in Riverton. We wish Brett all the best for his teaching career.

## Students/work experience

Max Winnen, Year 11 student at Urrbrae Agricultural High School undertook work experience at MAC on 10-13 April and 10 -14 July. Lauren Innes, University of Adelaide third year student did work experience from 3-13 July.

## Visits

Eighty students from years six to twelve from Cleve, Karcultaby, Miltaburra and Wudinna Area Schools visited MAC on 23 October 2017. The students were given a tour of the farm and heard about what goes on at the Centre. 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.

## Events

A large range of events were held or attended by MAC staff, with details listed in *Minnipa Agricultural Centre Events in 2017*. Two major events out of the ordinary included the GRDC Dry Start Forums, in response to the dry start of 2017, and the GRDC Stubbles Extravaganza – an event aimed at researchers and advisors, to discuss the latest research around overcoming the barriers to stubble retention. Both events were very well attended and received great feedback from participants.

## Projects

| 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. **End: June 2018** |
| 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. **End: June 2019** |
| 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. **End: June 2019** |
| 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. **Completed: June 2017** |
| **SARDI Projects** | | |
| Boosting profit and reducing risk of mixed farms in low and medium rainfall areas with newly discovered legume pastures enabled by innovative management methods | TBC | Dryland Legume Pasture Systems (DLPS) Develop recently discovered pasture legumes together with innovative management techniques that benefit animal and crop production and farm logistics, and promote their adoption on mixed farms over one million hectares in the low and medium rainfall areas of WA, SA, Victoria and southern NSW. **End: June 2022** |
| Swathing for barley grass weed seed collection and applying drone technology | SAGIT *S117* | Swathing cereal crops with problem weed issues early (between 20 and 40% grain moisture) for grass weed seed capture into windrows, followed by harvest and using a chaff cart for weed seed collection may provide farmers with another tool for integrated weed management. Testing the use of UAV (drone) technology to assess barley grass weed density in crop. **End: June 2020** |
| 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. **Completed: Feb 2018** |

| Project name | Funder | Summary |
|---|---|---|
| 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. **End: June 2018** |
| 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: • 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 • 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. **Completed: June 2017** |
| 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. **End: June 2019** |
| 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. **Completed: June 2017** |
| 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. **Completed: June 2017** |
| 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 or 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. **End: Sept 2018** |
| 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. |

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 2018, and wish you all the best for a productive season!

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# MAC staff and roles 2017

| | |
|---|---|
| Nigel Wilhelm | Science Program Leader Farming Systems |
| Dot Brace | Senior Administration Officer |
| Leala Hoffmann | Administration Officer |
| Naomi Scholz | Project Manager |
| Jake Hull | Farm Manager |
| Amanda Cook | Senior Research Officer (Farming Systems) |
| Fabio Arsego | Senior Research Agronomist (Minnipa/Port Lincoln) |
| Jessica Crettenden | Research Officer (Livestock) |
| Fiona Tomney | Research Officer (Pastures) |
| Brenton Spriggs | Agricultural Officer (NVT, Contract Research) |
| Ian Richter | Agricultural Officer (Farming Systems) |
| Brett Hay | Agricultural Officer (Farming Systems) |
| Wade Shepperd | Agricultural Officer (MAC Farm) |
| John Kelsh | Agricultural Officer (MAC Farm) |
| Sue Budarick | Casual Field Assistant |
| Rochelle Wheaton | Casual Field Assistant |
| Katrina Brands | Casual Field Assistant |
| Lauren Cook | Casual Field Assistant |

## DATES TO REMEMBER

**EPARF Member's Day: Adjuvant roadshow planned for mid-2018**

**MAC Annual Field day: Wednesday 5 September 2018**

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

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# Eyre Peninsula Agricultural Research Foundation Annual Report 2017

**Simon Guerin**
Chairperson, EPARF

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

## Board of Management

Simon Guerin, Bryan Smith, Shannon Mayfield, Dion Trezona , Greg Scholz, Wes Matthews, Andy Bates, Mark Stanley, Dr Kathy Ophelkeller (SARDI), Prof Jason Able (University of Adelaide).

**Ex Officio members:** Mary Crawford (EPNRM), Andrew Ware (Snr Research Scientist EP, LEADA), Dot Brace (EO).

## Values

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

## Role of EPARF

The Eyre Peninsula Agricultural Research Foundation (EPARF) was incorporated in 2004 and has a Board comprising representatives of farmers, University of Adelaide, SARDI, local consultants and the EPNRM Board. Its purpose is to represent the interests of research, development and extension on Eyre Peninsula.

The EPARF Board is committed to ensuring the ongoing development of agricultural systems in low rainfall zones of Australia and recognises its obligations to Eyre Peninsula.

EPARF is a not for profit foundation drawing its income from membership, industry funding and sponsorship.

The main publication funded is the "Eyre Peninsula Farming Systems Summary" booklet, a highly regarded annual summary of the trials conducted on EP.

## Membership

Membership support is a critical factor when seeking funding for projects on the Eyre Peninsula to address local research needs. EPARF value your membership and support.

Annual subscriptions run from January to December and fees for 2018 are: $132 for the first member of your business or entity, and $66 per additional members (GST inclusive). Subscription forms are available on our website, or alternatively, contact Minnipa Agricultural Centre.

## Activities

*Dry Start Forums*

2017 has given us a few challenges with what looked like a very good opening rain for some early, then a long dry spell. Some farmers sowed early and others missed these rains. EPARF worked with GRDC to facilitate a series of "Dry Start" forums to help farmers come to grips with some of the issues they may be facing. These meetings, held in Wudinna, Cummins, Cleve and Streaky Bay were well attended and showed a good response to the seasonal conditions.

*Ag Ex Alliance Perpetual Award*

Local Minnipa farmer, Bruce Heddle was awarded the Inaugural Ag Excellence Perpetual Award for outstanding service to agriculture within South Australia at the 12th Ag Excellence Alliance Annual Forum held in April. Bruce, a very worthy winner was nominated by EPARF and this Inaugural Award gave an opportunity to recognise an individual involved within a grower group who has made a significant contribution within their community.

*Strategic Planning*

Following a recent strategic plan and review the Board identified a number of key issues and opportunities to better serve members. EPARF value their membership base and the EPARF Board are continually looking for ways to improve the services that the organisation delivers for agriculture in the region.

Initially, to gain an insight to what EPARF member's value from their membership and to provide future guidance to the Board, a member's survey was sent out. The survey results are published on the EPARF website. One of the additional services identified was the inclusion of a regular e-newsletter to the members. This has progressed and feedback has indicated it is being well received.

The survey has also given the Board a list of issues that members identified as important to be addressed in the future, with managing soil constraints a high priority. Building agricultural scientific and technical capacity for the EP, through Agricultural Graduate programs is also being pursued, aiming at being proactive in attracting and retaining the best agricultural science graduates onto the EP.

*Projects*

The Reducing Methane Emissions from Improved Forage Quality project has been completed with the final report accepted by DAFF, along with the GRDC RCSN Soil Nitrate project.

Current projects directly managed by EPARF are:

- Using soil water information to make better decisions (EP Soil Probe Network), funded by SAGIT;
- Maintaining profitable farming systems with retained stubble (EPFS4), funded by GRDC;
- EP Farming Systems Summary, funded by SAGIT and
- Regional Landcare Facilitator, funded by EPNRM.

## MAC Staff

There have been a number of staff changes at MAC and some new faces about, we wish those leaving all the best and welcome the new ones on board and hope we can show them a lot of support in their new roles.

## 2017 EPARF Member day

Due to the very dry weather conditions in 2017, it was decided not to proceed with our member day as our plan was to focus on legume pulse crop management. As not much was sown at the time the committee thought we should postpone the event. The date is now set for Wednesday 14 February 2018.

## Sponsors 2017

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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.

## 2018 EPARF Adjuvant roadshow

EPARF are holding an Adjuvant information session. This will be a 'roadshow' type event, going to three locations on the upper EP. It will be an open event, free entry for EPARF members and an entry fee for non-members. Trusting you will come along to support the event and go away with new knowledge and skills, or reaffirm your current understanding. Dates and program to be confirmed – check the website for details.

## Appreciation and thanks

Thank you to SARDI and the team at MAC.

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Minnipa Agricultural Centre

www.eparf.com.au

## 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**

# Eyre Peninsula Agricultural Research Foundation Members 2017

| | | |
|---|---|---|
| Michael | Agars | PORT LINCOLN SA |
| Terry | Baillie | TUMBY BAY SA |
| Karen | Baines | UNGARRA SA |
| Andrew | Baldock | KIMBA SA |
| Graeme | Baldock | KIMBA SA |
| Heather | Baldock | KIMBA SA |
| Tristan | Baldock | KIMBA SA |
| Geoff | Bammann | CLEVE SA |
| Paul | Bammann | CLEVE SA |
| Ashley | Barns | WUDINNA SA |
| Andy | Bates | STREAKY BAY SA |
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| Xavier | Beinke | KYANCUTTA SA |
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| Ian | Bergmann | CEDUNA SA |
| Bill | Blumson | SMOKY BAY SA |
| Reg | Brace | POOCHERA SA |
| Dion | Brace | POOCHERA SA |
| Jason | Brace | POOCHERA SA |
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| Alexander | Cant | CLEVE SA |
| Brian | Cant | CLEVE SA |

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| Matthew | Carey | CHANDADA SA |
| Paul | Carey | CUNGENA SA |
| Peter | Carey | MINNIPA SA |
| Shaun | Carey | CHANDADA SA |
| Mark | Carmody | COWELL SA |
| Symon | Chase | COWELL SA |
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| Trevor | Cliff | KIMBA SA |
| Trevor | Clifford | KIMBA SA |
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| Neil | Cummins | LOCK SA |
| Richard | Cummins | LOCK SA |
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| Robert | Dart | KIMBA SA |
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| Ray | Elleway | KIELPA SA |
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| Tasman | Fitzgerald | KYANCUTTA SA |
| Scott | Forrest | MINNIPA SA |
| Jane | Forrest | MINNIPA SA |
| Ben | Forrest | MINNIPA SA |
| Matthew | Foster | WUDINNA SA |
| Rhianna | Foster | WUDINNA SA |
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| Tim | Franklin | COWELL SA |
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| John | Freeth | KIMBA SA |

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| Farren | Frischke | KYANCUTTA SA |
| Jerel | Fromm | MINNIPA SA |
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| Kade | Gill | POOCHERA SA |
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| Tim | Howard | WIRRULLA SA |
| Warwick | Hutchings | MINNIPA SA |
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| Janeen | Jericho | POOCHERA SA |
| San | Jolly | KAPUNDA SA |
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| Roger | Lienert | ARNO BAY SA |
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| Craig | Lynch | POOCHERA SA |
| Joel | Lynch | POOCHERA SA |
| Paul | Lynch | CHANDADA SA |
| Andrew | Mahar | CEDUNA SA |
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| Troy | Maitland | KIMBA SA |
| Andrew | Major | KIMBA SA |
| Justine | Major | KIMBA SA |
| Beth | Malcolm | ARNO BAY SA |
| Shane | Malcolm | ARNO BAY SA |
| John | Masters | ARNO BAY SA |
| Linden | Masters | ARNO BAY 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 |
| Sarah | Meyer | CLEVE 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 |

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|---|---|---|---|---|---|
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| Darren | Mudge | MILTABURRA SA | Greg | Scholz | WUDINNA SA |
| Damien | Mullan | WUDINNA SA | Leigh | Scholz | MINNIPA SA |
| Blake | Murray | PENONG SA | Lyle | Scholz | YANINEE SA |
| Lynton | Murray | PENONG SA | Mick | Scholz | YANINEE SA |
| Len | Newton | ELLISTON SA | Neville | Scholz | WUDINNA SA |
| Anthony | Nicholls | CEDUNA SA | Nigel | Scholz | WUDINNA SA |
| Ian | Noble | WHARMINDA SA | Stuart | Scholz | WUDINNA SA |
| Sarah | Nobel | CLEVE SA | Yvonne | Scholz | WUDINNA SA |
| Daryl | Norris | RUDALL SA | Brook | Seal | KIMBA SA |
| Steven | North | WARRAMBOO SA | Sam | Shipard | PENONG SA |
| Bronwyn | O'Brian | WIRRULLA SA | John | Simpson | WUDINNA SA |
| Craig | O'Brien | KYANCUTTA SA | Renee | Simpson | PORT LINCOLN SA |
| Darren | O'Brien | KYANCUTTA SA | Bryan | Smith | COORABIE SA |
| Clinton | Olsen | WIRRULLA SA | Dustin | Sparrow | WUDINNA SA |
| Clint | Oswald | YANINEE SA | Mark | Stanley | PORT LINCOLN SA |
| John | Oswald | YANINEE SA | Rodger | Story | COWELL SA |
| Nigel | Oswald | WUDINNA SA | Susan | Story | COWELL SA |
| Tim | Ottens | WHARMINDA SA | Lubin | Stringer | KYANCUTTA SA |
| Joe | Pedler | GILLMAN SA | Aleks | Suljagic | CLEVE SA |
| David | Peters | CHANDADA SA | Mark | Thiele | UNLEY SA |
| Ashley | Phillips | MINNIPA SA | Zac | Tiller | LOCK SA |
| Darcy | Phillips | MINNIPA SA | Clint | Tomney | STREAKY BAY SA |
| Andrew | Polkinghorne | LOCK SA | Jarad | Tomney | CHANDADA SA |
| Tim | Polkinghorne | LOCK SA | Myles | Tomney | CUNGENA SA |
| Ben | Pope | WARRAMBOO SA | Rhys | Tomney | CHANDADA SA |
| Lindsay | Pope | WARRAMBOO SA | Gareth | Tomney | CUNGENA SA |
| John | Post | MINNIPA SA | Dion | Trezona | PETINA SA |
| Clint | Powell | KIMBA SA | Neville | Trezona | STREAKY BAY SA |
| Kevin | Preiss | ARNO BAY SA | Craig | Trowbridge | CEDUNA SA |
| Rowan | Ramsey | KIMBA SA | John | Turnbull | CLEVE SA |
| Ben | Ranford | CLEVE SA | Mark | Turnbull | CLEVE SA |
| Dale | Rayson | KIMBA SA | Nigel | Turnbull | CLEVE SA |
| Peter | Rayson | KIMBA SA | Quentin | Turner | ARNO BAY SA |
| Gavin | Rehn | ARNO BAY SA | Tim | van Loon | PORT ELLIOT SA |
| Jason | Ridgway | PORT LINCOLN SA | Daniel | Vater | GLEN OSMOND SA |
| Marty | Rodda | KIMBA SA | Leon | Veitch | WARRAMBOO SA |
| Bradley | Rowe | COWELL SA | Daniel | Vorstenbosch | WARRAMBOO SA |
| Martin | Ryan | KIMBA SA | Dallas | Waters | WUDINNA SA |
| Kane | Sampson | WARRAMBOO SA | Graham | Waters | WUDINNA SA |
| John | Schaefer | KIMBA SA | Tristan | Waters | WUDINNA SA |
| Michael | Schaefer | BALHANNAH SA | Peter | Watson | WIRRULLA SA |
| Paul | Schaefer | KIMBA SA | Ryan | Watson | WIRRULLA SA |
| Wes | Schmidt | KIMBA SA | Paul | Webb | COWELL SA |
| Thomas | Schmucker | KYANCUTTA SA | Ken | Webber | PORT LINCOLN SA |
| Terry | Schmucker | KYANCUTTA 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 |
| 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 |
| Michael | Zacher | LOCK SA |
| Lisa | Zibell | KIMBA SA |


***Photo: Left to Right. Michael Moodie, Andy Bates, Larn McMurray, Liz Farquharson, Jenny Davidson and Sam Holmes were speakers at the EPARF Member Day, February 2018.***

# Minnipa Agricultural Centre events in 2017

**Naomi Scholz**
SARDI, Minnipa Agricultural Centre

| Event | Topics | Attendance |
|---|---|---|
| **SAGIT/EPARF Soil Moisture Probe Meeting**<br>*Port Lincoln*<br>*17 February* | Organised by Naomi Scholz (SARDI). Key speaker was Shane Oster (Alpha Group Consulting). | 20 advisors |
| **Sheep Reproduction Workshops**<br>*Darke Peak, Wudinna and Ceduna*<br>*6-8 March* | Presenters included Dr Colin Trengrove, Jessica Crettenden (SARDI), Kate Taverner and Ben Tucker (Darke Peak); Luke Nettle (Wudinna) and Andrew Sleep (Ceduna). The workshops were supported and funded by the Eyre Peninsula NRM Board with funding from the National Landcare Programme and Sheep Connect SA. | 41 farmers |
| **GRDC Partners in Grain Workshop**<br>*MAC*<br>*10 March*<br>*MAC*<br>*10 April* | Dr Colin Trengrove and Jessica Crettenden (SARDI) presented information about sheep reproduction, nutrition and health. Second workshop greater focus on lamb survival. | 10 farming businesses attended both workshops |
| **Grass Weed Management Workshop**<br>*MAC*<br>*15 March* | Presented by Rick Llewellyn (CSIRO) and Amanda Cook (SARDI)<br>• Looked at the latest research on grass weed management practices<br>• Participants used the integrated weed management tool RIM, adapted for brome grass, to work through developing and comparing the profitability of different herbicide and non-herbicide strategies for grass weed management for their farm. | 13 farmers |
| **Upper Eyre Peninsula Farmer Meetings** *x 8*<br>*Minnipa, Wirrulla,Ceduna, Elliston, Kyancutta, Rudall, Cowell, Buckleboo*<br>*20-24 March* | Presentation of research results from 2016 and discussion of emerging issues for 2017.<br>• Medic pastures<br>• Stubble loads<br>• Weeds<br>• Disease<br>• Snails<br>• Mice<br>• Nutrition<br>• Controlled traffic farming<br>• Varieties<br>• Livestock opportunities<br>• Soil Moisture Probe Network | 157 farmers and advisors |

| Event | Topics | Attendance |
|---|---|---|
| **"Dry Start Forums – Maximising returns despite a dry start"**<br>*Wudinna (15 June), Cummins (16 June), Cleve (22 June), Streaky Bay (23 June)* | Naomi Scholz (SARDI) coordinated at the request of GRDC and on behalf of EPARF and LEADA. Speakers were: Dale Grey (DEDJTR VIC), Kenton Porker (SARDI), James Edwards (AGT), Tim McClelland (BCG), Hamish Dickson (AgriPartner Consulting), Chris Fitzgerald (Rural Business Support), Andy Bates (Bates Ag Consulting), Bill Long and Peter Kuhlmann (GRDC), Simon Guerin (EPARF) and Bruce Morgan (LEADA). Amanda Cook (SARDI) presented Tim McClelland's information at the Cleve and Streaky Bay Forums. | Wudinna (143 people), Cummins (136 people), Cleve (22 people), Streaky Bay (31 people) |
| **'Managing sheep in dry times' information session**<br>*MAC*<br>*10 July* | Organised by Mary Crawford (DEWNR) and Jessica Crettenden (SARDI). Presenters were Tim Leeming (Paradoo Prime), Nigel Baum (PIRSA Biosecurity) and Ken Solly (Solly Business Services). Topics were:<br>• Sheep nutrition<br>• Managing yourself in lean times<br>• Sheep health<br>• Sheep management options in dry times<br>• Lamb survival | 19 farmers and 2 industry reps |
| **GRDC Regional Update**<br>*Kimba*<br>*10 August* | Amanda Cook (SARDI) presented her paper, 'Options for managing barley grass in crop'. | 79 farmers and advisors |
| **SARDI Minnipa Agricultural Centre Annual Field Day**<br>*MAC*<br>*6 September* | • MAC farm update<br>• Controlled traffic<br>• Barley grass management<br>• Time of Sowing Trial<br>• National Variety Trials wheat and barley<br>• Pre-emergent Herbicides<br>• Stubble management<br>• Moving machinery on public roads<br>• Livestock tips for dry years<br>• EPARF AGM<br>• Herbicide efficacy<br>• Break options<br>• Nitrogen and water co-limitation<br>• Improving medic performance<br>• Lentils | Over 100 people including farmers, advisors, researchers and agricultural industry representatives. Field day booklet distributed. |
| **Women in Agriculture visit to Minnipa Agricultural Centre**<br>*MAC*<br>*22 September* | SARDI staff provided an overview of the Centre, how we conduct research trials, and presented current projects and trials. | 12 women from the Wudinna/ Minnipa district |
| **Schools Visit (Wudinna, Cleve, Karcultaby, Miltaburra)**<br>*MAC*<br>*23 October* | SARDI Staff gave presentations to students on:<br>• Minnipa Ag Centre, why it exists and what work is done there, why trials are done, and how they are run<br>• tour of the farm visiting 'time of sowing' trials and the National Variety trials<br>• work with sheep, including the research projects<br>• tour of the buildings and research specific machinery | 80 students from years six to 12 and their teachers |

| Event | Topics | Attendance |
|---|---|---|
| **Sticky Beak Days x 12**<br>*Franklin Harbour, Far West, Charra/ Goode, Lock, Central Eyre, Wirrulla, Tuckey, Wharminda, Minnipa, Elliston, Mount Cooper, Streaky Bay*<br>*1 September-5 October* | Common topics included:<br>• Rotations<br>• Chemical usage<br>• Cereal cultivars<br>• Windrow burning and chaff carts<br>• National Variety Trials<br>• Russian Wheat Aphid<br>• Sheep production, infrastructure<br>• Moisture Probes<br>• Sandy Soils<br>• Grain marketing | 431 farmers, advisors and researchers |
| **EP 'Stubbles Extravaganza' forum for researchers and advisors**<br>*Port Lincoln*<br>*9 November* | Naomi Scholz (SARDI) hosted this event on behalf of EPARF and LEADA. Attendees heard the latest research and recommendations on overcoming the barriers to stubble retention and participated in discussions.<br>Speakers were:<br>• Naomi Scholz – GRDC Stubble Initiative<br>• Rick Llewellyn (CSIRO) – Weeds in stubble retained systems<br>• Greg Baker (SARDI) – Snails in retained stubble systems<br>• Gupta Vadakattu (CSIRO) – N cycling in stubble retained systems<br>• Jack Desbiolles (SARDI) – Considerations for successful residue handling at seeding (disc and tine seeders)<br>• Nigel Wilhelm (SARDI) – Overcoming water repellence in retained stubble systems<br>• Marg Evans (SARDI) – stubble management implications for disease (Crown rot, Eyespot, YLS, Barley net form of Net Blotch, Take-all)<br>• Greg Mutze (PIRSA) – Effect of stubble management on mice | 39 advisors and researchers |
| **Livestock Containment and Supplementary Feeding workshops**<br>*Kimba, Warramboo and Piednippie*<br>*13-15 December* | Jessica Crettenden (SARDI), Mary Crawford and Cathy Paterson (EPNRM) facilitated the workshops which were presented by Hamish Dickson (Agri-Partner Consulting).<br>Topics covered included:<br>• Containment area set-up<br>• Equipment and technologies<br>• Nutrition<br>• Ration formulation<br>• Health and husbandry | 39 farmers and 6 industry reps |
| **Livestock Containment Sticky Beak Day**<br>*Darke Peak*<br>*18 December* | Facilitated by Corey Yeates and Elly Schultz (EPNRM)<br>• Jessica Crettenden (SARDI) spoke to producers about containment area set-up and design, feeding and watering equipment, feed rations, nutrition, health and husbandry.<br>• Visit to four containment feeding systems in the area, where each owner spoke about their feeding systems. | 25 farmers and 3 industry reps |

# Eyre Peninsula seasonal summary 2017

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

The 2017 season can only be described as extremely challenging, which in many districts, finished better than expected. Most districts experienced an extremely late start, with many not recording a significant rainfall event until the last week of June. This presented growers with the difficult decision of how much, if any of their crop area to sow?

Crops that were sown early on good rains, around Kimba and east of Cleve, germinated and grew quickly. However, most areas had slow, patchy germination and many dry sown crops did not germinate for more than six weeks because topsoils were so dry. Significant areas around Streaky Bay, Port Kenny, Poochera, Kielpa, Lock, Rudall and Wharminda did not receive adequate early rainfall and most growers significantly reduced the area of crop. Crops that were sown in these districts grew poorly and generally yielded well below average. Russian wheat aphid were common in crops across the region, aphids and native budworm impacted yields on canola and peas, and frosts significantly reduced yields in central Eyre districts. With these challenges in mind, growers in most districts were relieved to finish harvest with average to slightly below average yields.

Thunderstorms in January and February brought widespread rainfall and by the end of summer most soils had high levels of stored moisture. Warm, damp conditions germinated summer weeds and volunteer cereals. Multiple herbicide applications were required to control this 'green bridge' and conserve moisture ahead of the 2017 cropping season. As Russian wheat aphids were detected in the region in 2016, many growers applied insecticides to seed or paddocks to protect early sown crops. Summer rainfall also increased snail activity. Very few hot days during summer provided limited opportunities to control these by chaining/rolling, with increased baiting and stubble burning prior to seeding to reduce numbers.

Some long season wheat, feed and canola were dry sown in April. Extremely dry conditions, extending to late June halted seeding until good opening rains were finally received in early July. Dry, cold conditions restricted pasture germination, and many growers removed livestock from paddocks at the end of April to protect vulnerable areas from wind erosion and allow pasture plants to grow. Surplus stock, including weaned lambs, were sold early to reduce grazing pressure on establishing pastures. Supplementary feeding of livestock continued until good rainfall and warmer temperatures in late August brought on good pasture growth.

Dry conditions restricted weed growth, with many growers choosing to manage grass weeds by spraytopping rather than grass-freeing pastures, to maximise paddock dry matter. Most crops had full canopy closure at the end of August and the unevenness observed early in the season was less pronounced. Frosts in late winter saw some cereal and pea crops cut for hay. Although some vetch and oat paddocks were also cut, hay yields were well below average.

Insect pests were an issue in early spring, with high numbers of aphids and native budworm impacting canola yields. Livestock grazing on medic and vetch infested with Cow pea aphid in early spring suffered from photosensitization. Stock were removed to shaded areas and paddocks were sprayed to control the aphids. Chemical control measures were generally effective against Russian wheat aphid. Disease levels were generally low in crops, due to lower biomass levels and fungicide applications.

Regular small rainfall events in September and October kept crops fresh during grain fill. Hot days in September stressed crops near Buckleboo, with moisture probe data showing crops were drawing moisture from below 40 cm in the soil profile. Strong winds in mid-October caused some damage to ripe canola and barley crops in Western and Eastern Eyre districts. Little damage was reported in lower Eyre districts as crops were not yet ripe.

Instead of windrowing more growers direct headed canola this season, as lower crop biomass provided easier paddock trafficability, the cost of windrowing was high compared to the potential crop returns and growers had increased confidence in the efficacy of desiccants.

Yields were highly variable depending on rainfall, sowing time and soil type. Peas generally yielded well, with many reports of yields above 1.5 t/ha, whilst other pulses yielded poorly. Canola yields were below average in most areas as they were impacted by poor germination and poor biomass production due to cold, dry conditions, insects and frosts. Cereal yields were generally better than expected given the season and some districts produced well above average yields. Grain quality was good with generally high protein levels, except in those few districts with high yielding crops.

# DISTRICT REPORTS

## WESTERN EYRE PENINSULA

Thunderstorms brought well above average rainfall for January and February, with several districts reporting their highest January rainfall on record. Most growers sprayed all paddocks at least once to control summer weeds and volunteer cereals, to manage insect pests and diseases and conserve moisture. A there were few hot days during summer to control them by chaining/rolling stubbles snail activity also increased. As a result more paddocks were baited than normal. Increased Lincoln weed growth on calcareous coastal soils resulted in higher levels of Diamond back moth than is normal for the time of year.

Despite some stored subsoil moisture, continued dry conditions during March and April dried out topsoils. Scattered showers brought above average April rainfall to districts north of Wirrulla. Although some growers began sowing following this rain, rainfall distribution was very patchy and by the end of April only very small areas of feed were sown. There were isolated reports of increased mice activity in sown paddocks, but widespread baiting did not occur. Dry conditions continued through May and June. Some centres, including Minnipa and Wudinna, reported their lowest June rainfall on record and by the end of June only around 60% of the intended crop area for western Eyre Peninsula was sown. Canola and cereal crops that were sown on sandy soils around Wudinna had patchy germination, and some emerging crops and pastures suffered sand blasting. Little crop was sown in areas around Streaky Bay, Port Kenny, Poochera and Minnipa.

Regular showers during July enabled growers to sow a few more paddocks, but very cold nights slowed the growth of crops and pastures and by the end of July most crops had not yet reached canopy closure. Crop growth was highly variable within paddocks and many growers elected to manage different zones in paddocks instead of applying uniform rates of pesticides and fertilisers across the whole paddock. Paddock feed levels were extremely low at the end of July with livestock producers selling surplus stock, including weaners, to reduce pressure on feed reserves. As large variations in weed maturity made timing of applications difficult, and growers wished to preserve as much surface cover as possible, there was little "grass-freeing" of pastures during this period.

Above average August rainfall and warm conditions late in the month produced rapid growth and evened out some of the variability seen earlier in the season. Many crops in paddocks where summer weeds were controlled had better crop vigour, more biomass and estimated yield potential that were more than 40% higher than in paddocks which didn't.

Few pasture paddocks contained enough biomass in spring to cut for hay. Some frosted pea and wheat crops near Wudinna were cut for hay, along with some vetch and oats, but yields were less than half the average.

Russian wheat aphids were observed in many crops but chemical control measures were effective in minimising damage in most paddocks. Sheep grazing on paddocks infested with Cow pea aphid suffered photosensitization. Mice also caused issues in maturing crops and some late baiting was undertaken in crops near Wirrulla and Nunjikompita. Adequate control during the season meant that snails did not present unusual problems at harvest.

Isolated scattered showers in October were generally too late to increase yields with above average temperatures and low soil moisture resulting in rapid senescence of crops and pastures.

Some growers in Far West districts began harvest in October with good harvest conditions enabling most western Eyre growers to finish in early December. Crop yields were highly variable depending on rainfall distribution, summer weed control and soil type, but were generally better than expected given the challenging season.

Pea crops not impacted by frost generally yielded well, with reports of 0.8 to 1.6 t/ha around Wudinna. Canola yields in the Wudinna district were in the range 0.7 to 1.0 t/ha. Lentil yields were generally disappointing between 0.5 and 0.7 t/ha. Few canola and pulse crops were sown at Mt Cooper this season.

In the Far West cereal yields of 0.7 to 1.1 t/ha were average to slightly below average. The earlier sown crops around Wirrulla/Nunjikompita yielded 1.0 to 1.3 t/ha and there were reports of yields up to 3.5 t/ha on the loamier soils south of Wudinna. Crops on heavier soil types in districts which did not receive early rains yielded very poorly. Wheat had generally high protein and much of it achieved AH classification. In coastal districts high protein levels in barley made malt grade difficult to achieve.

## EASTERN EYRE PENINSULA

Well above average January and February rainfall resulted in rapid germination of summer weeds. Most growers sprayed all paddocks at least once to minimise the impact of pests and diseases on emerging crops and pastures. Grower confidence for a good season was boosted by good soil moisture levels and many considered increasing the area of dry sown crop.

There was some difficulty sourcing seed for particular canola varieties, however most growers were able to find suitable replacement varieties. Given high levels of volunteer crops in paddocks and the presence of Russian wheat aphids most growers applied insecticide to at least some of their seed to minimise damage to early sown crops.

March and April were dry, except around Kimba which received 60 mm of rain late in the month. Feed paddocks and small areas of canola were sown during April. Although soil profiles had moisture below 40 cm, topsoils were dry by the end of April and most growers waited for opening rains to sow the majority of their crops. Paddock feed supplies were very low by the end of April, with producers feeding livestock in containment areas to allow pastures to germinate and bulk up before grazing. There was some concern regarding the amount of feed which might be available over summer and some growers sold surplus stock, but most did not reduce flock numbers significantly.

Isolated rainfall in May in the eastern Cleve Hills, and from Cowell to Port Neill resulted in large variations in seeding completion and crop development. Crops near Kimba which were sown on earlier rains were moisture stressed by the end of June and soil moisture probes showed that cereal crops were drawing moisture from below 40 cm in the soil profile. Continued very dry conditions west of Cleve from May to July restricted the area of crop sown near Wharminda, Rudall, Verran, Lock and Kielpa. In these districts, crop and pasture germination was poor and some erosion was observed on sandy rises. Rains in early July enabled growers near Darke Peak to finish seeding, but cool conditions, including a number of light frosts, slowed crop and pasture growth. Well above average August rainfall was recorded in most districts, resulting in some stored soil moisture, and by the end of August the earlier sown crops on lighter soils in the Franklin Harbour, Crossville and Buckleboo districts looked healthy with above average yield potential.

Broadleaved weed sprays were applied in early spring as the variability in crop growth evened out. Growers ‘spray topped’ rather than ‘grass-freed’ pastures to retain as much paddock biomass as possible. Low numbers of Russian wheat aphids were reported in most districts, with chemical control measures effectively minimising crop damage. Sheep grazing on medics infested with Cow pea aphid suffered photosensitization. Stock were removed from these paddocks. Turnip and cabbage aphids and native budworm also infested canola crops in early October with numbers building quickly and growers spraying to minimise crop damage. There were reports that crops near Buckleboo suffered damage from unusually large mobs of kangaroos and mice, which were observed chewing on cereals and canola crops during grain fill. However, numbers did not increase significantly and there was minimal yield loss.

Canola and pulse crops were desiccated at the start of October to encourage even ripening, and harvest began in late October. Pea crops that were not affected by frost yielded very well (1.7 to 2.0 t/ha), however yields for canola and other pulse crops were generally disappointing due to poor seasonal growth and damage from frost and insect pests. Strong hot winds damaged ripe canola and barley crops around Kimba and Cleve in late October, with estimates of up to 20% yield loss on affected paddocks.

Widespread thunderstorms and cool conditions during November and early December frustrated harvest efforts. However, most growers finished harvest by mid-December. Cereal yields reflected the seasonal variability with crops east of Cleve having above average yields, in the order of 2 to 3 t/ha, whilst yields from districts west of Cleve were well below average. Except on exceptionally yielding paddocks, protein levels were generally high. There was some fungal staining resulting from the damp conditions at harvest. A number of growers used the late rainfall as an opportunity to sow summer forage crops such as sorghum, canola and millet.

## LOWER EYRE PENINSULA

Above average rainfall was recorded in January and February, and areas from Coffin Bay to Cummins received their highest January rainfall on record. Warm, damp conditions mineralised soil nitrogen and increased snail activity during this period. Increased stubble burning and baiting of canola and pulse crops was undertaken prior to seeding to control numbers.

Summer weeds and volunteer crops germinated rapidly and most growers sprayed all paddocks at least once to control the ‘green bridge’ and reduce potential crop pests and diseases. Herbicide applications combined with dry conditions to the end of June significantly slowed weed growth. There was more gypsum and lime applied for improving soil condition than in recent years.

Growers with large cropping programs began to dry-sow canola, pulses and long season wheats in April but dry conditions halted seeding in most districts. A lack of profitable legume crops suitable for the region and poor profitability from growing barley meant that growers intended to sow more canola. Although there were issues with supply of some canola varieties, most growers were able to source suitable replacement varieties to fit their rotations. Continued dry conditions dried out topsoils resulting in up to 20% less area sown to canola than average.

A cold front brought rain to areas south of Edilillie in the last week of June, however this did not extend further north. By the end of June only 20% of growers had finished seeding. Districts which received isolated rains, such as near Butler, Moody and Point Bolingbroke had good crop germination and growth. In other areas emergence was patchy, with dry conditions restricting growth. Many crops took 6 to 8 weeks from sowing to germinate.

Pastures germination was slowed by cool, dry conditions and livestock producers were forced to supplementary feed stock in containment areas to protect soils and allow pasture growth to occur. Although most growers had stored hay and grain on farm these reserves were depleted by continued dry conditions and poor pasture growth, and most growers needed to source extra feed from other regions. Surplus stock, including weaned lambs, were sold.

Well above average August rainfall resulted in temporary waterlogging in paddocks near Stokes and south of Edilillie. Warmer days late in the month resulted in rapid growth of crops and pastures, and some growers applied urea to crops showing symptoms of nitrogen deficiency. By the end of August the uneven crop germination and growth was less pronounced than observed earlier in the season.

Low spring biomass resulted in much less hay being cut than normal. Sheep grazing on vetch pastures infested with Cow pea aphid suffered photosensitization and growers had to remove them to a shaded area whilst treating these paddocks.

Although a number of days above 35°C in middle of October brought October temperatures above the monthly average, regular small rainfall events kept crops green. Very early sown crops on the Tumby Bay flats were harvested at the end of October whilst other crops were not ready for harvest until late November. Thunderstorms during November and December resulted in above average rainfall for this period and frustrated growers wanting to harvest ripe crops. Many growers scrambled to harvest high value crops such as lentils and canola ahead of impending rain bands.

Crop yields and quality were highly variable, but generally better than landholders expected given such a challenging season. Pulse crops generally yielded poorly, with lentils and beans producing less than 1.0 t/ha and lupins 1.0 to 1.5 t/ha. Pea crops were better with some crops yielding 1.8 t/ha. Generally poor canola yields of less than 1.0 t/ha yield were reported near Cockaleechie and Ungarra. Staggered germination, low biomass and insect damage all had some impact on potential yield. However, crops near Kapinnie, Cummins, Koppio and Wanilla yielded well between 1.4 and 2.0 t/ha and oil content was generally good.

Where sowing could be undertaken early, cereal yields were around the long term average. Reports of 2.0 to 3.5 t/ha were common around Karkoo, Kapinnie and Koppio and 3.0 to 4.0 t/ha on the better soil types around Cummins. However, where dry conditions caused late sowing at Ungarra and Cockaleechie crop production was below average, with yields of 1.5 to 2.0 t/ha.

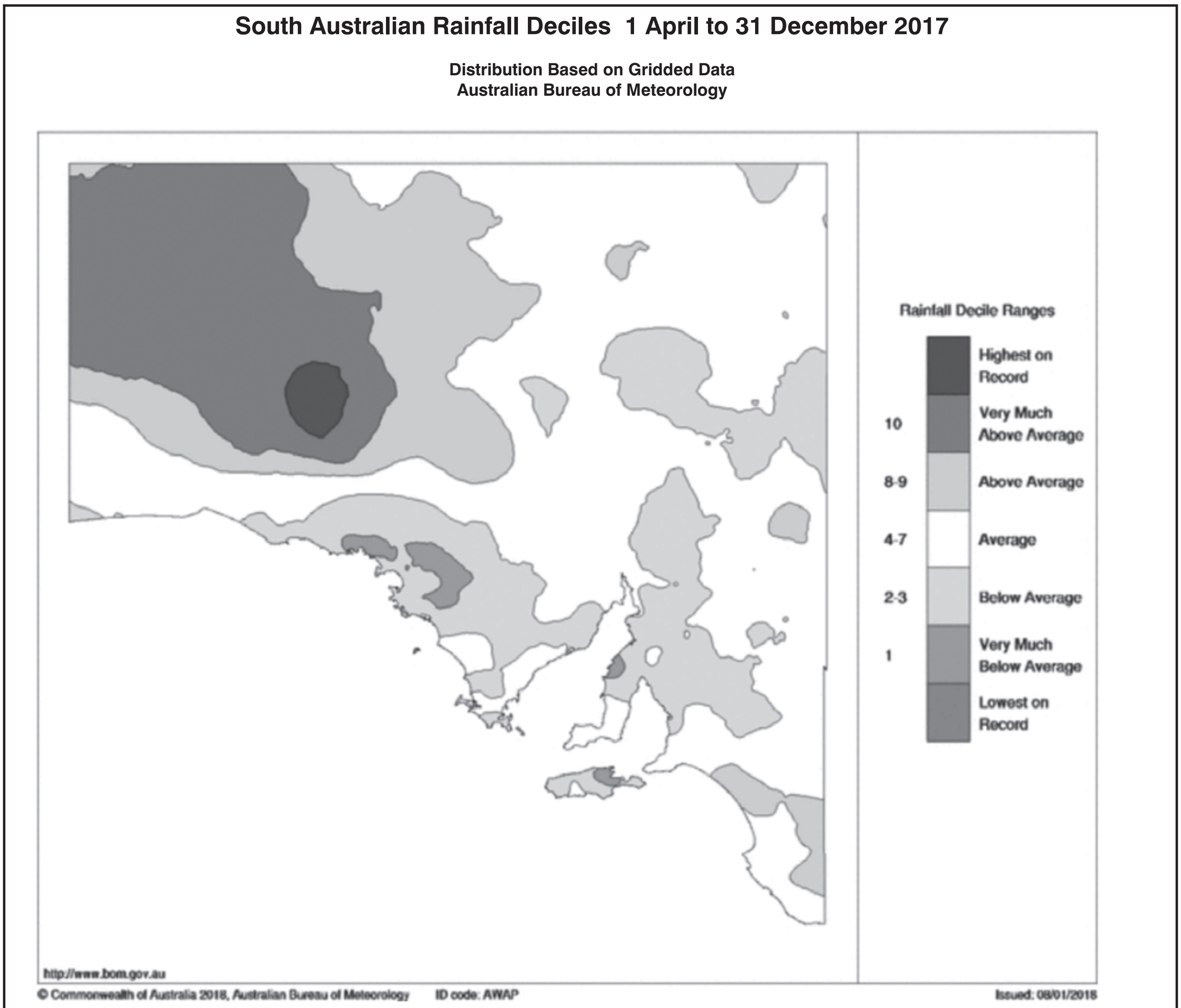
Protein levels were generally good and a high proportion of delivered wheat achieved AH and APW classification, with higher yielding crops achieving ASW. Barley quality was also good. Malting varieties generally achieved malt grade and the remainder made F1. Apart from minor sprouting on some varieties and some issues with low test weights there were few impacts on grain quality. Rain at harvest and warm conditions resulted in rapid germination and growth of summer weeds, with some growers using the opportunity to sow summer forage crops, including sorghum and millet.

## Acknowledgements

The author wishes to acknowledge that much of the information contained within this summary has been compiled from PIRSA's 2017 Crop and Pasture Reports.

Government of South Australia

Primary Industries and Regions SA




http://www.bom.gov.au

***Figure 1. South Australian rainfall deciles 1 April to 31 December 2017***

# MAC Farm Report 2017

**Jake Hull**
Farm Manager
SARDI, Minnipa Agricultural Centre

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**Location**
Minnipa Agricultural Centre
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281 mm
2017 GSR: 155 mm

## Key outcomes

- **On average MAC wheat yielded 0.9 t/ha, barley 0.65 t/ha (25 ha yielded 0.1 t/ha), canola (failed), lentils 0.15 t/ha, vetch 0.1 t/ha, oats (grazed and spray topped).**
- **80% of total farm area sown to crops and pastures.**
- **355 breeding ewes produced 127% lambs at marking including crossbred lambs from dry ewes mated to White Suffolk rams.**
- **Ten tonnes of certified Longsword seed made available for sale to growers.**

## Background

The performance of the Minnipa Agricultural Centre (MAC) commercial farm is an essential component in the delivery of relevant research, development and extension to Eyre Peninsula. The effective use of research information and improved technology is an integral part of the role of the farm. MAC had white peg trials in 10 paddocks and continued to take full pedigree records and production measurements on the sheep research flock in the 2017 season.

## What happened?

### *Weather*

What a year we had weather wise in 2017! It started with off with a bang, 56 mm in January followed by 29 mm in February. March became dry with only 0.4 mm and then 15 mm fell in April. Rain came in spits and spurts through April, May and June, this year being the driest for that period since 1982. July and August were the pick of the growing season months with 32 mm recorded in July and 50 mm fell in August. September was a month of small but helpful rainfall events with 15 mm in total, which kept things cool enough for crops to fill as best they could. October was very similar to September with milder weather, small rain events and 17.8 mm in total. Overall, we received 155 mm of growing season rainfall (GSR), compared to 268 mm of GSR in 2016.

### *Seeding*

The program began on 11 April with Cummins vetch sown in N3 and MAC Airport, which we completed on 13 April. Stingray canola was sown in N7/8 on 18 May after a long wait for a somewhat reasonable rain event. Volga vetch went in on 24 April in S3S with the rest of the paddock completed with Cummins vetch. Waiting for rain was the main game and when a forecast for some precipitation came for late May, Spartacus barley went in dry before the rain, starting from 24 May until 26 May in S1, S4 and S7. Following rain on 29 May, the seeding program started in earnest beginning with Scepter wheat in N4, then N5S, Minnipa Hill, N11, S6, S2/8 and S10. A variety switch to Mace occurred half way through S10 on 4 June and completed on 5 June in AP Town and N12. The new variety Longsword (RAC2341) followed, sown in S9, also Hatchet CL in S9 and the Golf Course. Next after a short delay to repair a missing wheel from the air cart, we made the change to Compass barley and this went in on 7-9 of June in Ronnie's, S5 and N2.

Over the entire operation, total areas sown in 2017 were wheat 360 ha (33%), barley 196 ha (18%), oats 20 ha (2%), vetch 148 ha (14%), canola 110 ha (10%), lentils 35 ha (3%) and 219 ha regenerated medic pasture (20%).

To try to prevent erosion, Super Sweet Sedan (forage sorghum-Sudan hybrid) was sown after rain in paddock N7/8 (17 November) where the canola failed and N5S (21 November) where pasture cover was minimal. At the time of writing (30 January), the sedan is yet to be grazed but with 13 mm of rain and a reasonable cover of plants, particularly in N7/8, it will be moderately grazed.

### *Certified seed*

Longsword (RAC 2341) wheat grown as certified seed, with 10 tonnes prepared for sale.

### *Harvest*

Harvest commenced on 31 October (Volga and Cummins vetch) and finished on 13 November (Compass barley). The program was completed with no interruptions. The average farm yields were; wheat 0.9 t/ha, barley 0.65 t/ha, canola (failed), lentils 0.15 t/ha, oats were grazed and vetch yielded approximately 0.1 t/ha.

***Issues encountered in 2017:***

- Poor establishment of canola due to lack of moisture
- Lack of early season rainfall
- Lack of paddock feed for livestock
- Caltrop in summer of 2017
- Photosensitisation in ewes and lambs
- Germination of all crops elongated

***Table 1. Harvest results, 2017 grain yields and protein aligned with paddock rotational histories.***

| Paddock | Paddock History 2012-2016 | Crop 2017 | Sowing date 2017 | Yield (t/ha) | Protein (%) | Screenings (%) |
|---|---|---|---|---|---|---|
| North 1 | P W W P W | Medic (P) | | | | |
| North 2 | W B P C W | Compass (B) | 9 June | 0.80 | 16.5 | 6.1 |
| North 3 | W W V W B | Cummins (V) | 11 April | Grazed | | |
| North 4 | B P W W P | Scepter (W) | 30 May | 0.71 | 14.1 | 6.1 |
| North 5 N | P W W B P | Scepter (W) | 31 May | 0.76 | 14.5 | 5.5 |
| North 5 S | W W W P W | Medic (P) | | | | |
| North 6 E | B Pe W W B | Medic (P) | | | | |
| North 6 W | W W C W B | Medic (P) | | | | |
| North 7/8 | P W P W P | Stingray (C) | 18 April | Fail | | |
| North 9 | W B V W B/W | Wintaroo(O) | 28 April | Grazed | | |
| North 10 | P W W P W | Medic (P) | | | | |
| North 11 | W P W W C | Scepter (W) | 1 June | 0.85 | 13.5 | 5.4 |
| North 12 | W W S S W | Mace (W) | 4 June | | 13.8 | 5.2 |
| South 1 | B C W Pe W | Spartacus (B) | 24 May | 0.78 | 17.2 | 5.7 |
| South 2/8 | W Pe W W P | Scepter (W) | 2 June | 1.01 | 12.4 | 3.4 |
| South 3 S | W P P W B | Cummins/Volga (V) | 25 April | 0.10 | | |
| South 3 N | W B P W B | Medic (P) | | | | |
| South 4 | P W P O/V W | Spartacus (B) | 25 May | 0.75 | 16.8 | 5.2 |
| South 5 | C B W P W | Compass (B) | 8 June | 0.10 | - | - |
| South 6 E | M W W B P | Scepter (W) | 1 June | 0.89 | 14.9 | 5.6 |
| South 6 W | W Pe B O P | Scepter (W) | 1 June | 0.89 | 14.9 | 5.6 |
| South 7 | P W W P W | Spartacus (B) | 26 May | 0.64 | 16.9 | 4.9 |
| South 9 | W W B P P | Hatchet/Longsword (W) | 5 June | 0.84/0.77 | 14.7/15.2 | 7.2/2.4 |
| South 10 | W V B B V | Scepter/Mace (W) | 3 June | 0.98 | 12.1 | 3.1 |
| Barn | X P P W O | Medic (P) | | | | |

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

### *Farm improvements and equipment*

A new Sonic 5027T boom spray and two new mobile sheep lick feeders were purchased during 2017 for improved technology and labour efficiency, respectively.

## Livestock

Stock currently on the farm: 335 merino ewes, 186 merino ewe lambs, 172 merino wether lambs, 87 crossbred lambs and 7 merino rams.

Reproduction results overall for 2017 from 355 ewes mated were 124% born and 98% marked, the low marking percentage was mostly due to failure of one ram. Excluding the 93 dry ewes (of which 51 were from the failed ram), the MAC flock had a scanning percentage of 167%, with 456 born, 361 marked and 132% lambing. The 93 dry ewes were joined to White Suffolk rams after pregnancy scanning revealed the failed sire, of which 75 had 91 lambs born in late September/ early October.

During the year, photosensitisation (a symptom where the skin becomes abnormally sensitive to sunlight) became an issue with livestock over much of Eyre Peninsula and MAC experienced major setbacks, particularly with young sheep, from the affliction, caused by grazing aphid-infested vetch. Livestock slated for sale had to remain on the research centre because of the photosensitisation causing scabbing and a reduction in condition. These animals needed to be hand fed while also reducing stubble feed, which over summer has been critical for the rest of the flock.

Shearing was completed on 31 January 2018, with the previous shearing completed in the last week of August 2017. From five months of wool, the ewes averaged 3.4 kg and 48.3 mm staple length per animal. Ewe lambs shorn at the same time with 7 months' wool averaged 2.6 kg greasy fleece weight (GFW) and 57.3 mm staple length (SL) per animal and the wether lambs averaged 2.8 kg GFW and 57.3 mm SL per animal. Ewe and wether lambs averaged 25.2 kg live weight as weaners.

One ram was purchased in 2017, from a stud presenting ASBVs on Eyre Peninsula.

## Acknowledgements

MAC farm staff Wade Shepperd and John Kelsh, MAC research staff Jessica Crettenden and Fiona Tomney, and MAC Administration staff Leala Hoffmann, Dot Brace and Naomi Scholz.

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LEADA Lower Eyre Agricultural Development Association

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

### *LEADA's 2017 achievements and 2018 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 Weed Management Workshop was held in March 2017 covering areas of Weed Management, recent research and an introduction to the integrated weed management tool (RIM) providing participants to input information. Trials are continuing and results from the project will be extended through LEADA's Expo and Field Days in the following year. LEADA along with EPARF hosted a 'Stubble Extravaganza' in November 2017. 39 researchers and advisors attended the interactive workshop, heard the latest research and recommendations on overcoming the barriers to stubble retention in relation to nutrition, weeds, pests (snails, mice), disease and stubble management, and participated in discussions. Thanks to Naomi Scholz for arranging and hosting the event.

Due to the dry start to the season in 2017 funding gained through the National Landcare Program to conduct pH mapping of a total of 1,000 ha and prepare best practice guidelines for management of low pH soils, including 2 case studies from farmer experience was granted an extension to June 2018. LEADA is hoping for a wetter start to the season to enable the pH mapping to be carried out.

LEADA was successful in securing a three year SAGIT grant looking at Copper Management for the Future. The project aims to explore different management strategies to overcome copper deficiency in cereals, comparing the effectiveness of copper sulphate and copper chelate applied either as liquids banded at seeding or as a foliar spray.

A very successful GRDC Dry Start Forum was held on 16 July 2017 in Cummins with assistance from LEADA. The forum was very timely, with excellent speakers covering cropping and livestock areas and allowed the 130 participants time for questions and conversations throughout the sessions. LEADA also provided assistance and support to GRDC for the GRDC Farm Business Update held in Port Lincoln on 5 July 2017 and the GRDC Grains Research Update held in Cummins on 11 August 2017.

GRDC funding for three years has been secured to establish and run nine 'pulse check' groups across the Southern Region of Australia and LEADA is facilitating the Lower Eyre Peninsula group learning/discussion and practical field sessions that focus on 'back to basics' lentil and/or chick pea production.

LEADA gained funding support through the EPNRM Sustainable Farming Systems Project Grant to run a second 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 II will be held in February 2018.

Into the future LEADA's focus will be around profitable pulses and pastures, cover crops and soil carbon and summer fodder trials. LEADA has applied for NLP Smart Farms Small Grant for a Deep Ripping/Slotting project and is involved in several Smart Farming Partnership projects from Sneaking Acidity, Cover Cropping, Deep Ripping and Farm Resilience.

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.

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John Richardson, Daniel Adams, David Giddings, George Pedler, Bruce Morgan, Dustin Parker, Mark Habner, Kieran Wauchope, Derek Macdonald, Josh Telfer, Sam Ness, Tom Nelligan, Mark Dennis, Mary Crawford (EPNRMB), Andrew Ware (SARDI), David Davenport (RSSA) and Mark Stanley (Ag Ex Alliance).

Regional Landcare Facilitator

*An initiative of the Australian Government Department of Agriculture.*

Government of South Australia
Eyre Peninsula Natural Resources Management Board

RURAL SOLUTIONS SA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

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# 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)

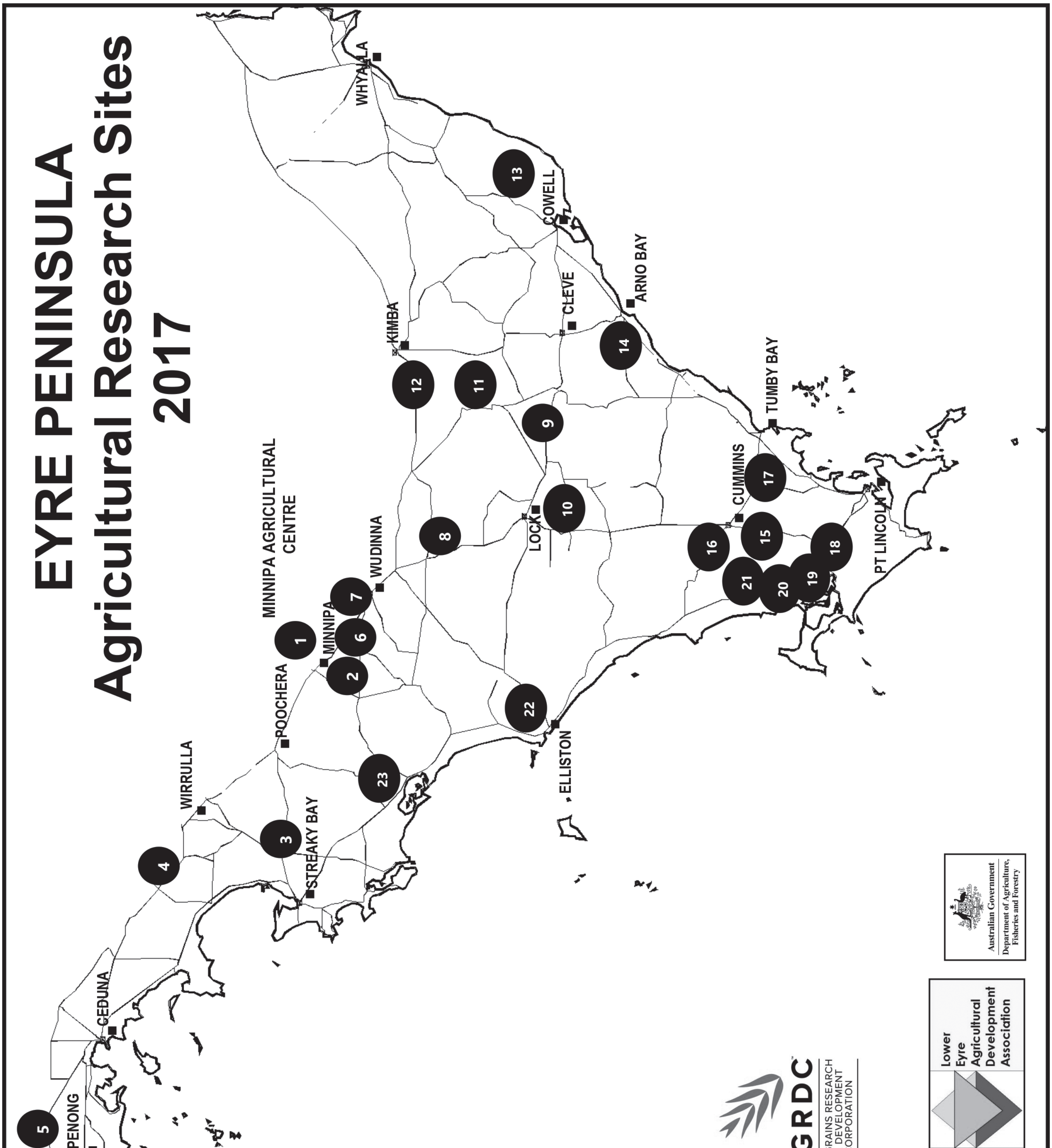
25 psi = 1.7 bar = 172 kPa

### 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
2017
MINNIPA AGRICULTURAL CENTRE
WHYALLA
COWELL
ARNO BAY
CLEVE
KIMBA
TUMBY BAY
CUMMINS
LOCK
WUDINNA
MINNIPA
POOCHERA
WIRRULLA
STREAKY BAY
ELLISTON
PT LINCOLN
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GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION
LEADA
Lower Eyre Agricultural Development Association
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Department of Agriculture, Fisheries and Forestry
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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE
EPARF
EYRE PENINSULA Agricultural Research Foundation
Government of South Australia
Eyre Peninsula Natural Resources Management Board
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***Eyre Peninsula agricultural research sites 2017 map references.***

| Map reference | Location | Trials | Host farm business |
|---|---|---|---|
| 1 | Minnipa | Herbicide efficacy in retained stubbles, Stubble management and seeding position, 2 year pasture break benefits, New herbicides for barley grass management, Two year pastures for barley grass management, Time of sowing including winter wheat, Impacts of controlled traffic, Improving medic performance, NVT wheat, barley, canola, Low rainfall break crops, Break crop performance, Canola establishment (timing, sowing rate, depth), Nitrogen and water co-limitation, Blackspot in peas, Lentil and faba bean time of sowing, UAV monitoring grass weeds, Vetch | SARDI<br>Minnipa Agricultural Centre |
| 2 | Minnipa | Swathing crops for barley grass control, UAV monitoring grass weeds | Bruce Heddle |
| 3 | Piednippie | Improving medic performance | Brent Cronin |
| 4 | Nunjikompita | NVT wheat | Tim Howard |
| 5 | Penong | NVT wheat | Butch Dunn |
| 6 | Yaninee | UAV monitoring grass weeds | Gregor Wilkins |
| 7 | Pinbong | Improving medic performance | Greg Scholz |
| 8 | Warramboo | NVT wheat | Murphy family |
| 9 | Rudall | NVT wheat, field pea | Jason Burton |
| 10 | Lock | Nitrogen and water co-limitation | Ian Burrows |
| 10 | Lock | Seed placement in non-wetting soils | Andrew & Tim Polkinghorne |
| 11 | Darke Peake | NVT barley | Mark Edwards |
| 12 | Kimba | NVT wheat | Shannon Mayfield |
| 13 | Cowell | Crown rot, NVT wheat | Kaden family |
| 14 | Wharminda | Water repellency | Chris Prime |
| 14 | Wharminda | District wheat trial, NVT barley | Tim Ottens |
| 15 | Cummins | Nitrogen and water co-limitation, NVT wheat, barley | Stuart Modra |
| 16 | Yeelanna | Eyespot in wheat | Ian Proctor |
| 16 | Yeelanna | Canola agronomy | Mark Modra |
| 16 | Yeelanna | Pulse and bean agronomy, NVT field pea, lentil | Chad Glover |
| 17 | Ungarra | Pre-emergent herbicides in dry sowing conditions, Stubble trials | Jamie Phillis |
| 18 | Wanilla | NVT wheat, barley | Bruce Morgan |
| 19 | Mt Hope | Sclerotinia in canola, Nitrogen trials | Ashley & Sam Ness |
| 20 | Greenly | Snail control | Neville & Dustin Parker |
| 21 | Brimpton Lake | New Horizons (soil amelioration) | Luke Moroney |
| 22 | Elliston | District wheat trial, NVT barley | Nigel & Debbie May |
| 23 | Mt Cooper | Pasture germination in barley stubble | Angus Gunn |

Section 1

**Section Editor:**
**Nigel Wilhelm**
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# Farming Systems

## Farming systems projects on Eyre Peninsula in 2017

INFO

**Naomi Scholz**
SARDI, Minnipa Agricultural Centre

There were three major farming systems projects funded by GRDC, delivered on upper Eyre Peninsula in 2017 (Table 1) and four SAGIT funded projects (Table 2).

***Table 1. GRDC funded farming systems projects on Eyre Peninsula in 2017.***

| **Title** | **Maintaining profitable farming systems with retained stubble** | **Application of CTF in low rainfall zone** | **Overdependence on Agrochemicals** |
|---|---|---|---|
| **Project code** | EPF00001 | ACT00004 | CWF00020 |
| **Funder** | GRDC | GRDC | GRDC |
| **Partners** | Lead: EPARF<br>SARDI (delivery) | Lead: Australian Controlled Traffic Farming Association (ACTFA)<br>SARDI (delivery) | Lead: Central West Farming Systems |
| **Duration** | 5 years, end 30/06/2018 | 5 years, end 30/06/2019 | 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.<br>Other groups involved are Upper North Farming Systems, Central West Farming Systems, Mallee Sustainable Farming, BCG, SPAA, DEPI Vic. | 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. | 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 | 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. | 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 2017** | Lock – Polkinghorne, comparing crop establishment based on seeding rate and position on non-wetting sand.<br>MAC – South 7, sowing into stubbles, height and in-row vs inter row.<br>MAC – S3S, cereal after two year pasture break.<br>MAC – S3N, herbicide efficacy in stubbles.<br>Mt Cooper – Gunn, establishment of pasture in heavy barley stubble.<br>MAC and 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 sites on upper EP. | Nil, trials completed in 2016. |
| **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. | Research and development sites, extension of information through existing events and publications. |

*Table 2. SAGIT funded farming systems projects on Eyre Peninsula in 2017.*

| 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 31/12/2017 |
| **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 2017** | 32 sites across EP. Visit www.eparf.com.au to access soil moisture probe network – view sites and data.<br>Username: eparf<br>Password: eparf | Piednippie (grey calcareous sand)<br><br>Pinbong (loamy sand)<br><br>MAC Airport | Nil, trials completed in 2016. | 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 (32 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.<br>Results presented at farmer meetings, MAC field day and published in EPFS Summary 2017. | 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.<br>Results presented at farmer meetings and published in EPFS Summary 2017.<br>Final summary articles for wheat and canola published in EPFS Summary 2017.<br>Completed. | Results presented at farmer meetings and published in EPFS Summary 2017.<br>Completed. |

# Outcomes from the GRDC Stubble Initiative on upper Eyre Peninsula

**Naomi Scholz, Amanda Cook and Nigel Wilhelm**
SARDI, Minnipa Agricultural Centre

EXTENSION

The GRDC funded project 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' aimed to produce locally relevant, 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 was increased knowledge and skills allowing farmers and advisers to improve farm profitability while retaining stubble in farming systems on upper Eyre Peninsula.

The project commenced in July 2013, with trials commencing in the 2014 season. Trials were conducted on three sites across upper EP (Minnipa, Lock and Mount Cooper). Activities at the sites focused on addressing local barriers to profitability in farming systems with retained stubble. These issues were identified in conjunction with farmers and included weeds (mainly barley, brome and annual rye grass), pests (snails and mice), establishment on non-wetting soils, herbicide efficacy in stubbles, establishment into cereal and medic residues, disease and the use of break crops in rotations.

Guidelines to overcome these barriers were developed with the use of local advisors, growers, collaboration with other farming systems groups and past research findings, and further validated and demonstrated through the R&D component of the project. Economic and risk analyses were also conducted on practices likely to impact on yield, to determine the those profitability of practices adapted to local situations.

The guidelines listed below are compiled in a booklet *"Guidelines for maintaining profitable farming systems with retained stubble on upper Eyre Peninsula"* (initially distributed in conjunction with this publication), and are also available via the EPARF website www.eparf.com.au/publications

1. Break crops in low rainfall farming systems
2. Cereal stubble management at harvest
3. Mice and stubble management
4. Snails and stubble management
5. Stubble management and cereal disease impacts
6. Herbicide efficacy in cereal stubbles
7. Sowing position and row spacing in cereal stubbles
8. When to reduce stubble loads
9. Sowing into medic stubbles
10. Stubble management during the break phase
11. Stubble management and weed control
12. Economic and risk analysis of break crops compared to continuous wheat farming systems
13. Economic analysis of reduced row spacing
14. Economics of near-row or on-row sowing compared to inter-row sowing on non-wetting sands

Specific research outcomes of 2017 trials are reported in this publication, with previous years reported in the Eyre Peninsula Farming Systems Summaries 2014-2016.

# Lessons learnt from a dry start

**Dale Grey[1], Ken Solly[2], Jessica Crettenden[3], Andrew Ware[4], Nigel Wilhelm[3], Amanda Cook[3], Greg Baker[5], Helen Brodie[5] and Jacob Giles[4]**

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## Introduction

2017 started well with well above average rainfall for January and February, with many growers spraying to control summer weeds and volunteer cereals, to manage insect pests and diseases and conserve soil moisture; thinking we were ready for another good season. However very dry and challenging seeding conditions, with little rain in late April, May and June coupled with low wheat prices, resulted in many growers questioning their management decisions and choices; if, when and how much should they sow? In response to this, GRDC, EPARF and LEADA provided "Dry Start Forums – Maximising returns despite a dry start" in mid-June across the EP. The following article captures some of the lessons learnt in 2017 to potentially help with decision making in future challenging seasons.

## Seasonal climate review of 2017 for Eyre Peninsula - Dale Grey

The 2017 growing season on the Eyre Peninsula was below the average, varying between decile 1 to decile 4, with the majority falling between decile 2-3. Ironically, the season didn't start out like this, with significant summer rain as a result of troughs and cyclonic breakdowns coming in from the north west. Most areas got over 100 mm for summer, which was decile 10. In February, the northern EP had a further 25 mm and this put deep soil moisture over the EP in the rare position of highest 1% of years. March was dry as a cracker. April saw a patchy start to the season where the far NE of the EP had a decile 8 start with 25 mm plus, but the rest of the EP had barely any useful rainfall for crop germination. This continued into May, with nothing of major use falling and June followed up with almost nothing as well. A fair bit of crop had been sown dry by now, but the longer season crops sown two months earlier were not ideal for what turned out to be a late break. Some proportion of the crop had not been sown and the hard decision of whether to pull the pin was being considered. The southern half finally got a start with 50 mm in July and the north got a useful but below average 25 mm. This was followed up by an average to wetter August which finally put the season on the map, with most of the EP receiving 50 mm plus. September "maketh the crop" and it was disappointing. The northern EP struggled for 15 mm and the southern region ticked over with just 25 mm. October was average or below, with the NE corner missing out again. As luck would have it the tap turned on in November, with a decile 8-9 drink of 25 mm. This was too late for some crops, but saved some others. To rub salt into wounds, December was wetter, with the eastern half of the EP getting a harvest interrupting 25 mm.

So what could explain this crazy level of variability? The last time such a poor start occurred was around 1993 and 2017 was the driest ever April-June in some areas of the EP. Other poor starts were as far back as 1930, 1941, 1959 and 1967, so not unprecedented, certainly infrequent, but not in recent memory for young farmers.

The 2016/17 summer experienced higher amounts of low pressure over SA, indicating favourable conditions for troughing moisture to the south from the tropics. In February the models first started sniffing the possibility of an El Niño in winter. There was a split in the models between a drier and average autumn. The problem with the El Niño prediction was that there were no real indicators in the ocean or the atmosphere that suggested this was possible; the chances looked unlikely. Couple this with the poor performance that most models have in doing autumn predictions and there was no reason to be too defensive in decision making, especially with a deep profile of moisture.

As luck would have it, the random weather conditions in the western Pacific required to start an El Niño failed to occur. By April-May some models started to get off the El Niño horse, but autumn was still dry. The pressure went much higher than normal over SA and a persistent high sat from Perth across to SA, stopping at the Victorian border. This meant that triggers for starting the seasonal break were all pushed south and couldn't get a connection to the good tropical moisture to the north.

By June all models had hopped off an El Niño, but despite this an average to drier outlook for spring prevailed. Things changed for the better in July and August with the ridge of high pressure moving much further north than normal, centred around Coober Pedy, causing the air pressure over southern SA to drop. This allowed frequent fronts and lows through, so connections to the tropics were once again back on.

But unfortunately it stayed this way for September and October, a critical transition time where things need to change from a winter pattern to a summer pattern. Whilst a northern position of the pressure ridge is good during winter, it starts being a problem in spring, as it starts blocking tropical feed from the north. In September a large number of models were gunning for a summer forming La Niña, which has in fact come to pass; but the horse had bolted, as summer La Niña's are very hit and miss as to their rain effects on the EP, and it was too late to be useful if it had been wet.

Now we are in the start of 2018 and there is little guidance from any scientific authority as to what is likely to happen this coming year. Whatever the predictions are in autumn, be very careful about basing too much decision making on them. Take more heed of soil moisture and concentrate on climate forecasts when it gets to July.

## Farm business management - Ken Solly

Making decisions in difficult situations with limited precedents is one of the most challenging things that famers can have to deal with. Experience is not experience until you have experienced it, and most good decisions are built on the back of experience. You can discuss the past until the cows come home but most of the real lessons in life are learned by your eyesight and your bank account.

Many young farmers are well advised to have a good farmer as a mentor who is a generation older, so that s/he can tap into another 20 to 30 years of experience and more importantly wisdom. Younger farmers are well advised to develop an extreme drought plan and do this when times are good. It is only when you are in a positive frame of mind that you can make the best decisions. In drought you must look after the most important four things on your farm, yourself, your family, your soil and your livestock. In planning for drought it is important that you make sure the decision maker is performing as best s/he can. Droughts pass but the impacts can last for many years. That said I consider it important to plan for a drought after you have had a good year. This will ensure that the available cash is being spent or directed correctly and that you will have sufficient working capital to get through a very bad year. Remember it is a physical drought one year and a financial drought the following year or maybe longer. Tools such as Farm Management Deposits (FMD) can be very useful but this will depend on your tax rate, equity level and other circumstances. If FMD'S can be built to the level of a year's working capital that can take a huge amount of stress out of the system.

It is even more important to have a plan for poor years that contains trigger points for performing certain tasks. Remember the soil is the basis of your business and a failure to take good care of it can have long term ramifications. The most important part of having a plan is that feeling of being in control of things when in fact most are out of your control. Poor management in tough years can affect the performance of the farm for many years to come, so it is important to always have a plan B for everything. Quite often your success is only as good as your back-up plan. Ensure that your plan is written down so you can reference it in the future and remind yourself what worked and what did not for the next time, and there will be a next time. My final piece of advice is to never go into unchartered waters on your own. Always make sure you have a good team around you, a problem shared is a problem halved they say.

## Livestock - Jessica Crettenden

In the 2017 season, the majority of regions across Eyre Peninsula experienced a significant period of minimal feed availability for their livestock enterprises, with some areas having to supplementary feed for over half of the year once stubble and pasture resources were depleted. The late 'break' and subsequent lack of natural pasture fodder took many farmers by surprise and the decision of whether to feed, agist and/or sell livestock was, and still is, rather challenging.

Considerable research has been undertaken in mixed farming areas of Australia that have experienced dry seasons and droughts to investigate and understand some of the tactical management options and strategic decisions made by businesses in these situations, and have found that successful livestock farmers;

- Make plans and take action early (decide to feed, agist and/or sell)
- Undertake simple budgets for various feeding and selling options (exit strategies)
- Know their fodder supplies (on hand and what is available, market outlooks)
- Prepare cash-flow budgets for their livestock enterprises for up to three years
- Reviewed decisions regularly, assessed risks and looked for opportunities.

Optimistically, farmers have learnt from this past season that flexibility is particularly important in livestock enterprises, as many different factors can influence business and operational decisions rapidly. Consequently, it is essential to understand how to manage livestock nutrition, reproduction, health and husbandry and flock/ herd structure according to the current environment and market outlooks.

Decisions can be complex when operating a mixed farming system, which many businesses on Eyre Peninsula would have observed over the past year, however this can also present more opportunities, such as the chance to graze failed crops or obtain cheaper supplementary feed for the livestock enterprise if seasonal and market conditions do not prevail for the cropping enterprise. In the 2017 harvest, some mixed farmers made the decision to hold onto some of their grain for feed due to poor grain prices and positive livestock market outlooks. Farmers who also did this after the 2016 harvest avoided having to pay high prices for supplementary feed in autumn when their on-farm stocks ran out, as others across the state were trying to source similar commodities.

Having enough supplementary feed on-hand for a minimum of two seasons is a lesson that most livestock producers should now understand and having a flexible business plan for their farming systems to cater for the variable environmental conditions is an essential measure for the successful productivity and profitability of the enterprise.

Other useful articles in the Eyre Peninsula Farming Systems Summary 2017 are *Sheep health issues in dry seasons*, and *Livestock supplementary feeding in mixed farming systems.*

## Cereal selection - Andrew Ware

The delayed start to the season in 2017 left many wondering if they should have a short season variety available in the silo, ready if similar conditions ever repeated themselves. The 2017 NVT trials and how their performances related to long term averages may provide some answers.

NVT trials in 2017 generally yielded lower than in the previous five seasons (averaging 1.3 t/ha across seven upper Eyre Peninsula sites). While some variability occurred between sites, when averaged across all upper EP sites, Scepter was the highest yielding entry, yielding 109% of the site mean yield. This was followed by Gladius, Mace, Trojan, and Axe yielding between 103-104% of site mean yield as the next highest yielding milling wheat varieties. Scepter's good relative performance in 2017 matches long term yields that show Scepter to be the highest yielding wheat variety across a wide range of yield environments in South Australia.

Only one NVT barley trial on upper Eyre Peninsula (Elliston) performed well enough to be released in 2017. Trials at Minnipa and Darke Peak had a number of plots that weren't able to be harvested due to varieties dying early and not being able to head. Observations of these trials showed that varieties such as Fathom, Hindmarsh, La Trobe, Spartacus CL, Scope, Rosalind and Compass all visually appeared to head well, however some of the European introduced varieties such as RGT Planet had largely died before heads had emerged.

Dry sowing, in general terms, proved a reasonably successful approach with cereals in 2017. While many growers that tried this practice reported lower than normal establishment, generally establishment still remained acceptable and these paddocks yielded higher than crops that were sown after the break to the season. Dry sown field trials conducted on lower EP found that increasing seeding rate did not significantly improve yield. Careful consideration of weed and mouse control was needed and patchy establishment on small rainfall events resulted in an unsightly range of plant growth stages across the paddock during the growing season.

## Nutrition - Nigel Wilhelm

One of the most vexing issues with managing the nutrition of broad-acre crops is that if nutrients additional to the soil supply are needed for a productive and profitable crop, they are best applied early in the crop's development, as early as seeding. This means that the majority of fertiliser investments are made early and committed to paddocks before any reliable signals of seasonal outlook are present. As you all know, there are always exceptions in agriculture, and foliar sprays of trace elements and mid-season spreading of N before the next rain are two obvious ones. However, in general supplementary nutrients applied at seeding give the best return on investment.

In years like 2017 with such a horrible start, and for many areas also a horrible finish, it is natural to be anxious about the value of all the fertilisers applied at seeding. While it is true that if the crop never gets the chance to perform well due to ongoing dry conditions, then the cash return to those fertilisers in that year is likely to be small or negative. But all is not lost. Under dry conditions, crops are more dependent on fertiliser nutrients than those in the soil because often they are close and readily available and thus easy for the crop to access. Another positive aspect is that unless the soil blows away, those fertiliser nutrients will not be lost to the paddock. They will contribute to the performance of crops in following years, so some of the fertilisers applied in a very dry year become an investment in the performance of those following crops. This happens a lot with P but even very soluble and mobile nutrients like bagged N will carry over from one year to the next, especially after very dry years.

This means that fertiliser rates in the year following a dry season can be discounted because of extra carry-over from the poor year prior.

In the higher rainfall areas, which often have to use a combination of nutrients applied at seeding and during the season to achieve the rates required to satisfy high yielding crops, farmers already have some wriggle room built in to adjust rates for poor outlooks. The amounts applied at seeding are committed very early in the programme but mid-season “top-ups” can be adjusted to current conditions and seasonal outlooks. Preserving this mix of seeding and midseason applications (e.g. 60:40 split of seeding and midseason for N) is a valuable risk management tool.

## Weeds and herbicides - Amanda Cook

The dry seeding conditions and lack of rainfall at the start of the 2017 season resulted in challenging conditions for both establishing crops and achieving weed control. There was little herbicide activity especially for those herbicides which rely on soil moisture and soil mobility for grass weed control. Barley grass generally all germinates in the following season, however in drier conditions the germination is lower as the seed does not have enough moisture to imbibe and germinate. Also grass weeds which set seed in cool mild spring conditions like 2016 generally have higher seed dormancy (Preston, 2017 Kimba GRDC Update).

Increased seed dormancy in cropped paddocks is also resulting in barley grass germinating later, which limits early grass control with pre-emergent herbicides. Reducing the weed seed bank is pivotal in managing all grass weeds so effective two year breaks during the pasture/break crop phase is important in paddocks with high grass weed numbers to reduce the grass weed seed bank. Using integrated weed management strategies such as crop competition is important to reduce weed numbers and the weed seed bank.

In 2017 at MAC, dry sowing on 26 April (TOS 1) in the herbicide efficacy trial resulted in significantly lower plant numbers due to seedling deaths with only 70 plants/m$^2$ after eight weeks of very dry conditions, compared to 30 May TOS 2 with 112 plants/m$^2$ after four weeks of dry conditions, and 10 July TOS 3 with 113 plant/m$^2$ sown into moist conditions. The earlier TOS 1 had higher weed numbers earlier in the season (26 barley grass/m$^2$) and lower crop establishment resulting in lower grass weed competition and greater barley grass weed seed set. In 2017 in extremely dry conditions and in a heavy soil type, the earlier TOS 1 (0.37 t/ha) did not result in higher grain yield compared to TOS 2 (0.49 t/ha). Sowing late into adequate moisture (TOS 3) resulted in very low grass weed numbers, average 4.5 barley grass/m$^2$ and low weed seed set, however there was a yield penalty (0.43 t/ha).

Hopefully the 2017 seeding conditions won’t be repeated and due to the very low rainfall in May and June may be one of the few times early sowing did not increase grain yield. Earlier sowing did result in higher numbers of grass weeds compared to later sowing.

## Russian Wheat Aphids - Maarten Van Helden

In 2017 the Russian Wheat Aphid (RWA) was found all over the Eyre Peninsula. SAGIT funded research done by SARDI Adelaide showed that this aphid prefers drier climates, and especially drought stressed young cereals. Autumn populations in (low rainfall) Loxton were 4-5 times higher than in medium and high rainfall areas!

RWA survives the summer mainly on volunteer cereals. It is often very easy to find in a paddock if there is some re-growth. Wild grasses (native or exotic) do not seem to play a major role for over-summering. Avoiding this ‘green bridge’ is important and this requires these plants to be killed at least 2 weeks before sowing, either by spraying, grazing or tillage. Cereals sown in April and early May seem to have a slightly higher risk of RWA colonisation. Fortunately, well-established crops (GS>35) seem no longer attractive for the aphid in spring. Little or no yield loss was observed in our trials on crops sown in mid-May.

Neonicotinoid seed treatments prevented aphid infestation in April and May sown crops, but some symptoms can still occur due to aphid probing. Over time the seed treatment wears off, but the bigger plants are no longer attractive.

Results however showed that sowing too late (June) is an even greater risk since RWA migration started in August, and young crops were very susceptible (Figure 1). Aphids probably built up in autumn on wild weedy grasses such as barley-grass and then migrated when these matured in August. So crops that are still at a vulnerable growth stage (GS<30) in August seem to be at high risk of RWA damage.

## Snail management - Greg Baker, Helen Brodie and Jacob Giles

The pre-season weather conditions and the timing and ‘decisiveness’ of the season break can influence the effectiveness and choice of snail management tactics.

Under a dry start there are several potential benefits for snail control. Firstly, a higher aestivation mortality may result from the greater dehydration in an extended dry and hot summer-autumn period.

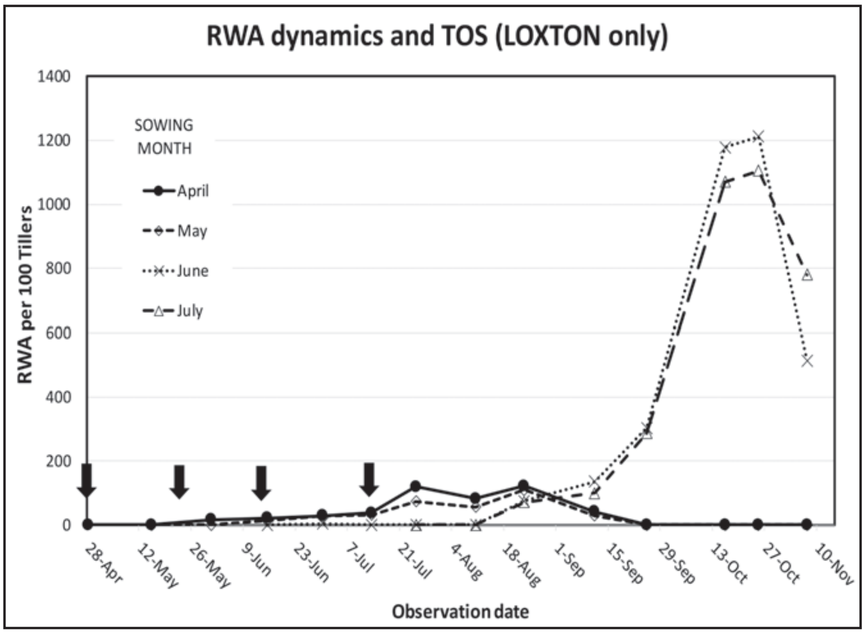


***Figure 1. RWA dynamics and time of sowing in Loxton 2017. Arrows indicate sowing dates.***

Also, a reduced green-bridge may provide less refuge and less chance for snails to revive and rehydrate during this period.

Secondly, there may be better opportunity to burn heavily-infested paddocks because the dry period may extend beyond the fire ban period.

However, a dry start also poses some potential disadvantages for snail management. Firstly, there are likely to be fewer good opportunities to bait early. Delayed rainfall is likely to limit the periods of early-season snail activity suitable for baiting. This increases the likelihood that baiting may not take place until cold 'winter' temperatures have set in, which reduces baiting effectiveness. If a grower is tempted to bait during an extended dry period, on the off-chance that it might rain, the baits are likely to be degraded under warm temperatures and hence may have lost their effectiveness when snail activity does commence.

Secondly, the staggered timing of snail activity (movement, feeding and egg laying) as a result of smaller, inconsistent rain events may require more repeated baiting applications to achieve good control.

Thirdly, a flow-on effect of late sowing may mean that crops mature later. Hence near to harvest snails may be less inclined to respond to light dews or rains that would otherwise result in them descending temporarily from standing crops. This may cause more snail contamination at harvest.

### *General recommendations for effective snail baiting*

Irrespective of the timing of the season break, the primary factors for effective snail bait application are a) a high level of snail activity and feeding at the time of baiting, and b) an adequate rate of bait application. Both must be achieved to ensure a high chance of bait encounter and a good baiting kill.

Autumn is the ideal time to bait snails and ensure good kill before egg laying has commenced. Baiting after egg laying has started will be less effective, because reducing the juvenile population is more difficult, newly germinating weeds and crop plants distract snails from baits, and lower temperatures often associated with later baiting reduce bait efficacy.

In a dry start we recommend to continue to monitor snail activity and bait when weather conditions have triggered sufficient snail movement and feeding activity to ensure good bait encounter.

## What have we learnt?

- Summer weed spraying to conserve soil moisture made a very important contribution to crop yields.
- Across all upper EP sites, Scepter was the highest yielding entry, yielding 109% of site mean yield followed by Gladius, Mace, Trojan, and Axe yielding between 103-104% of site mean yield.
- Make a business plan for tough times during the good times, and have a good team to help make the decisions.
- For some businesses making the decision not to crop was the right one (even though it's a very hard decision).
- Putting some grazing cereal in early and having adequate feed on hand is very important.
- Containment feeding is important to keep livestock off vulnerable paddocks
- Under dry conditions, crops are more dependent on added fertiliser nutrients than those in the soil as they are close, readily available and easier for the crop to access. Providing the soil does not blow away, fertiliser nutrients will not be lost to the paddock and most will be available for future crops.

# Impact of retaining stubble in low rainfall farming systems

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

**Searching for answers**

**Location**
Minnipa Agricultural Centre, paddock S7
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281 mm
2017 GSR: 155 mm
**Yield**
Potential: 2.1 t/ha (B)
Actual: 0.4 t/ha
**Paddock History**
2017: Spartacus CL barley
2016: Scope CL 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

- **Standing stubble cut low (15-17 cm) resulted in the highest level of stubble being maintained into the following season.**
- **Stubble management and seeding position had little effect on grass weeds.**
- **Snail numbers were higher in standing stubble cut high (30 cm) and stubble removed had the lowest numbers.**
- **Stubbles can be estimated using 1.3-2.8 times the grain yield, but it may underestimate the stubble in an average season following a good year, or after a very poor season.**
- **In many low rainfall farming systems livestock are still a very important part of the farming system and the level of stubble carryover is reduced after grazing.**
- **Stubble management and seeding position have not impacted greatly on crop production, weeds, disease and pests over three years with relatively high stubble loads for low rainfall farming systems.**

## Why do the trial?

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

The Minnipa Agricultural Centre (MAC) S7 stubble retention trial was established to maintain or improve crop production through applying alternative weed, disease and pest control options in pasture wheat rotations in the presence of crop residues. The trial was established in 2013 with wheat and different stubble treatments imposed at harvest annually. It was sown either inter row or on row in 2014-17 to determine the impacts of stubble management on crop production, weeds, disease and pests in low rainfall farming systems.

## How was it done?

The replicated plot trial was established in 2013 in MAC S7 paddock within the district practice non-grazed zone. The stubble treatments imposed after harvest each season were:

i. Stubble removed after mowing to ground level
ii. Stubble harvested low (15 cm)
iii. Stubble reapt high (30 cm)/ standing (district practice)
iv. Stubble reapt high then cultivated with offset disc in April.

In 2014-17 the trial was sown either:

i. Inter row (between last season's stubble)
ii. On row (in same position every season over the top of the previous crop rows).

In 2015-16 nitrogen treatments were added:

i. Nil
ii. 40 kg/ha urea at seeding and extra depending on seasonal conditions.

In 2017 no urea was applied due to the dry seasonal conditions.

The trial was sown dry on 16 May in 2017 before a predicted rainfall front with Spartacus CL barley @ 60 kg/ha with Systiva seed treatment and base fertiliser of DAP @ 60 kg/ha treated with flutriafol. Measurements taken during the season were stubble load and snail numbers (5 April), soil moisture (16 March), grass weeds pre-sowing (15 May), crop emergence (7 June), early grass weed counts (17 August), late weed and snail numbers (12 Oct), grain yield (8 Nov) and grain quality.

See previous Eyre Peninsula Farming Systems Summaries for details of the treatments imposed.

Data were analysed using Analysis of Variance in GENSTAT version 18. Data is presented as the main effects unless the interactions were significant.

## What happened?

See previous EPFS Summaries for more detailed information on previous seasons. The 2017 rainfall at Minnipa was within decile 1, so the trial information was collected in a severe drought season.

### *Site characteristics*

In 2017 soil characteristics in the 0-10 cm layer were soil pH ($CaCl_2$) 7.8 and Cowell P 23 mg/kg. In 2017 Predicta B soil analysis indicated a high risk of Rhizoctonia disease (159 pg DNA/g soil), Yellow leaf spot inoculum was high and *Pratylenchus thornei* levels were medium risk (15 nematodes/g soil).

Average soil mineral N for depths of 0-100 cm ranged from 92 kg/ha for the no added urea treatment, to 172 kg/ha soil N for the stubble removed treatment (Table 2), with an average across all treatments of 123 kg mineral N/ha.

### *Yield and biomass production*

Again in 2017 the greatest stubble carryover was in the stubble standing low cut treatment. The stubble fractions were separated into the standing stubble residue and the stubble on the ground. The low cut treatment had larger stubble pieces from previous seasons on the ground than other treatments.

In 2017 the trial had a staggered emergence with most plants germinating on 30 May after 6 mm of rainfall, however these plants became stressed until late June/early July when a total of 21 mm of rain fell. The dry seasonal conditions severely limited early plant growth.

In 2017 plant germination was affected by stubble management with cultivated stubble and removed stubble having the highest germination in dry conditions and high standing stubble having a lower germination (Table 2). Standing stubble cut low was not different to stubble removed for plant establishment, but plant establishment for low stubble was significantly lower than cultivated and higher than standing stubble cut high (Table 2).

Barley yields with standing stubble cut low and cultivated stubble yielded higher than the other stubble management treatments (Table 3). Stubble cut low and stubble cut high had lower protein levels, with no differences between stubble treatments for screenings (Table 3). The added urea treatment had higher grain protein and screenings in the dry 2017 season (Table 3).

Stubble dry matter after harvest was higher in the stubble standing cut low, sown inter row with extra N applied in the previous two seasons (Table 4). The standing stubble treatments tended to have higher retained stubble loads (Table 4).

### *Agronomic factors*

*Weeds:* In 2017 there were no grass weeds germinated before seeding on 16 May. Grass weed numbers counted on 17 August showed lower barley grass numbers compared to ryegrass, but management treatments had no influence (Table 2).

***Table 1. Stubble loads and grain yield as affected by stubble management, seeding alignment and nutrition at Minnipa 2013-16.*** *Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.*

| 2013-17 Stubble treatments | 2014 stubble load (t/ha) | 2014 wheat yield (t/ha) | 2015 stubble load (t/ha) | 2015 wheat yield (t/ha) | 2016 stubble load (t/ha) | 2016 barley yield (t/ha) |
|---|---|---|---|---|---|---|
| Stubble standing high | 3.4 | 2.40 | 5.8 | 1.19 | 4.3 | 2.14 a |
| Stubble standing low | 3.8 | 2.45 | 6.9 | 1.28 | 5.1 | 2.24 a |
| Stubble cultivated | 3.4 | 2.58 | 4.3 | 1.26 | 4.0 | 1.99 b |
| Stubble removed | - | 2.62 | - | 1.20 | 0.6 | 1.91 b |
| *LSD (P=0.05)* | *ns* | *0.08* | *ns* | *ns* | *0.6* | *0.14* |
| Inter row | | 2.55 | | 1.24 | 3.3 | 2.11 |
| On row | | 2.47 | | 1.22 | 3.6 | 2.02 |
| *LSD (P=0.05)* | | *0.06* | | *ns* | *ns* | *ns* |
| *No extra N | | | | 1.22 | 3.3 | 2.06 |
| *60 kg/ha N | | | | 1.25 | 3.6 | 2.08 |
| *LSD (P=0.05)* | | | | *ns* | *ns* | *ns* |

**N applied as 2015 and 2016 treatment, not applied in 2017 due to dry seasonal conditions.*

***Table 2. Stubble loads, establishment, pest and weed numbers in barley as affected by stubble management, seeding alignment and nutrition in 2017.*** *Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.*

| 2013-17 Stubble treatments | Total soil N kg/ha for 0-100cm* | Stubble load (t/ha) | Standing stubble load (t/ha) | Stubble on ground load (t/ha) | Snails pre sowing (snails/m²) | Barley establishment (plants/m²) | Early in-crop barley grass (plants/m²) | Early in-crop ryegrass (plants/m²) |
|---|---|---|---|---|---|---|---|---|
| Stubble standing high | 100 | 4.38 a | 1.58 a | 2.80 b | 18.1a | 96 c | 2.7 | 9.9 |
| Stubble standing low | 120 | 4.60 a | 0.93 c | 3.68 a | 7.1 b | 109 b | 2.9 | 8.6 |
| Stubble cultivated | 105 | 3.03 b | 1.39 b | 1.64 c | 11.9 b | 123 a | 2.9 | 13.3 |
| Stubble removed | 172 | 1.43 c | 0.15 d | 1.28 c | 1.2 c | 116 ab | 2.2 | 3.7 |
| *LSD (P=0.05)* | * | *0.42* | *0.21* | *0.80* | *6.0* | *12.0* | *ns* | *ns* |
| Inter row | 125 | 3.47 | 0.96 | 2.51 | 11.1 | 109 | 2.2 | 6.9 |
| On row | 127 | 3.25 | 1.06 | 2.19 | 8.1 | 114 | 3.2 | 10.9 |
| *LSD (P=0.05)* | * | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| *No extra N | 92 | 3.36 | 0.98 | 2.38 | 9.1 | 113 | 1.8 | 6.1 |
| *60 kg/ha N | 149 | 3.36 | 1.05 | 2.32 | 10.1 | 109 | 3.6 | 11.7 |
| *LSD (P=0.05)* | * | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |

**Samples bulked for soil nutrient analysis so no replication for statistical analysis*

***Table 3. Dry matter, weed number, grain yield and quality in barley as affected by stubble management, seeding alignment and nutrition in 2017.*** *Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.*

| 2013-17 Stubble treatments | Late dry matter (t/ha) | In-crop late ryegrass (plants/m²) | 2017 Barley yield (t/ha) | Protein (%) | Screenings (%) |
|---|---|---|---|---|---|
| Stubble standing high | 0.83 | 1.3 | 0.37 b | 13.9 ab | 9.0 |
| Stubble standing low | 0.89 | 1.4 | 0.41 a | 13.7 b | 8.8 |
| Stubble cultivated | 0.93 | 1.1 | 0.42 a | 14.1 a | 8.9 |
| Stubble removed | 0.73 | 0.6 | 0.36 b | 14.3 a | 9.0 |
| *LSD (P=0.05)* | *0.12* | *ns* | *0.02* | *0.3* | *ns* |
| Inter row | 0.87 | 1.0 | 0.39 | 14.0 | 9.3 |
| On row | 0.82 | 1.1 | 0.39 | 14.0 | 8.6 |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* | *ns* |
| *No extra N | 0.86 | 0.9 | 0.39 | 13.9 b | 8.5 b |
| *60 kg/ha N | 0.83 | 1.2 | 0.39 | 14.1 a | 9.3 a |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *0.1* | *0.8* |

***Table 4. Final stubble dry matter (t/ha) after harvest 2017.***

| 2013-17 Stubble treatments | Position | On row | On row | Inter row | Inter row |
|---|---|---|---|---|---|
| | Nutrition | No extra N | 60 kg/ha N | No extra N | 60 kg/ha N |
| Stubble standing high | | 2.5 bc | 1.9 cde | 2.5 bc | 2.1 bcd |
| Stubble standing low | | 2.8 b | 2.4 bc | 2.5 bc | 4.4 a |
| Stubble cultivated | | 1.4 def | 1.3 def | 1.8 cde | 2.1 bcd |
| Stubble removed | | 1.1 ef | 0.9 f | 0.8 f | 0.6 f |
| *Stubble Treatment x Position x Nutrition LSD (P=0.05)* | *0.83* | | | | |

*Disease:* Rhizoctonia inoculum levels were high in 2017, however disease symptoms were not visual due to drought stress and limited plant growth. Some spot form of net blotch was detected in the trial this season.

*Table 5. Actual stubble loads and predicted stubble loads for 2014-2017 at Minnipa.*

| 2013-17 stubble treatments | 2014 stubble load (t/ha) | 2014 wheat yield (t/ha) | Predicted stubble load 1.3-2.8 of grain yield | 2015 stubble load (t/ha) | 2015 wheat yield (t/ha) | Predicted stubble load 1.3-2.8 of grain yield | 2016 stubble load (t/ha) | 2016 barley yield (t/ha) | Predicted stubble load 1.3-2.8 of grain yield | 2017 stubble load (t/ha) | 2017 barley yield (t/ha) | Predicted stubble load 1.3-2.8 of grain yield (t/ha) | After harvest 2017/2018 stubble load (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stubble standing high | 3.4 | 2.40 | 3.1-6.7 | 5.8 | 1.19 | 1.6-3.3 | 4.3 | 2.14 | 2.8-6.0 | 4.38 | 0.37 | 0.5-1.0 | 2.3 |
| Stubble standing low | 3.8 | 2.45 | 3.19-6.9 | 6.9 | 1.28 | 1.7-3.6 | 5.1 | 2.24 | 2.9-6.3 | 4.60 | 0.41 | 0.5-1.2 | 3.0 |
| Stubble cultivated | 3.4 | 2.58 | 3.35-7.2 | 4.3 | 1.26 | 1.6-3.5 | 4.0 | 1.99 | 2.6-5.6 | 3.03 | 0.42 | 0.6-1.2 | 1.7 |

*Pests:* In 2017 in a non-grazed paddock and after a wet summer/autumn period the pre-sowing snail numbers were greater in the high cut stubble treatment compared to cultivated stubble or low cut stubble, and the lowest snail numbers were in the stubble removed treatment (Table 2).

The GRDC Stubble Management Fact Sheet (2011) predicts wheat stubble loads or volume can be estimated using 1.3-2.8 times the grain yield, and can start causing issues in farming systems from 3-4 t/ha dry matter. Table 5 shows the non-grazed stubble loads at Minnipa follow this estimation except in an average season following a very high yielding season, as in 2016 the stubble load was higher than predicted, and very low seasons (decile 1) where the 2017/2018 stubble load is also higher than predicted.

## What does this mean?

Standing stubble cut low (15-17 cm) resulted in the highest level of stubble being maintained into the following season. Low cut standing stubble and cultivated stubble yielded higher this season, despite cultivated and removed stubble having better plant establishment. The removed stubble treatment resulted in an extra 50 kg mineral N/ha over the average N level which equates to $49/ha, costed using urea at $450/tonne. There were no differences due to sowing position in 2017, and little difference in the extra nitrogen treatment with only 0.2% higher protein and 0.8% higher screenings in a dry season. Maintaining standing stubbles is 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.

In 2017, as in most previous seasons, stubble management and seeding position had little effect on grass weeds. Initial snail numbers in 2017 were highest in standing stubble cut high (30 cm) and stubble removed had the lowest numbers. Removal of stubble decreased 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.

Estimated stubble yield of 1.3-2.8 times the grain yield can be applied within ungrazed low rainfall farming systems, however this may underestimate the stubble in an average season following a good year, or after a very poor season, possibly due to higher carry over and lower breakdown of stubble from the previous season. In many low rainfall farming systems livestock are still a very important part of the farming system and the level of stubble carryover is reduced after grazing.

Overall, 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

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# Crop establishment on non-wetting sand

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RESEARCH

**Searching for answers**

**Location**
Lock
**Rainfall**
Av. Annual: 336 mm
Av. GSR: 250 mm
2017 Total: 338 mm
2017 GSR: 185 mm
**Yield**
Potential: 2.0 t/ha (B)
Actual: 0.5 t/ha
**Paddock History**
2017: Spartacus barley
2016: Kord wheat
2015: Mace wheat
**Soil Type**
Non-wetting sand
**Plot Size**
12 m x 2 m x 3 reps

## Key messages

- **Neither crop establishment, grain yield nor quality were changed by on-row seeding or by increased seeding rate in 2017, similar to results in 2016.**
- **Crop establishment in the non-wetting soil was poor in 2017.**
- **In 2015, with low moisture at seeding, improved crop establishment from on-row seeding in the non-wetting soil increased crop competition and lowered brome grass weed seed set.**

## 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 crop establishment and performance with 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 due to excessive weed issues.

## How was it done?

Treatments in 2016 were imposed on the same plots in 2017. Those treatments were two row placements; on previous crop rows and between previous crop rows (inter-row), each at two seeding rates of 50 and 70 kg/ha.

The trial was sown with Spartacus barley on 19 May at 30 cm row spacings. Base fertiliser was 18:20:0:0 (DAP) @ 60 kg/ha and a trace element mix of manganese sulphate @ 1.5 kg Mn/ha, zinc sulphate @ 1 kg Zn/ha and copper sulphate @ 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, LI700, prior to sowing.

Measurements taken during the season were pre-seeding soil moisture, emergence counts – three timings, late dry matter, grain yield and grain quality. The trial was harvested on 21 November.

## What happened?

The sand had a near neutral pH (7.1 in $CaCl_2$), good P reserves (Colwell P of 36 mg/kg in 0-10 cm) and very low phosphorus buffering index, and reasonable N reserves (mineral N 49 kg/ha in 0-100 cm) in March. In 2016 the MED non-wetting soil test was 1.2 which is moderate. The initial soil moisture at sowing in 2017 was 66 mm within the profile to 100 cm, with most located below 20 cm.

In 2017, topsoil moisture at seeding was just sufficient and there was also good soil moisture below 20 cm, however these were not joined. Barley establishment was very uneven and poor, with seedlings still emerging on late rainfall events in August as shown with plant establishment in Table 1. The overall establishment was very low with highly variable growth stages, which was reflected in the low yields achieved. There were no differences between either row placement or seeding rate (Table 1). There were also no differences in late dry matter, grain yield or quality (Table 1). Grass weed numbers were low in 2017.

There were no differences in final soil moistures with the average volumetric soil moisture after harvest (0-100 cm) being 87.5 mm, which was more than at the start of the season due to a large rainfall event shortly after harvest.

*Table 1. Plant growth, grain yield and quality as affected by seed placement and seeding rate at Lock in 2017.*

| Placement | Sowing rate | June establishment (plants/m²) | July establishment (plants/m²) | September establishment (plants/m²) | Early dry matter (t/ha) | Late dry matter (t/ha) | Yield (t/ha) | Protein (%) | Screenings (%) |
|---|---|---|---|---|---|---|---|---|---|
| On-row | 50 kg/ha | 4.6 | 9.9 | 24 | 0.38 | 1.51 | 0.45 | 12.7 | 5.9 |
| | 70 kg/ha | 8.6 | 9.6 | 26 | 0.35 | 1.08 | 0.44 | 11.5 | 2.9 |
| Inter-row | 50 kg/ha | 9.8 | 15.2 | 21 | 0.44 | 1.21 | 0.47 | 13.0 | 2.5 |
| | 70 kg/ha | 12.8 | 15.0 | 23 | 0.46 | 1.41 | 0.61 | 12.7 | 3.7 |
| *LSD (P=0.05)* | | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *2.5* |

## What does this mean?

In 2017, for the non-wetting soil trial and in reasonable topsoil soil moisture at sowing, there were no differences in crop establishment or yield due to seed placement or sowing rate. In 2015 in a similar trial but with a dry start to the season the sowing position of on-row resulted in better crop establishment which increased crop competition with brome grass.

In 2017 there were no differences in plant dry matter, grain yield or grain quality. In 2016 there were early dry matter differences due to the higher sowing rate, but these reduced during the growing season. In 2016 there were no differences in grain yield or grain quality due to seed placement or sowing rate.

Over the five growing seasons of the GRDC project 'Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula' this research has shown that sowing on-row may be an advantage for improving crop establishment and lowering brome grass weed seed set by increased crop competition on non-wetting soils with low moisture at sowing.

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EPARF Eyre Peninsula Agricultural Research Foundation Inc.

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

# Herbicide efficacy in retained stubble systems

RESEARCH

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**Searching for answers**

**Location**
Minnipa Agricultural Centre, paddock N6E
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281 mm
2017 GSR: 155 mm
**Yield**
Potential: 1.7 t/ha (W)
Actual: 0.43 t/ha average (early 0.37, mid 0.49, late 0.43)
**Paddock History**
2017: Mace wheat
2016: Compass barley
2015: Emu Rock wheat
**Soil Type**
Red loam
**Plot Size**
12 m x 2 m x 3 reps

## Key messages

- **Dry seeding conditions and lack of rainfall at the start of the 2017 season resulted in challenging conditions for both establishing crops and weed control.**
- **Stubble residues reduced plant establishment and weed numbers; standing stubble in dry conditions had higher wheat germination than chained stubble.**
- **April dry sowing had lower wheat numbers than later sowings, which reduced grass weed competition during the season. Grass weed numbers were higher and set more seed in the April sowing.**
- **No pre-emergent herbicide provided total barley grass weed control and keeping the weed seed bank low through other methods is important.**
- **Under the production regimes of upper EP, stubble management is unlikely to impact negatively on performance of pre-emergence herbicides targeting grass weed control, providing adequate water rates and best practice application techniques are used.**

## 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). One of the barriers to retaining stubble is the perceived reduction in pre-emergent herbicide effectiveness (efficacy) in stubbles. This component of the project is testing whether various stubble management activities impact on herbicide efficacy.

Weed control in stubble retained systems can be compromised when stubbles and other plant residues intercept the herbicide and prevent it from reaching the desired target, or the herbicide is tightly bound to organic matter. Reduced herbicide efficacy in the presence of higher stubble loads is a particular issue for pre-emergence herbicides. Current farming practices have also changed weed behavior; e.g. prolonged dormancy in barley grass has been confirmed in many paddocks on Minnipa Agricultural Centre (MAC). As a part of the stubble project this trial was undertaken to assess herbicide efficacy in different stubble management systems.

This article reports on the results of the third and final year of the trial. See EPFS Summaries 2015 and 2016 for previous trial reports.

## How was it done?

The 2017 trial was located at Minnipa Agricultural Centre (MAC) in paddock N6E. The stubble management treatments imposed were; (i) Cut low and traditional spread stubble and (ii) Cut low at harvest and prickle chained (6 April).

Mace wheat @ 60 kg/ha with DAP @ 60 kg/ha was sown on:

i. dry sowing 26 April (selected treatments) (TOS 1)
ii. 30 May dry sowing before predicted rainfall front (main trial with all treatments) (TOS 2)
iii. 10 July in moist conditions (selected treatments) (TOS 3).

All spray treatments were applied at 8 km/h using a shrouded boom with a 100 L/ha water rate, pressurised canisters at 2 bar and medium size spray nozzles.

Weed germination early in the season at the site was nil, due to low rainfall with no knockdown being required before any of the sowing times. The plants in TOS 1 and TOS 2 had poor emergence and did not fully emerge until late June/early July when significant rainfall events occurred. Due to the very late start to the season another small replicated trial was sown into a moist seedbed with selected treatments.

The paddock is a red loam with alkaline pH (7.7 in $CaCl_2$), P reserves of 36 mg/kg in 0-10 cm (Colwell P), a P buffering index of 120 and reserves of 67 kg mineral N/ha in the top 100 cm of soil.

The Predicta B soil analysis predicted a high risk of Rhizoctonia disease (279 pg DNA/g soil) and Yellow leaf spot inoculum was also present. The average barley stubble load on the trial at the beginning of 2017 after a light grazing was 3.5 t/ha DM.

Measurements taken were stubble load pre-seeding, soil moistures, plant emergence counts, early (17 August) and late (16 October) dry matter, early, mid (11 September) and late grass weed counts, grain yield (17 November) and grain quality. Harvest grass weeds were counted for tillers, seed heads, head weight and 100 seed weight.

Data were analysed using Analysis of Variance in GENSTAT version 18. The least significant differences are based on F prob=0.05. There was no interaction between Stubble and Herbicide treatments, so the data is presented as the main effect of either Stubble management or Herbicide treatment.

## What happened?

### *Rainfall*

Good summer and autumn rainfall occurred with an average of 95 mm stored soil moisture in the profile below 30 cm in April. A 6 mm rainfall event occurred on 30 May, 6.4 mm on 29 June and 15 mm over 3 days between 7-9 July resulting in poorly established crops. The 2017 season was a decile 1 which resulted in poor growth and low yields.

### *Time of sowing*

Plant establishment was lower with April sowing, averaging only 70 plants/m$^2$ compared to 113 plants/m$^2$ in TOS 2 and TOS 3 (Table 1). Trifluralin (2 L/ha) also reduced plant establishment compared to the control in the TOS 3 sowing when the topsoil was moist (Table 6).

TOS 2 (30 May) resulted in reasonable plant establishment, greater dry matter and higher yield. TOS 1 had higher barley grass numbers throughout the season with higher seed set, and TOS 3 had the lowest grass weed numbers in crop (Table 2).

### *Stubble management*

Standing stubble had better plant establishment than chained stubble (Table 1). April chained stubble had higher grain yields (Table 1), lower grass weed numbers and grass weed seed set (data not presented).

***Table 1. Effect of stubble treatments and time of sowing on plant establishment and wheat yield at MAC 2017.***

| Stubble treatment | Wheat plant establishment (plants/m$^2$) | | | Grain yield (t/ha) | | |
|---|---|---|---|---|---|---|
| | TOS 1 26 April | TOS 2 30 May | TOS 3 10 July | TOS 1 26 April | TOS 2 30 May | TOS 3 10 July |
| Chained | 65.2 | 108.6 | - | 0.45 | 0.52 | |
| Standing stubble | 75.3 | 116.5 | 113.4 | 0.28 | 0.46 | 0.43 |
| *LSD (P=0.05)* | *9.7* | *6.2* | - | *0.03* | *0.02* | - |

***Table 2. Time of sowing effects at MAC 2017.***

| Sowing Date | Late wheat dry matter (t/ha) | Barley grass plants/m$^2$ Sept | Barley grass plants/m$^2$ Oct | *Total number of Barley grass seed/m$^2$ Oct |
|---|---|---|---|---|
| TOS 1 26 April | 1.01 | 28.1 | 24.2 | 2353 |
| TOS 2 30 May | 1.23 | 14.9 | 13.7 | 776 |
| TOS 3 10 July | 1.04 | 5.0 | 1.6 | 64 |
| *LSD (P=0.05)* | *0.10* | *13.5* | *10.4* | *674* |

** calculated from weight of barley grass heads and average barley grass 100 seed weight.*

*Table 3. Stubble management and plant measurements in dry sown TOS 1 (26 April) and TOS 2 (30 May) trials, MAC 2017.*

| Time of sowing | Stubble management | Barley grass plants/m$^2$ Aug | Late wheat dry matter (t/ha) | Barley grass plants/m$^2$ Sept | Barley grass plants/m$^2$ Oct | Barley grass height Oct (cm) | Total number of Barley grass seed/m$^2$ Oct |
|---|---|---|---|---|---|---|---|
| 26 April TOS 1 | Chained | 8.4 | 1.16 | 9.1 | 6.1 | 16.1 | 235 |
| | Standing stubble | 42.7 | 0.85 | 47.2 | 42.3 | 13.8 | 4470 |
| *LSD (P=0.05)* | | *18.3* | *0.11* | *19.4* | *13.6* | *2.1* | *1176* |
| 30 May TOS 2 | Chained | 4.3 | 1.28 | 4.8 | 6.9 | 13.6 | 276 |
| | Standing stubble | 23.2 | 1.19 | 25 | 20.5 | 15.6 | 1276 |
| *LSD (P=0.05)* | | *6.6* | *0.08* | *7.2* | *5.8* | *1.9* | *258* |

***Weeds and herbicide treatments***

Plant establishment was not affected by any herbicide treatment in TOS 1 and TOS 2 (Table 4 and 5) in drier conditions. In colder moister soil conditions (TOS 3) Trifluralin (2 L/ha) reduced plant numbers compared to the control, which may have been due to the Trifluralin being more active at the rate of 2 L/ha or less physical separation of the seed and herbicide (Table 6).

Barley grass numbers were generally low in the 2017 season with an average of 13 plants/m$^2$ across the whole trial site in August, regardless of treatments. The stubble management showed differences in barley grass germination, with the standing stubble block (23 plants/m$^2$) having greater grass weed numbers than the chained stubble (4 plants/m$^2$). The chained stubble block may have had lower barley grass weed seed germination due to; very small rainfall events and less moisture reaching the soil and grass weed seeds, and the wheat germination was also lower in TOS 1 and TOS 2 with chained stubble; generally soil disturbance does not increase barley grass weed seed germination, unlike ryegrass (B Fleet, per comm.) so this may have resulted in lower barley grass germination; and some variation in background weed seed populations.

In the TOS 1 trial all treatments had lower barley grass weed numbers than the control (Table 4). However, by the end of the season barley grass numbers had increased resulting in higher weed seed set compared to the control except in the Sakura and the Trifluralin (2 L/ha) + Avadex (1.6 L/ha) + 900diuron (500 g/ha) treatments. Some herbicides showed suppression with decreased height of grass (Table 4 and 5), fewer tillers and smaller heads (data not presented). There were no differences in TOS 1 in early or late dry matter of wheat between treatments, or barley grass and ryegrass weed numbers late in the season. There were no differences in grain quality with protein averaging 13.2%, screenings averaging 10.9% and a test weight of 74.3 kg/hL.

***Table 4. Herbicide effects on barley grass and wheat establishment and yields in dry sown TOS 1 trial (26 April).***

| Treatment | Establishment (plants/m$^2$) | Barley grass (plants/m$^2$) Aug | Barley Grass (plants/m$^2$) Sept | Barley grass height Oct (cm) | Total number of barley grass seed/m$^2$ | Grain yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 80.7 | 51.5 | 52.0 | 16.0 | 3726 b | 0.37 |
| Trifluralin (2 L/ha) | 69.1 | 31.5 | 36 | 16.2 | 3807 b | 0.33 |
| Sakura (pre-emergent) | 75.1 | 5.3 | 4.7 | 12.8 | 609 a | 0.40 |
| Boxer Gold (pre-emergent) | 66.9 | 32.1 | 40.7 | 14.5 | 2060 ab | 0.38 |
| Trifluralin (2 L/ha) + Avadex (1.6 L/ha) + 900diuron (500 g/ha) | 59.3 | 7.4 | 7.3 | 15.3 | 1562 a | 0.34 |
| *LSD (P=0.05)* | *ns* | *13.8* | *30.6* | *ns* | *1858* | *ns* |

*Table 5. Herbicide effects on barley grass and wheat establishment and yields in dry sown TOS 2 trial (30 May).*

| Herbicide treatment | Group | Herbicide cost ($/ha) | Establishment (plants/m²) | Barley grass plants/m² Oct | Barley grass height Oct (cm) | Total number of seed/m² ** | Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Control Untreated | | - | 116.9 | 24.6 b | 16.2 | 1008 defg | 0.47 |
| Trifluralin (1.5 L/ha) | D | 9 | 114.6 | 22.9 b | 16.5 | 1177 efg | 0.47 |
| Trifluralin (2 L/ha) | D | 12 | 109.6 | 23.8 b | 17.3 | 1265 fg | 0.48 |
| Trifluralin (1.5 L/ha) + Lexone (metribuzin) 180 g (post)* | D+C | 15 | 104.2 | 5.6 a | 15.7 | 543 abcde | 0.47 |
| Trifluralin (1.5 L/ha) + Diuron 900 (400 g/ha = 360 ga/ha)*(pre-emergent) | D+C | 14 | 105.2 | 13.8 ab | 16.3 | 658 abcdef | 0.49 |
| Trifluralin (1.5 L/ha) + Diuron 900 (high rate)* (pre-emergent) | D+C | 19 | 121.5 | 14.0 ab | 18.3 | 1603 g | 0.50 |
| Trifluralin (1.5 L/ha) + Avadex (Tri-allate) (1.6 L/ha) (pre-emergent) | D+J | 25 | 113.1 | 11.1 ab | 16.0 | 725 bcdef | 0.52 |
| Trifluralin (2 L/ha) + Avadex (1.6 L/ha) + 900diuron (500 g/ha)* (pre-emergent) | D+J+C | 28 | 115.8 | 12.9 ab | 15.3 | 1043 defg | 0.47 |
| Trifluralin (1.5 L/ha) (pre) + Monza (sulfosulfuron) (25 g/ha) (post) | D+B | 35 | 108.4 | 18.2 ab | 10.6 | 753 bcdef | 0.50 |
| Monza (sulfosulfuron) 25 g (pre-emergent) | B | 26 | 117.3 | 4.2 a | 9.2 | 222 abc | 0.50 |
| Sakura (118 g) (pre-emergent) | K | 40 | 112.6 | 7.6 a | 14.2 | 525 abcd | 0.51 |
| Monza (sulfosulfuron) (25 g) + Sakura (118 g) (pre-emergent) | B+K | 66 | 113.3 | 4.7 a | 11.2 | 105 ab | 0.49 |
| Sakura (118 g)+ Avadex (Tri-allate) 3 L (pre-emergent) | K+J | 70 | 111.9 | 5.6 a | 8.0 | 402 abcd | 0.49 |
| Boxer Gold (2.5 L/ha) (pre-emergent) | K+J | 37 | 105.7 | 10.4 ab | 16.3 | 777 cdef | 0.49 |
| Boxer Gold (2.5 L/ha) (post) | K+J | 37 | 117.0 | 24.0 b | 16.2 | 1304 fg | 0.44 |
| Sakura (118g)+ Avadex (Tri-allate) 3 L/ha (pre-emergent) + Boxer Gold 2.5 L/ha (post) | K+J | 107 | 109.1 | 5.1 a | 14.7 | 68 a | 0.52 |
| *LSD (P=0.05)* | | | *ns* | *14.5* | *4.7* | *652* | *ns* |

**use with caution in light soil types, and heavy rainfall events post sowing can cause leaching and crop damage. Note some treatments in the trial are for research purposes only.*
***calculated from weight of barley grass heads and average barley grass 100 seed weight*

There were no differences in wheat establishment, early or late dry matter or grain yield in TOS 2 (Table 5). However, grain quality was slightly higher with standing stubble with 13.0% protein compared to 12.7% chained, and 9.8% screenings in standing stubble compared to 8.2% in chained. There were no differences due to the herbicide treatments in early and mid-season barley grass weed counts (data not presented). Sakura/mixes and Monza had better late weed control and lower weed seed set (Table 6). The expensive mixes of Sakura (118 g)+ Avadex (Tri-allate) 3 L (pre-emergent) + Boxer Gold 2.5 L (post), Monza (sulfosulfuron) 25 g (pre-emergent) or Monza (sulfosulfuron) (25 g) + Sakura (118 g) (pre-emergent) were the only herbicide treatments to lower barley grass weed seed set in very dry conditions compared to the control. Monza has longer persistence and will reduce medic plant numbers so may only be an option in first year of cereal crops in rotation.

TOS 3 had very low grass weed numbers compared to the other trials (Table 6) however, this did not result in better yield due to the later seeding. In TOS 3 there were no differences in grain quality with protein averaging 14.1%, screenings 6.5% and test weight 76.0 kg/hL.

***Spray coverage***

There were no differences in spray coverage due to stubble management in the preceding 3.5 t/ha barley crop using spray cards on selected treatments in TOS 2 trial (Figure 1).

*Table 6. Herbicide treatments and plant and weed measurements in TOS 3 trial (10 July).*

| Treatment | Plant establishment (plants/m$^2$) | Early barley grass (plants/m$^2$) Aug | Early dry matter (t/ha) | Late barley grass (plants/m$^2$) Oct | Barley grass height (cm) | Grain yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 121.5 | 0 | 0.31 | 1.8 | 18.3 | 0.44 |
| Trifluralin 2 L/ha (pre-emergent) | 91.1 | 14.8 | 0.25 | 1.8 | 5.3 | 0.42 |
| Sakura (pre-emergent) | 112.2 | 2.5 | 0.27 | 0.9 | 11.0 | 0.42 |
| Boxer Gold (pre-emergent) | 128.9 | 1.2 | 0.30 | 1.8 | 7.0 | 0.45 |
| *LSD (P=0.05)* | *12.3* | *ns* | *ns* | *ns* | *ns* | *ns* |

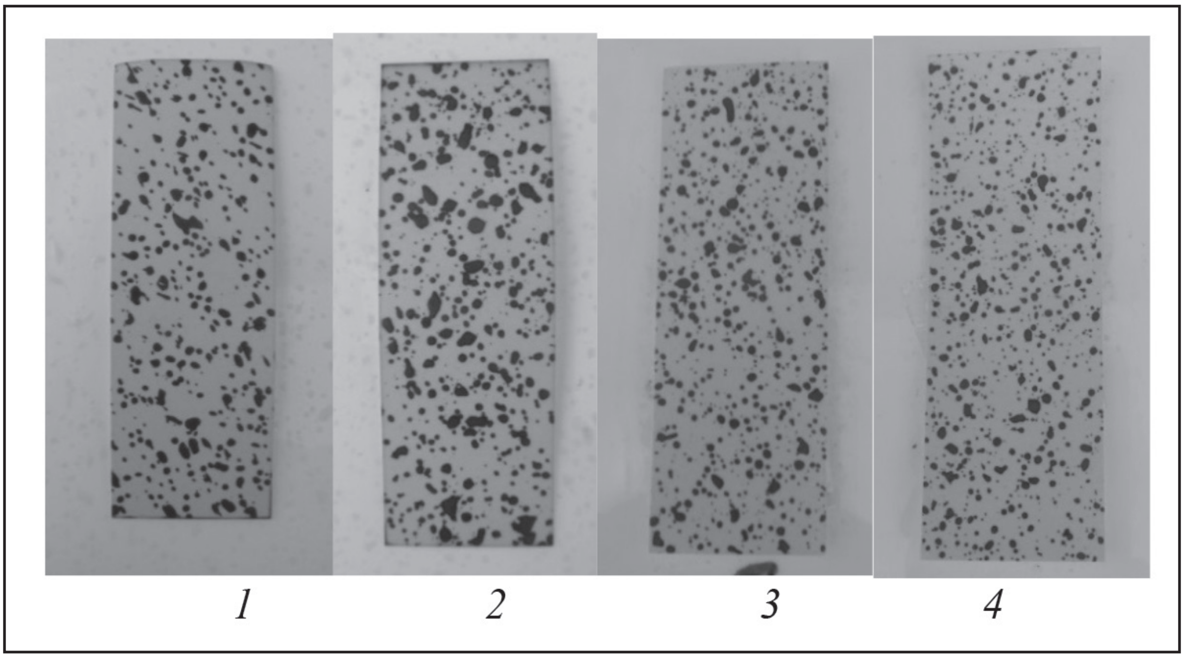


***Figure 1. 2017 spray cards (1) 1.5 L Trifluralin in chained stubble (2) 1.5 L Trifluralin in standing stubble (3) Sakura (118 g) pre-emergent in chained stubble, and (4) Sakura (118 g) pre-emergent in standing stubble.***

## What does this mean?

The dry seeding conditions and lack of rainfall at the start of the 2017 season resulted in challenging conditions for both establishing crops and weed control. Early dry sowing (26 April) had poor plant establishment resulting in low crop competition, increased barley grass seed set and a lower yield.

Barley grass generally all germinates in the following season after shedding, however in drier conditions germination is lower as the seed does not have enough moisture to imbibe and germinate, so increased viable seed carry over can be expected in 2018. Also the weed seed produced in cool mild conditions like the 2016 spring have been shown to generally have higher seed dormancy, which would be the majority of the 2017 weed seed bank. There was little herbicide activity, especially for those more reliant on soil moisture for activation and movement into the soil.

In the dry 2017 seasonal conditions stubble management by chaining in April had lower grass weed numbers resulting in higher grain yield. Barley grass prefers less disturbance or no tillage to increase germination, unlike ryegrass (B Fleet, per comm), so the lower germination may have been due to the tillage effect or less moisture reaching the seed compared to standing stubble, hence lowering the germination. The wheat germination with standing stubble was higher than the chained stubble, so soil moisture and germination may have been a factor. Sowing late into adequate moisture (TOS 3) resulted in low grass weed numbers, as the seed dormancy may have broken and tillage at sowing lowered the grass weed numbers resulting in low weed seed set, however there was a yield penalty for sowing late.

2017 has not placed the herbicide packages "under pressure" because the grass weed populations were low. Under low populations of barley grass, weaker herbicide options may perform adequately compared to high weed population situations. Sakura still provided the best option for managing barley grass weeds and reducing weed seed set, with Monza also performing well in the dry conditions, however be aware of residual carry over which may impact on medic pasture regeneration in the following season. Caution must be taken with some of the herbicides, especially in lighter soil types and with rainfall events after seeding as they may wash into the crop root zone.

This research suggests that under the production regimes of upper EP, stubble management is unlikely to impact negatively on performance of pre-emergence herbicides targeting grass weed control, with adequate water rates.

Due to the prolonged seed dormancy in barley grass at MAC, early grass control with pre-emergence herbicides is very limited. Reducing the weed seed bank is pivotal in managing all grass weeds, so effective two year breaks during the pasture/ break crop phase is very important in paddocks with high grass weed numbers to adequately reduce the barley grass weed seed bank. 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 herbicides for longer residual grass control. Extra crop competition by using narrower row spacings and/or increasing seeding rates have also been effective tools to reduce weed numbers and weed seed set.

If herbicide resistance in barley grass is an issue or a concern, the first step is to test the population to know exactly what you are dealing with. While barley grass resistance is not widespread, as most seed germinates the following season, it is essential to control any potentially resistant survivors as they may quickly become the greater proportion of the weed seedbank. To ensure Group A resistance is kept in check, make sure any suspected resistant plants are dealt with within pasture systems by following up with a knock down herbicide as early as possible to prevent any seed set. Always have a follow up option to control any survivors and to preserve group A herbicides. Another option may be to use other chemical groups like propyzamide (in moist conditions) to reduce the barley grass population before using a group A herbicide. Using alternative chemical groups by including canola or Clearfield systems as a different rotational break may also be an option. The Group As are easily the cheapest and most effective way to control barley grass within current farming systems so we need to ensure this herbicide group remains a cheap and viable option.

## Acknowledgements

Thank you to Brett Hay, Katrina Brands and Rochelle Wheaton for collecting grass weeds data. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001). Registered products: see chemical trademark list.

EPARF Eyre Peninsula Agricultural Research Foundation Inc.

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

# Grass weed management in pasture

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

RESEARCH

**Searching for answers**

**Location**
Minnipa Agricultural Centre, paddock S3S
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281 mm
2017 GSR: 155 mm
**Yield**
Potential: 5.6 t DM/ha (pasture)
Actual: 1.1 t DM/ha (October)
**Trial History**
2017: Regenerated medic pasture
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

- **Hay cutting in 2013 resulted in lower medic dry matter in 2017.**
- **Grass weed numbers were very low in 2017 due to low opening rains and poor germination.**
- **Two years of wheat increased Rhizoctonia, Yellow leaf spot and *Pratylenchus*.**
- **A two year pasture break was beneficial to the following cereal because of lower grass weed numbers, higher soil reserves of N and lower disease levels.**

## 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 the impact of a two year medic pasture break on barley grass. The trial had different grass weed management and tillage treatments imposed in 2013 and 2014. The trials were sown with wheat in 2015 and 2016, and allowed to regenerate with medic pasture in 2017.

## How was it done?

The replicated trial was established in 2013 at Minnipa Agricultural Centre in paddock S3S. Pasture treatments imposed in 2013 were:

i. selective grass control,
ii. selective grass control and mowing/haycut,
iii. selective grass control and pasture topping.

In 2014 on 1 March the 3 blocks established in 2013 (i – iii) were each split into:

a. worked (a light tillage with an off-set disc),
b. unworked.

In 2015 pre-sowing treatments within each of the 6 blocks from 2014 were:

1. harrowing to remove medic stubble,
2. disc/light tillage,
3. full cut tillage,
4. direct drill.

See previous Eyre Peninsula Farming Systems Summaries for details of the treatments imposed in previous seasons. Measurements taken during the 2017 season were soil moisture, soil-borne disease inoculum, emergence counts, medic dry matter and grass weed counts (pre-seeding, at establishment and at harvest).

Data were analysed using Analysis of Variance in GENSTAT version 18.

## What happened?

The red loam has an alkaline pH (8.4 in $CaCl_2$), with P reserves of 18 mg/kg in 0-10 cm (Colwell P), and P buffering index of 149.

In autumn of 2017, after two cereal crops, Predicta B soil analysis measured a high risk of Rhizoctonia disease (120 pg DNA/g soil), Yellow leaf spot inoculum was also high and *Pratylenchus neglectus* levels were medium risk (15 nematodes/g soil). The average wheat stubble load on the trial at the beginning of 2017 was 6.0 t/ha DM and was not affected by previous treatments.

The 2017 season was a decile 1 at Minnipa with very poor opening rains. Some medic germinated after 6 mm of rainfall on 30 May, however these plants were very small and stressed until late June/early July when a total of 21 mm of rain fell. Medic production in 2017 was very poor as the dry seasonal conditions severely limited plant growth. There were no differences between treatments in early 2017 soil moistures (March) with the average volumetric soil moisture being 123 mm (0-100 cm) with most below 30 cm.

*Table 1. Dry matter production of medic in 2017 as affected by previous medic pasture management and tillage.*

| 2013 treatment | 2017 medic DM (t/ha) | 2015 tillage treatment | 2017 medic DM (t/ha) | |
|---|---|---|---|---|
| | | | 2014 un-worked | 2014 worked |
| Selective grass only | 1.30 | Disc | 1.19 | 1.28 |
| | | Full cut | 1.56 | 1.00 |
| | | Harrow | 1.31 | 1.29 |
| | | Direct Drill | 1.27 | 1.48 |
| Selective grass + Mowing/haycut | 0.92 | Disc | 1.19 | 0.75 |
| | | Full cut | 0.82 | 0.91 |
| | | Harrow | 1.17 | 0.94 |
| | | Direct Drill | 0.87 | 0.72 |
| Selective grass + Pasture topped | 1.17 | Disc | 0.84 | 1.41 |
| | | Full cut | 0.87 | 0.82 |
| | | Harrow | 1.73 | 1.25 |
| | | Direct Drill | 1.24 | 1.20 |
| *LSD (P=0.05) 2013 treatments* | *0.2* | *LSD (P=0.05)* | *ns* | |

Tillage treatments imposed following the pastures of 2013 and 2014 had no effect on regenerating medic dry matter production in 2017. However, hay cutting in 2013, possibly in combination with the very poor season in 2017, resulted in lower dry matter production compared to herbicide only treatments from 2013 (Table 1). In 2013 after the hay cut, medic pod yield was only half that of the herbicide only treatments, and although dry matter production improved in June 2014, the medic pod production was still half at the start of the 2015 season, which was then followed by two cereal crops.

There were very few grass weeds in 2017 with no differences between treatments. There were no differences between treatments in late 2017 soil moistures.

## What does this mean?

Medic dry matter production in the very poor 2017 season was lower due to hay cutting in 2013. In 2013 after the hay cut, medic pod yield was half of the herbicide treatments imposed in the same season, and despite improved dry matter production in 2014, medic pod production was still half at the start of the 2015 season. This rotation was followed by two cereal crops which would not have allowed the medic seed bank to regenerate and improve, therefore the effect has been carried through for four seasons.

Grass weed numbers were very low in 2017 due to low opening rains and poor germination, and no differences between treatments were detected this season. In 2014 a 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 showed slightly higher grass weed numbers than hay cut or pasture topping, regardless of the 2015 tillage system. The grass weed numbers were highest in the second year medic pasture, with low barley grass and rye grass numbers in the first and second year wheat crop, and low numbers and no differences between treatments in the 2017 medic pasture.

Overall the effect of the two year pasture break was 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.

After two years of wheat, disease levels of Rhizoctonia, Yellow leaf spot and Pratylenchus risk had increased, which supports previous research showing the disease benefits of including break crops in the rotation.

## Acknowledgements

Thanks to Brett Hay, Katrina Brands and Rochelle Wheaton 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.

# Establishing pasture into heavy stubble at Mount Cooper

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

RESEARCH

**Searching for answers**

**Location**
Mt Cooper - Gunn family
**Rainfall**
Av. Annual: 435 mm
Av. GSR: 325 mm
2017 Total: 320 mm
2017 GSR: 233 mm
**Yield**
Potential: 7.3 t/ha (pasture)
Actual: 0.3 t/ha
**Trial History**
2017: Medic pasture
2016: Barley
2015: Mace wheat
**Soil Type**
Red loam
**Plot Size**
20 m x 4 m x 3 reps

## Key messages

- **In 2017 the removal of a high barley stubble load resulted in better medic plant numbers late in the season (September), and increased (but still very low) dry matter production.**
- **Heavy barley stubbles from harvesting either high or low resulted in similar medic regeneration.**
- **Treating heavy barley stubbles with either rolling, a light tickle or left standing did not change medic establishment or dry matter production in 2017.**

## 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 Mount Cooper farmers identified as an issue was the establishment of self-regenerating medic pastures into heavy stubble residues. The trial reported here was designed to compare medic establishment and production, with different management strategies imposed on the previous crop stubble residues.

## How was it done?

In late December 2016 three residue treatments were imposed on a barley stubble of 12 t/ha at Mount Cooper which had been harvested as high as possible. The stubble treatments were: cut high (30 cm), cut low (15 cm, with small plot header) and stubble removed (using ride on mower and rake). The paddock was a self-regenerating medic pasture in 2017. On 8 March 2017 three further treatments were imposed on each of the initial treatments of either: light tickle with prickle chain, rolling using a pea roller (twice over the plots so stubble was on the ground) or stubble left standing.

Measurements taken in 2017 were soil moisture at the end of the season, soil-borne disease inoculum, medic emergence counts and late dry matter. Data were analysed using Analysis of Variance in GENSTAT version 18.

## What happened?

The red loam was slightly alkaline pH (7.6 in $CaCl_2$), P reserves of 20 mg/kg in 0-10 cm (Colwell P), and low N reserves (40 kg mineral N /ha in 0-100 cm). All soil-borne disease inoculum levels were below detection levels at the start of 2017.

The stubble load was very heavy at Mount Cooper, and the stubble remaining on plots data are shown in Table 1. The cut low stubble treatment had greater dry matter in March, a similar result over several seasons has also been observed at Minnipa in the stubble trial, this may be due to greater amounts of previous year's stubble being retained on the surface. Despite trying to remove the 2016 stubble there was still a reasonable amount present on the soil surface at the beginning of the 2017 season.

2017 had a very dry start on upper Eyre Peninsula, including Mount Cooper. Small rainfall events resulted in very low medic plant numbers for the season and very little growth. There were no interactions between stubble management and tillage so the results are presented as the main treatments only. Initial plant counts on 25 July for medic pasture regeneration were similar and low for all treatments. Late plant populations were higher with stubble removal but tillage had no impact on numbers or dry matter production. Dry matter production was also greater with removed stubble.

Removal of stubble also resulted in lower soil moisture at the end of the season, (Table 2), possibly due to better medic production, and/or greater evaporation during the season.

*Table 1. Average stubble dry matter following stubble management and tillage treatments at Mount Cooper, March 2017.*

| Stubble management | Tillage treatment | Dry matter (t/ha) |
|---|---|---|
| Cut high | Standing | 8.3 |
| Cut high | Rolled | 7.6 |
| Cut high | Light tickle | 9.5 |
| Cut low | Standing | 10.0 |
| Cut low | Rolled | 12.0 |
| Cut low | Light tickle | 13.4 |
| Removed | Standing | 4.6 |
| Removed | Rolled | 3.6 |
| Removed | Light tickle | 4.2 |

*Table 2. Pasture and soil measurements following barley stubble treatments at Mount Cooper in 2017.*

| Treatment | Medic establishment 25 July (plants/m$^2$) | Medic establishment 14 Sept (plants/m$^2$) | Medic dry matter 10 Oct (t/ha) | Volumetric soil moisture (mm) |
|---|---|---|---|---|
| **Stubble management** | | | | |
| Cut high | 6.6 | 6.8 | 0.10 | 202 |
| Cut low | 7.0 | 6.2 | 0.16 | 211 |
| Removed | 21.4 | 24.4 | 0.51 | 152 |
| *LSD (P=0.05)* | *ns* | *10.2* | *0.18* | *25* |
| **Tillage treatments** | | | | |
| Standing | 10.7 | 7.7 | 0.22 | 195 |
| Light tickle | 16.0 | 15.1 | 0.29 | 183 |
| Rolled | 8.2 | 14.5 | 0.26 | 188 |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* |

## What does this mean?

In 2017 the dry seasonal conditions resulted in low medic establishment and very little growth. The removal of the high stubble load resulted in better medic establishment later in the season and increased (but still very low) dry matter production.

Stubble management of cutting height, or standing compared to rolling showed no differences in germination or production. This was a similar result to that achieved in 2015 at Mount Cooper in wheat stubble. The tillage treatments in 2017 had no effect on medic establishment or dry matter production. In 2015 similar results were achieved, with no differences in medic pasture regeneration and production given different harvest stubble heights (cut high or low), stubble management (standing or rolling) or tillage (harrowed, mowed to the ground (residue removal), cultivated with offset disc or the untreated control).

Grazing stubbles significantly reduces stubble biomass so possibly targeting paddocks which are going be self-regenerating pasture in the following season with extra grazing may remove more of the stubble load and potentially increase the medic performance in the following year.

The results from this research over four seasons have showed little differences in crop or pasture establishment or production, due to stubble management and tillage treatments. There were no major weed or pest issues at these sites.

## Acknowledgements

Thank you to the Gunn family for having the trial on their property. Trial funded by GRDC Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001).

# Soil moisture probe network - using soil water information to make better decisions on Eyre Peninsula

RESEARCH

**Andrew Ware[1], Naomi Scholz[2], Brenton Spriggs[2] and Sue Budarick[2]**
[1]SARDI, Port Lincoln, [2]SARDI Minnipa Agricultural Centre


## Key messages

- **A network of soil moisture probes and weather stations has been established across Eyre Peninsula.**
- **The 'live' data can be viewed by visiting the https://eparf.com.au/ website and then clicking on the yellow Soil Moisture Probe Network icon in the top right hand side and logging on using the user name: EPARF and password: EPARF.**

## Why do the trial?

Water is the principal limiting factor in rain-fed cropping systems in South Australia. The research that French and Schultz (1984) conducted linked growing season rainfall to grain production, providing growers and advisors with a target yield potential. However, this had deficiencies in that it didn't account for out of season rainfall and treated the water holding capacity of all soils equally.

A better understanding of the how plant available water content varies with changes to soil type and how valuable out of season rainfall can be to cropping systems in different environments improves the French Schultz model by allowing growers to define better define target yields, but also make informed in-season decisions based on the information they receive.

Being able to monitor soil moisture in real time by using technology such as soil moisture probes connected to the mobile phone network allows growers and advisors access to improved soil water information, allowing them to make more informed decisions.

In 2016 SAGIT and EPARF provided funding to create and monitor a network of new and existing soil moisture probes across Eyre Peninsula, with the aim assisting growers and advisors to interpret the data produced by the moisture probes and link the soil water information to yield potential so that improved crop decisions can be made.

## How was it done?

A network of a network of 32 soil moisture probes across Eyre Peninsula has been created by linking new and existing (EPNRM and LEADA funded) soil moisture probes found across Eyre Peninsula and providing access to the data via the EPARF website (Figure 1).

In addition, weather stations capable of logging temperature, humidity and wind speed have also been installed at ten soil moisture probe sites funded through contributions by EPARF and AgFarm. This data can also be accessed by logging into the soil moisture probe network via the EPARF website.

Soil testing for soil chemistry and soil moisture was conducted at 29 of the sites in late March 2017. In 2017, 15 of the sites were planted to wheat, seven to pasture, four to pulse crops, three to barley and two to canola. Soil moisture testing and hand harvest samples were conducted at 26 sites in early November, at crop maturity. The sites that weren't tested at this time were not mature and rainfall shortly after meant that soil testing for moisture at these sites was futile.

Eight sites were characterized for drained upper limit, crop lower limit and bulk density in 2017 and Yield Prophet® was also run at eight sites (Lock, Cleve, Elliston, Kimba, Ungarra, Warramboo, Pinkawillinie and Karkoo). Small trials were established at five sites (Pinkawillinie, Warramboo, Ungarra, Karkoo and Rudall), where additional nitrogen was applied in replicated plots adjacent to soil moisture probes.

## What happened?

Figure 2 demonstrates a soil moisture probe site that was planted to wheat in early May 2017, following a break to the season in late April. The figure shows how soil moisture started from a high point through being able to retain moisture from summer rainfall events, and then gradually declines as soil moisture is used throughout the growing season.


***Figure 1. Locations of the soil moisture probes on Eyre Peninsula.***

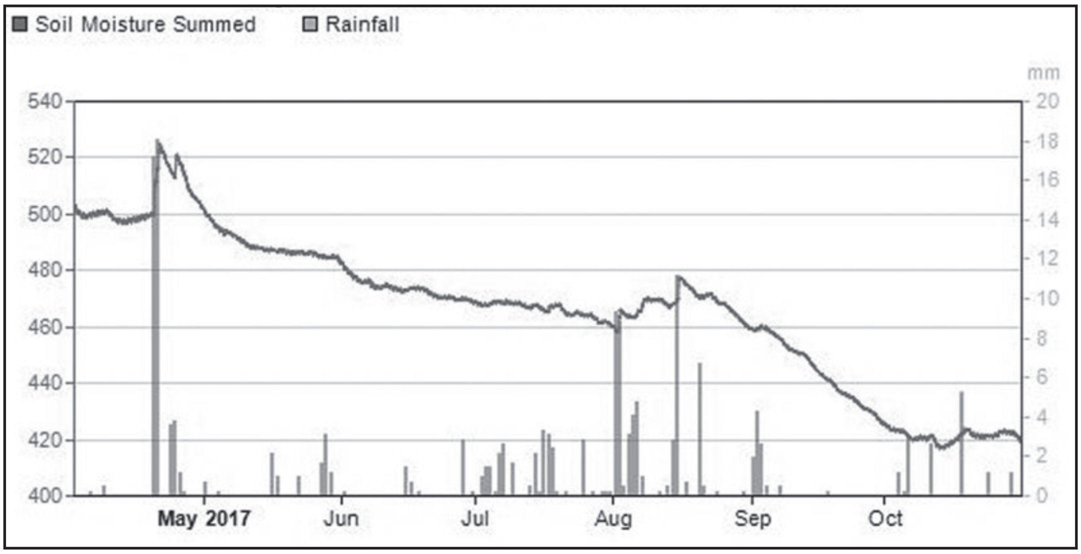


***Figure 2. Summed soil moisture chart showing total soil moisture in the soil profile (line) and rainfall (columns) during the 2017 growing season (April-October) at a site that was planted to wheat in 2017.***

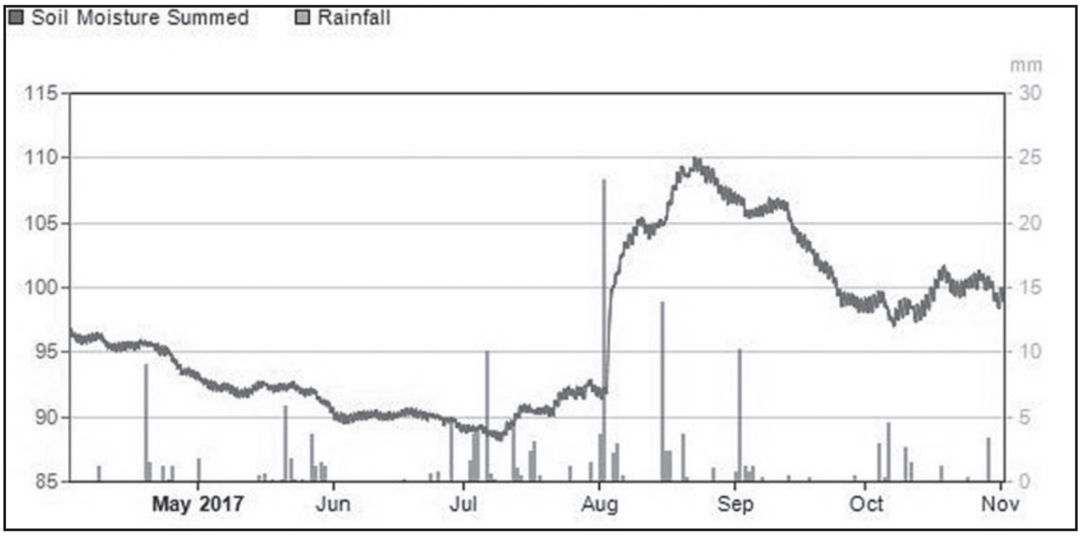


***Figure 3. Summed soil moisture chart showing total soil moisture in the soil profile (line) and rainfall (columns) during the 2017 growing season (April-October) at a site that was a regenerated pasture in 2017.***

Figure 3 demonstrates a soil moisture probe site that was pasture in 2017. The figure shows how soil moisture started from a low point after summer weeds were allowed to survive and use most of the out of season rainfall, and then how soil moisture was accumulated through the growing season, ending up in with more soil moisture at the end of the season compared to the start. This may indicate that the poor growth that pastures were able to achieve in 2017 may have a role in conserving moisture for following wheat crops, or have the potential to be better used to grow more fodder to feed livestock in the pasture phase.

## What does this mean?

The 2017 growing season was challenging for many growers on Eyre Peninsula, but having improved knowledge of soil water information will allow a better understanding of yield potentials during the growing season and help tailor inputs such as in-season nitrogen applications and assist in grain marketing decisions.

Interpretation of the information the soil moisture probes are providing will need at least another season to be fully realised. The extra season will help determine the 'bucket size' or soil water holding capacity at each site. Then a quick view of the soil moisture probe output through the EPARF website at any time during the season will allow growers to determine how full the bucket is.

## Acknowledgements

SAGIT for funding project EP216. EPARF, LEADA, EPNRM and Agfarm for also providing funding that has contributed to developing the soil moisture probe network. The various grower co-operators for allowing us to access to the soil moisture probes on their properties. Shane Oster, Alpha Group, for maintaining the probe network and developing the website platform so that soil moisture probe information can be viewed.

agfarm Working hard for growers

SAGIT

EPARF Eyre Peninsula Agricultural Research Foundation Inc.

SARDI South Australian Research and Development Institute

Government of South Australia
Eyre Peninsula Natural Resources Management Board

LEADA Lower Eyre Agricultural Development Association

# Fluid delivery systems and fungicides in wheat

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

RESEARCH

**Searching for answers**

**Location**
Warramboo - Darren Sampson and family
**Rainfall**
Av. Annual: 313 mm
Av. GSR: 227 mm
**Soil Type**
Red sandy loam, phosphorus responsive
**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
**Soil Type**
Grey calcareous sandy loam, phosphorus responsive
**Plot Size**
20 m x 2 m x 3 reps

## Key messages

- **Phosphoric acid as a liquid fertiliser resulted in 13% and 8% higher yields in 2014 and 2015 respectively at Streaky Bay, and an 8% yield increase at Warramboo in 2016 when compared to the same rate of P delivered in granular fertilisers.**
- **Despite the yield increases at Streaky Bay and Warramboo, the economics showed granular fertiliser had greater returns in $/ha compared to using phosphoric acid at 9 units of P.**
- **The guidelines for moving to the adoption of phosphoric acid as a P source exist in the Fluid Fertiliser Manual which adequately covers the principles, economics, recommendations and chemistry of adopting fluid delivery systems. The manual is available at www.fluidfertilisers.com.au.**
- **Knowing the responsiveness of a soil type to phosphoric acid is an important factor to consider before investing in a fluid delivery system. The responsive soil types are generally higher in calcium carbonate (greater than 25%). P source responses may also be driven by soil moisture conditions because in 2016, which had wetter seasonal conditions, phosphoric acid and granular P performed similarly in the same soil type at Streaky Bay.**
- **The adoption of fluid fertiliser systems to place fungicides in-furrow for rhizoctonia disease management is not recommended in this environment. The addition of fungicides showed small and variable yield advantages at Warramboo in 2014 and 2016 and Streaky Bay in 2016. Using fungicides in above average seasons the greatest yield benefit was only 0.22 t/ha with an in-furrow split application with granular phosphorus and trace elements. This is lower than the benefits achieved in other regions where yield increases of up to 0.49 t/ha in wheat with split applications of fungicides were achieved. Including fungicides on wheat up front will increase input costs and risk over a large cropping program.**
- **Large scale demonstrations by growers across Eyre Peninsula with in-furrow fungicide applications at seeding did not reduce rhizoctonia or produce yield benefits over three seasons.**
- **The adoption of fluid fertiliser systems will depend on growers' soil types for phosphorus responses, the existence of trace element deficiencies and ease or timing of application (in-furrow at seeding) and machinery ability to deliver fluids.**

## 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 using new fungicide products.

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 potentially may improve disease control and increase production. Trials were undertaken over three years 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 individual wheat trials in each season are reported in Eyre Peninsula Farming Systems Summary 2016, *Fluid delivery systems and fungicides in wheat* p 71, Eyre Peninsula Farming Systems Summary 2015, *Fluid delivery systems and fungicides in wheat* p 114 and Eyre Peninsula Farming Systems Summary 2014, *Fluid delivery systems and fungicides in wheat at Warramboo and Streaky Bay* p 98.

## How was it done?

In the 2014, 2015 and 2016 seasons, three replicated trials were established (total of 9 trials), 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 fluid system could also split the fluids to deliver the fungicide both below the seed at approximately 3 cm, and in the seeder furrow behind the press wheel in a band approximately 1 cm in width.

The control 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 kg/ha of phosphorus (P) and balanced with urea or UAN to 10 kg/ha of nitrogen (N). Manganese (Mn) was selected as the main focus trace element and a DAP fertiliser dry blend with Mn @ 1.5 kg/ha was used. Phosphoric acid and granular urea, or 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. The extra nitrogen at seeding treatment was applied as 40 kg/ha of granular urea.

The fungicides azoxystrobin + metalaxyl-M (Uniform), penflufen (EverGol Prime, and new formulation of EverGol Prime for fluid delivery in 2016) 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.

PreDictaB disease inoculum levels (RDTS), soil nutrition, soil moisture, plant establishment, Rhizoctonia seminal root score, Rhizoctonia crown root score, grain yield and quality were measured during each season. Rhizoctonia infection on seminal roots and crown roots was assessed using the root scoring method described by McDonald and Rovira (1983) approximately six to eight weeks after seeding. Crown roots per plant were also counted on these samples with the number of roots infected with Rhizoctonia used to calculate % crown root infection. Trials were harvested and grain quality analysed.

## What happened?

The trial sites selected were on the same property but in different paddocks each season.

### *Soil type*

Both soils have alkaline pH and reasonable soil phosphorus levels. The main difference between these soil types based from previous soil analyses is the calcium carbonate content of around 55- 80% to 60 cm at Streaky Bay and Piednippie compared to 0-25% calcium carbonate content on the red sandy loams of Central Eyre Peninsula. Mineral nitrogen level was much higher at Streaky Bay than Warramboo as is the PBI, especially in the 0-10 cm zone. Both of the soils chosen had been phosphorus responsive to phosphoric acid in previous research.

### ***Disease levels* - Rhizoctonia solani**

Rhizoctonia was the main disease inoculum present with most other diseases at low levels, except the Warramboo site in 2014 which also had a high Take-all disease risk level. The 2016 trial at Warramboo had very low risk of rhizoctonia disease level which was likely due to the pasture phase in 2015, which reduced inoculum levels compared with a wheat phase, however some Rhizoctonia patches were visible in the trial area early in the season. Overall the grey calcareous soil at Streaky Bay had higher Rhizoctonia disease risk level in each season than Warramboo.

### *Seasonal conditions, plant establishment and early dry matter*

Overall plant establishment showed no differences over the three seasons due to the fluid nutrition. The only lower plant establishment was in 2015 in good sowing conditions at Warramboo, where the in-furrow fungicide treatment and a fertiliser applied fungicide treatment resulted in poorer plant establishment. In 2015 in Streaky Bay the overall plant establishment was poorer than Warramboo due to the dry seeding conditions but wasn't affected by treatments applied.

### ***Disease infection* - Rhizoctonia solani**

In **2014** neither of the fungicide trials at Warramboo or Streaky Bay had differences in Rhizoctonia root assessment for the seminal nor crown roots taken at eight weeks. The average seminal root infection was 3.24 (0-5 score) at Streaky Bay and 81% average crown root infection, with Warramboo having 2.75 average seminal root infection, and lower average crown root infection of 44%.

In **2015** the fungicide treatments at Warramboo had Rhizoctonia infection on both seminal and crown roots however there were no differences between fungicide treatments in the rhizoctonia root assessment taken at eight weeks, with 3.11 average seminal root infection, and average crown root infection of 69%. Rhizoctonia patches were present in the Streaky Bay trial early in the 2015 season. The low soil moisture resulted in stressed plants and limited early plant growth. There were no differences due to the fungicides applied in the root assessments with the average seminal root infection being 3.09 (0-5 score) and 74% average crown root infection.

The **2016** Streaky Bay fungicide trial had more even 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%) between the fungicide treatments in 2016 but the EverGol Prime (new formulation) with extra nitrogen had lower Rhizoctonia seminal root infection scores than the control treatment in 2016. At Warramboo, in drier conditions, phosphoric acid + trace element + fungicide (Uniform and 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%).

## Grain yield and quality

Overall there was a 0.11 t/ha (8% from 1.25 t/ha using granular DAP to 1.36 t/ha with phosphoric acid 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 in 2016 of 0.17 t/ha yield increase or 8% from 2.11 t/ha using granular DAP to 2.28 t/ha using phosphoric acid.

Input costs were lowest for the control ($148/ha) so all other options would result in higher costs over a whole cropping program. Phosphoric acid fertiliser showed yield increases at Streaky Bay in 2014 and 2015, however the economics showed granular fertiliser still had greater returns in $/ha compared to using phosphoric acid (see 2016 article for further detail). At Warramboo in 2016 using phosphoric acid showed a positive economic return over granular fertiliser.

The gross margins in 2014 and 2015 at Warramboo showed that the addition of a balanced trace element mix for an extra $4/ha over the control provided the best return over these seasons. The 2016 gross margins showed the difference between applying a fungicide compared to the control but the increase in the input costs resulted in higher cost 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.

## Mixing fluid fertilisers

The chemistry of mixing fluids and the basic products have not changed, therefore the Fluid Fertiliser Manual is still an excellent information source. The Fluid Fertiliser Manual provides a comprehensive description of fluid fertilisers, mixing fertilisers, application technologies and includes a simple economic calculator for growers to compare costs and responses of fertiliser types. It also allows an economic analysis of conversion costs to be calculated. The manual is available at www.fluidfertilisers.com.au.

However, many of the products, including those for fungicide management in current farming systems, have changed so doing small product test mixing in jars is recommended when using new mixes or different product sources, as they may have different concentrations or compatibility and it is much easier to detect this early (in a jar) than having to clean tanks or fluid lines.

## What does this mean?

Over the three seasons of the fluid delivery trials on upper Eyre Peninsula the trial results at Streaky Bay 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. This yield response was 0.11 t/ha (8% from 1.25 t/ha using granular DAP to 1.36 t/ha in 2015) and 0.13 t/ha yield increase (13% in 2014).

However, in 2016 at Streaky Bay in a wetter season the phosphorus source showed no yield response.

Yield improvements to the fluid form of phosphorous (phosphoric acid) were not measured on the red sandy soil at Warramboo in either 2014 or 2015, however in a drier season in 2016 phosphorus responses to phosphoric acid of 8% occurred.

Previous research has shown that in drier soil conditions the movement of phosphorus via soil water to the plant roots 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. 2002, Lombi et al. 2004). Knowing whether the soil type is responsive is essential before changing to a fluid fertiliser system, as phosphorus and soil moisture conditions play a role in the effectiveness of fluid phosphorous fertilisers as opposed to granular phosphorus fertilisers.

The addition of extra starter nitrogen (40 kg/ha at seeding as urea in some treatments in 2016) has also increased yield responses indicating that despite high initial soil nitrogen levels in these soils the plants may have benefited from the addition of nitrogen early.

Rhizoctonia continues to be the main cereal disease impacting on yields in the upper Eyre Peninsula environment. The soil types, often high disease inoculum levels, low soil moisture levels and early nutrient limitations impact on the ability of the plant to grow away from the disease. The seminal root scores and crown root infection levels were still high and not different to the controls when assessed at six to eight weeks after seeding, despite the application of fungicide and visually appearing slightly more even in growth.

Treatments had little influence on plant establishment in this environment. The addition of fungicides showed small and variable yield advantages in these farming systems, at Warramboo in 2014 and 2016 and Streaky Bay in 2016. Using granular phosphorus and a trace element mix with fungicide showed the greatest benefit, and was 0.22 t/ha with a split application compared to other research which achieved up to 0.49 t/ha yield increases in wheat with split applications of fungicides (McKay et al. 2014). The research conducted in other regions also showed the yield response to fungicides was dependant on favourable spring conditions for grain filling.

The cost of including fungicides will increase input costs ($4-$25/ha) significantly over a whole cropping program, and even if high disease risk paddocks were targeted for use, the yield responses in these environments appear highly variable. It may be other factors in the Eyre Peninsula environment, either higher initial rhizoctonia inoculum levels especially in the grey calcareous soils, poorer plant nutrition and/or sharper spring conditions are limiting the response to fungicides compared to other regions. The gross margins in 2014 and 2015 at Warramboo show the addition of a balanced trace element mix for an extra $4/ha over the control and show the best return over these seasons. In 2016 the addition of fungicides to phosphoric acid and extra starter nitrogen at seeding as urea provided the greatest yield responses, however further validation over different seasons is recommended.

The most reliable method in this environment to reduce rhizoctonia inoculum and disease levels is still to include a break crop in rotation before a cereal crop (Gupta et al. 2013). All current information, including the increased input costs of including a fungicide, should be taken into account when formulating a management plan to control rhizoctonia in high risk situations.

The Fluid Fertiliser Manual still provides a comprehensive description of fluid fertilisers, mixing fertilisers, application technologies and includes a simple economic calculator for growers to compare costs and responses of fertiliser types. The manual is available at www.fluidfertilisers.com.au.

## References

Gupta V., Cook A., McKay A., Shepperd W., Richter I., Desbiolles J., Ophel-Keller K., Wilhelm N. and Roget D. (2014) *Management of soilborne Rhizoctonia disease risk in cereal crops*. Eyre Peninsula Farming Systems Summary 2013, p. 80-83.

Holloway, B. Brace, D., Frischke, B. and Hocking, P. (2002). *Responses of a Range of Crops to Fluid and Granular Fertilisers.* Eyre Peninsula Farming Systems Summary 2001, p. 89-90.

Lombi, E., McLaughlin, M., Johnston, C., McBeath, T., Stacey, S., Armstrong, R. and Holloway, R. (2005). *Phosphorus chemistry in highly fixing soils; can the efficiency of phosphorus fertilisers be improved.* Eyre Peninsula Farming Systems Summary 2004, p. 89-90.

McKay, A., Bogacki, P., Desbollies, J., Correll, R., Gupta, V., Huberli, D., MacLeod, B., McKee, K., May, L., Forsyth, L., and Roget, D. (2014) *Rhizoctonia Control improved by liquid banding of fungicides*, 2014 South Australian GRDC Grain Research Update for Advisers, p. 245-249.

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# Fluid delivery of fungicides and fertilisers for canola

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

**Searching for answers**

**Location**
Wangary - Morgan family
**Rainfall**
Av. Annual: 525 mm
Av. GSR: 465 mm
**Soil Type**
Grey loamy clay

## Key messages

- **Intake (on fertiliser) and Jockey (on seed) is current standard practice for lower EP canola and reduced Blackleg stem infection. In 2014 this practice also increased grain yield. This remains the recommended practice.**
- **The application method for the fungicide, either as seed treatments or in-furrow, did not increase canola yields in 2015 or 2016.**
- **The source of nutrients and application method, either fertiliser, in-furrow or foliar had no effect on canola yield in 2014, however further research should be undertaken in this area before final conclusions are drawn.**

## Why do the trial?

SAGIT funded a project to assess the potential of fluid nutrient delivery systems and disease control strategies compared to current systems. Fluid systems have the potential to increase production through more effective delivery of micro and macro nutrients, use of lower cost trace element sources and improved 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 fungicides may increase production and improve disease control. With the development of new fungicides and the technology 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. These trials compared the relative benefits of a range of fungicide strategies for blackleg control on canola compared to current practices.

The individual trials in the given seasons for this project are reported in Eyre Peninsula Farming Systems Summary 2016, *Fluid delivery systems in canola* p77, 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?

In each season the base fertiliser was 100 kg/ha of DAP (18:20:0:0) with additional in-furrow fungicides or trace elements delivered as fluids for treatments. The trace element mix was 1.5 kg/ha of Mn, 1 kg/ha Zn and 0.2 kg/ha Cu delivered as sulphates at a water rate of 100 L/ha. The fluid macro fertiliser treatments were equivalent to 100 kg/ha of 18:20:0:0 as phosphoric acid and granular urea banded below the canola seed variety Pioneer 45Y86 (CL). Trace elements were also delivered as foliar applications at 4-5 leaf stage, and also at a half rate, as separate treatments.

The fungicides evaluated for blackleg disease control were Jockey and Intake in all seasons, and new products Aviator and Prosaro in 2016 only. Application methods of fungicides were also assessed; either in-furrow liquids, Jockey as a seed dressing or Intake on fertiliser. In 2016 foliar Aviator and Prosaro were also applied at 400 ml/ha and 550 ml/ha respectively at the 4 leaf stage.

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.

Most in-crop operations such as chemical weed control, in crop applications of urea and insect control were applied broad acre by the farmer as required.

Data analysis was undertaken using Analysis of Variance in GENSTAT version 18.

## What happened?

2014 was the only year in which reliable nutrition data was achieved. In 2015 the nutrition trial at Farm Beach was not harvested as poor establishment, a very dry finish and extensive bird damage near maturity did not allow for fair comparisons between the treatments. In 2016 the nutrition trial site located at Piednippie had poor establishment, and despite re-sowing in early June did not establish due to wind damage. No data was collected from this site.

*Table 1. Dry matter and grain yield for Pioneer 45Y86 (CL) in Coulta canola nutrition trial, 2014.*

| Treatment | Early dry matter ($kg/m^2$) | Yield (t/ha) | Oil (%) | Protein (%) |
|---|---|---|---|---|
| Phos acid and 0.8 kg/ha MnSO4 liquid and Gran Urea | 0.12 | 1.49 | 42.5 | 21.0 |
| DAP and half rate Foliar Trace elements (4-5 leaf stage) Mn @ 0.8 kg/ha, Zn @ 0.5 kg/ha, Cu @0.1 kg/ha | 0.10 | 1.33 | 42.8 | 20.9 |
| APP and UAN | 0.10 | 1.33 | 43 | 21.0 |
| APP, UAN and liquid TE Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @0.2 kg/ha | 0.07 | 1.31 | 43.4 | 21.3 |
| DAP and Liquid Trace elements Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha | 0.10 | 1.25 | 43.3 | 20.7 |
| Control | 0.09 | 1.25 | 42.9 | 20.7 |
| Phos acid and 1.5 kg/ha MnSO4 liquid and Gran Urea | 0.10 | 1.24 | 42.8 | 21.2 |
| Phos acid and 3 kg/ha MnSO4 liquid and Gran Urea | 0.08 | 1.22 | 43 | 20.9 |
| DAP and Foliar Trace elements (4-5 leaf stage) Mn @ 1.5 kg/ha, Zn @ 1 kg/ha, Cu @ 0.2 kg/ha | 0.06 | 1.20 | 42.7 | 21.0 |
| Phos acid and urea (equivalent 100 kg/ha DAP) | 0.08 | 1.17 | 43 | 20.8 |
| DAP and Foliar Mn @ 1.5 kg/ha | 0.07 | 1.14 | 42.6 | 20.7 |
| DAP with Mn coated fertiliser @ 1.5 kg/ha | 0.08 | 1.09 | 42.1 | 21.3 |
| Urea only | 0.05 | 0.99 | 42.8 | 20.8 |
| Half rate Phos acid (equivalent 50 kg/ha DAP) and urea | 0.10 | 0.94 | 42.4 | 21.1 |
| *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* |

*Table 2. Average yields of CL canola with different nutrition treatments at Coulta trial, 2014.*

| Fertiliser source | Yield (t/ha) |
|---|---|
| APP and UAN | 1.32 |
| Control | 1.24 |
| Phosphoric acid | 1.21 |
| Granular fertiliser | 1.20 |
| Urea only | 0.99 |
| *LSD (P=0.05)* | *ns* |

### *Canola nutrition – Coulta 2014*

There were no differences in plant establishment with the average being 41 plants/$m^2$. In 2014 no treatments performed better than the control for early dry matter, yield or grain quality (Table 1). Plant tissue tests (youngest leaf) were taken at late cabbage stage, and showed no trace element deficiencies.

The average yield of the different fertiliser types, granular or fluid; APP and UAN, phosphoric acid, granular DAP or urea only (Table 2) showed no differences at this site in 2014.

### *Fungicides for Blackleg - Coulta 2014 & 2015, Wangary 2016*

In 2014 the treatment with both fungicides applied, Intake in furrow and Jockey seed dressing, increased yield over the nil treatment (Table 3), which is supported by previous research in this region. However, their effect on blackleg were not as clear – there were no differences in the blackleg disease levels between any treatments in the trial. There were also no differences in plant establishment or grain quality between fungicide treatment (data not shown; protein (average 21%), oil (average 43%)).

In 2015 the fungicide trial was located at Coulta within an intensive canola cropping region with potentially high Blackleg disease pressure. The initial soil data showed adequate phosphorus and trace elements at the trial site with 71 mm of soil moisture in the plant root zone.

Establishment was unaffected by fungicide treatments, averaging 34 plants/$m^2$. Blackleg infection was lower in 2015 (av. 15%) compared to 2014 (av. 29%). There were no differences in Blackleg infection between fungicide treatments and also no differences in yield (Table 3).

The 2016 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 3), but plant numbers were still reasonable at 38 plants/$m^2$.

*Table 3. Canola establishments, blackleg score and yield for CL canola with fungicide treatments in Coulta trial, 2014-16.*

| Fungicide treatment | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Canola establishment (plants/m²) | Blackleg score (% infection) | Yield (t/ha) | Canola establishment (plants/m²) | Blackleg score (% infection) | Yield (t/ha) | Canola establishment (plants/m²) | Blackleg score (% infection) | Yield (t/ha) |
| Intake (in furrow) | 48.3 | 15.7 | 1.33 ab | 35.0 | 11.1 | 2.01 | 39.7 ab | 22 a | 2.38 |
| Intake (on fertiliser) | 41.7 | 35.8 | 1.30 ab | 38.6 | 15.1 | 2.08 | 41.8 ab | 12 bc | 2.68 |
| Intake (in furrow) and Jockey (on seed) | 40.6 | 12.0 | 1.63 a | 32.7 | 10.2 | 2.18 | 38.3 b | 9 c | 2.15 |
| Jockey (on seed) | 42.8 | 34.8 | 0.98 b | 39.9 | 22.4 | 1.87 | 38.3 b | 23 a | 2.04 |
| Control - DAP @ 100 kg/ha | 45.6 | 33.0 | 0.99 b | 29.7 | 12.6 | 2.09 | 47.1 ab | 20 ab | 1.87 |
| Aviator Foliar | * | | | * | | | 47.1 ab | 14 abc | 2.29 |
| Prosaro Foliar | * | | | * | | | 57.5 a | 18 abc | 2.32 |
| *LSD (P=0.05)* | *ns* | *ns* | *0.35* | *ns* | *ns* | *ns* | *10.9* | *9.6* | *ns* |

**Product was not available*

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 yield increase (Table 3).

## What does this mean?

The canola nutrition trial in 2014 was the only year in which reliable nutritional data was collected and showed no differences in yield with different application methods. The site had no nutrient deficiencies detected so providing trace elements in various forms should not have produced yield benefits. However due to the failure of the other trial sites in 2015 and 2016, due to bird damage and poor plant establishment, further research into the effectiveness of fluid delivery of nutrients in canola should be undertaken before final conclusions are drawn.

In 2014 the fungicide treatments when combined increased yield over the nil fungicide control treatment, however the difference in blackleg disease levels scored was not significant. The application methods for blackleg fungicides trial in the 2015 and 2016 season have shown little or no change in either blackleg disease control or yield. The combined effect of fungicides giving additional protection has been reported in other research, and the early protection of plants is important to reduce blackleg infection early due to rain splash. Further evaluation with the newer fungicide products in the lower EP environment will continue. The selection of resistant varieties of canola 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 and providing in-crop management. Thank you to Nigel Wilhelm and Andrew Ware for scientific input into this research. Trial funded by SAGIT Improving fertiliser efficiency and reducing disease impacts using fluid delivery systems, S614.


Registered products: see chemical trademark list.

# Controlled traffic impacts on vetch production at Minnipa in 2017

RESEARCH

**Nigel Wilhelm[1], Peter Fisher[2], Chris Bluett[3] and Rebecca Mitchell[2]**

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**Searching for answers**

**Location**
Minnipa Agricultural Centre, paddock S3S
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 282 mm
2017 GSR: 155 mm
**Paddock History**
2017: Vetch
2016: Fathom barley
2015: Scepter wheat
2015: Medic pasture
**Trial History**
2017: Regenerated medic pasture
2016: Mace wheat
2015: Mace wheat
2014: Regenerated medic pasture
**Soil Type**
Calcareous red sandy loam
**Plot Size**
50 m x 3 m x 4 reps

## Key messages

- **Vetch production in a very tough season was little affected by trafficking imposed in 2015.**
- **After three years of crop production, low levels of trafficking have had little impact on grain yield on a Minnipa soil, multiple trafficking on wet soil (in 2015) increased grain yields in the second and third crops.**
- **Ripping conducted in 2015 lifted the soil substantially but has not benefited production in any of the following three crops.**

## 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 three years of crop performance after trafficking was imposed on a red calcareous sandy loam at Minnipa Agricultural Centre. A detailed summary of 2015 and 2016 results can be found in the 2015 and 2016 Eyre Peninsula Farming Systems Summaries, respectively. 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 except Swan Hill (land ownership has changed) will be maintained for at least the five years 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 implemented in 2015 with 50% overlap of the load bearing wheels to ensure even coverage and will not be re-imposed.

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

*Table 1. Performance of Volga vetch in 2017 after trafficking and ripping at Minnipa in 2015.*

| Treatment | Establishment (plants/m²) | Depth of seeding (mm) | Hay biomass (kg/ha) | Maturity biomass (kg shoots/ha) | Grain yield (kg/ha) |
|---|---|---|---|---|---|
| Control | 62 | 65 | 1376 ab | 664 | 320 |
| Single trafficking on dry soil | 46 | 64 | 1242 ab | 662 | 306 |
| Single trafficking on wet soil | 50 | 50 | 1796 b | 744 | 372 |
| Multi trafficking on wet soil | 51 | 47 | 1938 b | 843 | 416 |
| Ripping | 43 | 76 | 1090 a | 670 | 333 |
| *LSD (P=0.05)* | *ns* | *10* | | *ns* | *ns* |

*Note: for hay biomass, values with the same letter are not statistically different to each other.*

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 and Fathom barley in 2016. In 2017, Volga vetch was sown @50 kg/ha on 26 April with 50 kg/ha of DAP.

Crop performance was monitored at establishment, for hay production and at maturity (grain yield and biomass). Grain harvest was conducted by hand to avoid trafficking from a header on treated plots.

## What happened?

Emergence of vetch was very slow and staggered in 2017 due to very dry conditions around and after seeding. However, final establishment was similar across all treatments, despite seeding depth being slightly shallower after wet trafficking and slightly deeper after ripping (see Table 1). These treatments were imposed prior to seeding in 2015, but their impact on seeding depth has persisted into the third season on this heavy soil.

Production from the vetch was very poor due to dry conditions throughout the growing season in 2017 and hay cuts were less than 2 t/ha by early podding. Hay production after trafficking of any type was similar to the control although production after both wet trafficking treatments was better than after ripping (Table 1). Grain yields were very poor (average of 350 kg/ha for the trial) and similar for all treatments.

Trafficking on wet soil substantially increased the yield of barley in 2016. Ripping and trafficking on dry soil resulted in grain yields similar to the control.

Grain yields of wheat in 2015 were similar for all treatments, except for ripping which was lower (mostly due to low plant numbers and substantially deeper seeding).

## 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 ripping treatment is an attempt to remove any compaction already existing in our control areas due to historical traffic.

On this heavy Minnipa soil after three crops, trafficking has not caused any production losses, if anything less there has been an increase in production. This suggests that anybody moving into CTF on this type of soil will not see any improvements in crop productivity in the short term. We have no information about longer-term effects. Loosening up the soil by ripping has not resulted in any production increases either, a result which has been seen many times with ripping on this type of soil.

On very sandy soils where responses to deep ripping are common and often substantial, CTF is a complementary strategy which should not only increase and prolong the benefits from deep ripping operations, but also avoid trafficking issues with deeply loosened and fragile sands.

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 was severely depressed by any trafficking in the first year, but in the very wet year of 2016, production was similar across all treatments.

The benefits of improved traction and better fuel efficiency from driving on permanent traffic lanes are likely to be there, but again with smaller gains than in other zones because trafficability is less of an issue in the LRZ and the traffic lanes are likely to be sown, reducing the benefits of permanent wheel tracks.

The often poor performance of crops after multiple heavy vehicle passes on wet sandy soils indicates that while most of our cropping paddocks are probably already quite compacted, the current generation of very heavy machinery has the potential to further increase damage into the future on sandy soils.

This trial will be continued for one more season and we will continue to monitor the impact of trafficking imposed in 2015 on subsequent crop production and soil condition.

Generally, farmers under-estimate the extent of trafficking in their paddocks. For those farmers and advisers who would like to estimate current levels and simulate how they might change under various CTF options, there is a GRDC-supported app which walks you through the process (www.ctfcalculator.org).

## Acknowledgements

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Section
2

# Weeds

## Burning of weed seeds in low rainfall farming systems

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RESEARCH


### Key messages

- **Seeds of all species could be killed with heat, however there were differences in tolerance to heat.**
- **Duration of heat treatments had a significant impact on the efficacy on weed seeds in all species.**
- **Seeds of most weed species could be killed by simulating conditions similar to burning narrow harvest windrows.**
- **The efficacy of narrow windrow burning in the field is largely determined by the proportion of weed seeds that can be collected by the header and placed into harvest windrows.**

### Why do the trial?

Weeds are one of the largest costs to grain producers and a primary driver in how cropping systems are managed. Weeds are estimated to cost Australian grain growers $3,318 million annually (Llewellyn *et al*. 2016). Weeds will continue to drive crop management systems as weed challenges evolve, particularly from herbicide resistance. This will increase the importance of cultural control methods as part of any integrated weed management (IWM) strategy. Burning crop residues to destroy weed seeds is one of the oldest cultural weed control measures in agriculture. While information exists on annual ryegrass and wild radish efficacy from burning crop residues (Gill and Holmes, 1997; Walsh and Newman, 2007), little is known about other weed species. This study aims to investigate the potential of crop residue burning to control weeds that are problematic for low rainfall cropping systems in southern Australia. A method similar to Walsh and Newman (2007) was used to simulate different levels of heat (temperature) and duration experienced during crop residue burning on weed seeds.

### How was it done?

***Seed collection***

Seeds of 10 different weed species were collected from cropping fields at weed maturity (Table 1). Seed was cleaned and removed from associated structures for all species except Mallow that was left in individual seed pod segments. This was done to achieve consistency with the state of weed seeds shedding at the time of stubble burning. Seeds were counted and placed into packets of 100 seeds.

***Heat treatment***

A kiln (Woodrow GK63TL top loading glass kiln) was used to apply heat treatments to seeds. The kiln was preheated to the desired temperature. Seed of each species were placed in a ceramic dish, held in a rack and swiftly placed into the kiln for the desired duration. Seed was allowed to cool in the dishes and placed back into their packets for later germination assessment. Temperature readings from the kiln were calibrated against a laboratory infrared thermometer (MIKRON IR-MAN model 15t) shown below in Table 2.

*Table 1. Weed seeds and district of origin.*

| Weed species | Scientific name | Region |
|---|---|---|
| Barley grass | *Hordeum glaucum* | Upper Eyre Peninsula |
| Brome grass | *Bromus diandrus* | *Northern Yorke Peninsula & Mallee |
| Wild oats | *Avena fatua* - (1) | Lower North |
| Wild oats | *Avena fatua* – (2) | Upper Eyre Peninsula |
| Annual ryegrass | *Lolium rigidum* | 'safeguard ARG' control species |
| Onion weed | *Asphodelus fistulosus* | Upper Eyre Peninsula |
| Statice | *Limonium lobatum* | Upper North |
| Mallow | *Malva parviflora* | Upper North |
| Indian hedge mustard | *Sisymbrium orientale* | Lower North |
| Lincoln weed | *Diplotaxis tenuifolia* | Upper Eyre Peninsula |
| Wild turnip | *Brassica tournefortii* | *Mallee & Upper North |

** composite population, Mallow was treated in individual seed pod segments*

***Table 2. Kiln temperature calibration against laboratory infrared thermometer (IRT).***

| Kiln temp | 200°C | 250°C | 300°C | 350°C | 400°C | 450°C |
|---|---|---|---|---|---|---|
| IRT temp | 200.1°C | 246°C* | 300°C | 355.3°C | 400.6°C | 451°C |

*IRT temp mean of multiple readings, * kiln set to 255°C to achieve correct temperature*

***Germination assessment***

Treated seed packets were placed in petri-dishes with 2 filter paper discs on the base. 10 mm of 0.001M Gibberellic acid (GA) solution was applied to the seed, brome grass and barley grass requiring 12.5 mm and wild oats requiring 15 mm GA solution. Dishes were then sealed with parafilm and then all 19 dishes (single replicate of each weed species) was wrapped in two layers of aluminium foil and placed into a controlled environment growth room (Phoenix systems) at 20°C/12°C day/night temperature for approximately 14 days, at which time both germinated and non-germinated seeds were counted. At 14 days mallow seeds were counted and individual seeds were removed from seed pod segments. Mallow seeds that were deemed to be potentially viable (still hard), but not germinated were knicked with a scalpel and placed back onto dishes with fresh GA solution and returned to growth room for a further seven days when germination was again assessed. Wild oat populations were given extended time in the growth room, but failed to germinate and were excluded from the trial.

***Trial details and analysis***

The trial was replicated three times with 100 seeds in each sample. Germination in each dish was compared back to the relevant untreated control. This was then statistically analysed using an analysis of variance using GENSTAT 15th Edition statistical computer program.

## What happened?

The ability of weed seeds to tolerate heat varied considerably between species with Lincoln weed seed being the most susceptible and mallow seed being the most tolerant to heat (Table 2). Germination data was plotted against a heat index (HI = temperature °C x duration seconds), and a sigmoidal logistic 3 parameter model was fitted using SigmaPlot 12.5 v002 statistical program. Parameter $X_0$ from the fitted model represents the HI units required to suppress seed germination by 50%. X0 values were used to rank weed species for tolerance to heat. Tolerance of weed seeds to heat was not closely related to seed size or weed type. Brassica seeds with their smaller size and high oil content would be expected to be more sensitive to heat. This was the case for both Lincoln weed and Indian hedge mustard (IHM) which were the two most susceptible weed species to heat. However wild turnip, another brassica weed, was the second most tolerant species studied. Larger seed size did not correlate with tolerance to heat, with smaller seeded ryegrass showing greater tolerance to heat than larger brome or barley grass seeds.

***Grass weeds***

Barley grass has become a serious weed of many low rainfall cropping systems due to increased seed dormancy and incidence of herbicide resistance (Fleet *et al*. 2012; Shergill *et al.* 2015). The effect of heat, like that produced from burning crop residues, on barley grass was found to be strongly influenced by both temperature and duration (Table 4). Barley grass seed was completely killed at 350°C, but only at a duration ≥60 seconds. However, barley grass seed kill was significantly reduced at shorter durations. Exposure of barley grass seeds to 300°C for a duration of 60 seconds could halve barley grass seed viability. However, the same level of control could be achieved by exposure to >450°C for 20 seconds.

*Table 3. Ranking of weed seed tolerance to heat from least to the most tolerant, P<0.0001.*

| Rank | Weed | $X_0$ for HI (SEM) | HI $R^2$ |
|---|---|---|---|
| 1 | Lincoln weed | 6231 (325) | 0.78 |
| 2 | Indian Hedge Mustard | 10021 (929) | 0.70 |
| 3 | Onion weed | 15028 (391) | 0.77 |
| 4 | Barley grass | 16043 (373) | 0.82 |
| 5 | Brome grass | 16070 (562) | 0.73 |
| 6 | Statice | 16618 (298) | 0.88 |
| 7 | Annual ryegrass | 17505 (474) | 0.78 |
| 8 | Wild turnip | 18405 (484) | 0.74 |
| 9 | Mallow | 21197 (1413) | 0.44 |

*SEM - Standard error mean*

Based on the results of stubble burn temperatures from Walsh and Newman (2007), effective control of barley grass seed is only expected in heavy windrows or narrow windrows. Burning a standing stubble is unlikely to be effective in killing barley grass seed. Unfortunately, most barley grass seed has shed well before crop harvest and is unlikely to end up in the windrow for burning or captured by harvest weed seed capture (HWSC) systems. In a field trial in the Upper North, Fleet *et al*. (2014) found that when wheat was harvest-ready, <1% of barley grass had the potential of being collected, with the remainder either being shed onto the ground or below 10 cm in height. Similar results were found in plot studies where <6% of barley grass seed remained on the panicles when wheat was harvest-ready (Kleemann *et al*. 2016). Therefore, the effectiveness of windrow burning against barley grass is expected to be rather low.

The response of brome grass to high temperature exposure was very similar to barley grass (Table 5). Effective kill of brome grass seed is also likely to require crop stubble to be burnt in either a heavy row or narrow windrow to achieve required temperatures and duration of heat. Contrary to barley grass, brome grass is capable of retaining 75% of its seed on the panicle by earliest crop harvest. However brome grass plants can often lodge and fall below the harvest cutting height. In a field trial at Roseworthy, depending on weed density, 30-80% of brome grass panicles were below the height of crop harvest at earliest crop harvest (Kleemann *et al*. 2016). Despite this, HWSC followed by burning of windrows could provide some level of control of brome grass.

While ARG seed was found to be the most heat tolerant of the grass weeds trialled (Table 3), it followed a similar trend to brome and barley grass (Table 6). ARG required approximately 100°C more heat at equivalent duration than either brome or barley grass to achieve a high level of weed seed control. These results show ARG to be more tolerant to heat than previously reported by Walsh and Newman (2007). Given the temperatures required to control ARG seeds, HWSC tactics where harvest residue is placed in heavy rows or preferably narrow windrows for burning would be required. A South Australian study of the potential of HSWC tactics found that between 26-73% of annual ryegrass seed could potentially be captured and then placed in narrow windrows for burning (Fleet *et al*. 2014). While still highly variable, depending on the timing and seasonal conditionals, ARG has the potential for significant seed control with HWSC tactics and narrow windrow burning. Ranking of these grass species would be barley grass: unviable < brome grass some control < annual ryegrass moderate control.

*Table 4. Effect of heat on Barley grass seed viability (% survival).*

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 97 *a* | 100 *a* | 97 *a* | 97 *a* | 94 *a* | 57 *bc* |
| **40** | 96 *a* | 100 *a* | 100 *a* | 62 *b* | **19 *d*** | **0 e** |
| **60** | 97 *a* | 96 *a* | 51 *c* | 0 *e* | **0 e** | **0 e** |

*P<0.001, LSD=9.666, cv rep=5.6%, >80% reduction* ***bolded***

*Table 5. Effect of heat on Brome grass seed viability (% survival).*

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 100 *a* | 98 *a* | 100 *a* | 91 *a* | 71 *b* | 68 *b* |
| **40** | 97 *a* | 93 *a* | 98 *a* | 59 *b* | **7 c** | **0 c** |
| **60** | 98 *a* | 89 *a* | 72 *b* | **2 c** | **0 c** | **0 c** |

*P<0.001, LSD=16.07, cv rep=5.8%, >80% reduction* ***bolded***

***Table 6. Effect of heat on Annual ryegrass seed viability (% survival).***

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 93 *ab* | 98 *a* | 98 *a* | 98 *a* | 93 *ab* | 70 *b* |
| **40** | 98 *a* | 97 *a* | 99 *a* | 73 *b* | 54 *c* | **0 e** |
| **60** | 99 *a* | 95 *ab* | 82 *b* | 21 *d* | **1 e** | **0 e** |

*P<0.001, LSD=14.44, cv rep=3.2%, >80% reduction* **bolded**

***Table 7. Effect of heat on Onion weed seed viability (% survival).***

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 94 *ab* | 93 *ab* | 88 *ab* | 90 *ab* | 82 *b* | 38 *c* |
| **40** | 91 *ab* | 89 *ab* | 91 *ab* | 31 *c* | **1 *d*** | **0 *d*** |
| **60** | 87 *ab* | 86 *ab* | **11 *d*** | **0 *d*** | **0 *d*** | **0 *d*** |

*P<0.001, LSD=15.31, cv rep=7.9%, >80% reduction* **bolded**

***Table 8. Effect of heat on Statice seed viability (% survival).***

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 96 *ab* | 95 *ab* | 96 *ab* | 100 *a* | 99 *a* | 83 *b* |
| **40** | 98 *ab* | 92 *ab* | 97 *ab* | 76 *b* | 46 *c* | **4 e** |
| **60** | 94 *ab* | 91 *ab* | 48 *c* | 24 *d* | **2 e** | **4 e** |

*P<0.001, LSD=14.50, cv rep=3.3%, >80% reduction* **bolded**

### *Broad-leaved weeds*

Onion weed seed was more sensitive to heat than the grass species studied (Table 7.). Onion weed is usually found in areas of poor competition in crops and pastures (Pitt *et al*. 2006). Despite the potential of heat to control onion weed seeds it could be difficult to have enough crop or pasture biomass to achieve enough heat and duration for effective control, particularly if burning pasture residues or standing stubble. Such paddocks are also prone to wind erosion so the implications of burning need to be considered carefully.

Statice seed was significantly more tolerant of heat than onion weed (Table 3). It required temperatures ≥400°C for 60 s duration to achieve effective control of statice seeds. From the stubble burning temperatures reported in Walsh & Newman (2007), HWSC and narrow windrow burning would be required to possibly achieve effective control of statice seed. This species shows potential of HWSC techniques as it appears to retain seed pods and is often a grain contaminant in problem paddocks, however will require very hot and prolonged stubble burning conditions. As statice is often found in paddocks affected by some level of salinity, the level of crop residue present may be inadequate for achieving prolonged hot burn.

Mallow seed was treated in small pod segments as by autumn when crop residues are burnt the primary mallow pods have broken up and individual pod sections remain. Mallow was found to be extremely heat tolerant and would likely prove very difficult to control in many stubble burning situations. It was found to require ≥450°C for ≥40 seconds to obtain effective control of seeds (Table 9). At 450°C there was no seed kill at 20 seconds duration, but high levels of control at 40 seconds duration, indicating a critical heat duration time between 20-40 seconds at this temperature. Mallow was the most heat tolerant weed species in this study (Table 3).

### *Brassica weeds*

Lincoln weed seed was found to be the most sensitive weed species to high temperature exposure in this study (Table 3). Like other species, Lincoln weed seed control was dependent on both temperature and duration. However once temperature was ≥350°C, effective control could be achieved even with 20 s exposure (Table 10.). This indicates that there would be some potential to control Lincoln weed in standing stubble situations. An additional complication would be that such a small seed could fall between soil clods or cracks and be insulated from any heat caused by burning. Walsh and Newman (2007) reported that as little as 1 cm of soil cover could effectively insulate seed from heat produced from residue burning. Lincoln weed would not be suited for HWSC and narrow windrow burning as it is generally a weed of summer fallows where it grows after crop harvest.

*Table 9. Effect of heat on Mallow seed viability (% survival).*

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 100 *a* | 92 *ab* | 95 *ab* | 100 *a* | 100 *a* | 100 *a* |
| **40** | 97 *ab* | 75 *ab* | 100 *a* | 100 *a* | 92 *ab* | **3 c** |
| **60** | 92 *ab* | 88 *ab* | 95 *ab* | 44 *b* | 66 *b* | **9 c** |

*P<0.001, LSD=32.26, cv rep=3.1%, >80% reduction* ***bolded***

*Table 10. Effect of heat on Lincoln weed seed viability (% survival).*

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 97 *a* | 92 *a* | 62 *b* | **11 c** | **0 c** | **0 c** |
| **40** | 49 *b* | **18 c** | **0 c** | **0 c** | **0 c** | **0 c** |
| **60** | **18 c** | **3 c** | **0 c** | **0 c** | **0 c** | **0 c** |

*P<0.001, LSD=28.87, cv rep=17.1%, >80% reduction* ***bolded***

*Table 11. Effect of heat on Indian Hedge Mustard seed viability (% survival).*

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 71 *b* | 66 *bc* | 88 *a* | 54 *c* | 69 *b* | **0 e** |
| **40** | 73 *b* | 53 *c* | 47 *c* | **0 e** | **0 e** | **0 e** |
| **60** | 69 *b* | **19 *d*** | **1 e** | **0 e** | **1 e** | **0 e** |

*P<0.001, LSD=12.55, cv rep=4.2%, >80% reduction* ***bolded***

*Table 12. Effect of heat on Wild Turnip seed viability (% survival).*

| | Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| **Duration (s)** | **200** | **250** | **300** | **350** | **400** | **450** |
| **20** | 98 *a* | 98 *a* | 98 *a* | 100 *a* | 100 *a* | 99 *a* |
| **40** | 99 *a* | 99 *a* | 98 *a* | 99 *a* | 92 *a* | **0 c** |
| **60** | 100 *a* | 99 *a* | 98 *a* | 32 *b* | **0 c** | **0 c** |

*P<0.001, LSD=21.40, cv rep=3.7%, >80% reduction* ***bolded***

IHM seed was found to be more tolerant of heat than Lincoln weed (Table 3). While temperatures ≥450°C could completely control IHM seed at the shorter duration times, duration times of ≥60 seconds were required to achieve effective control at 250-300°C (Table 11). According to the temperature and duration results reported by Walsh and Newman (2007), potentially enough heat would be generated for long enough to effectively control IHM seed when either burning heavy conventional or narrow harvest windrows. IHM is also well suited for HWSC followed by windrow burning as it has high pod and seed retention (Fleet *et al.* 2016).

Wild turnip seed was found to be one of the most heat tolerant of the weed species studied, particularly when compared to other brassica weeds. Wild turnip was nearly 2 and 3 fold more tolerant than IHM and Lincoln weed, respectively (Table 3). Wild turnip required ≥400°C for 60 seconds to effectively kill seeds; a 40 second duration achieved the same results when temperature was increased to 450°C. However at 450°C, 20 second heat duration had no effect on seed viability (Table 12). Narrow windrow burning of stubble would be the only way to potentially achieve the temperatures and durations required to effectively control wild turnip seed (Walsh and Newman, 2007). Wild turnip is unlikely to be well suited to HWSC and narrow windrow burning as it is prone to shed seeds early before crop harvest.

## What does this mean?

All weed species investigated showed that exposure to heat could provide control of seeds, but there were large differences between weeds in their tolerance to heat. Combinations of high temperature and exposure time investigated could provide complete kill of all species except marshmallow. High temperature and duration of burn expected from burning narrow windrows should provide effective seed kill of most of these species. However, the performance of this method is completely dependent on how much of the weed seeds can be collected at harvest (HWSC) and placed into narrow harvest windrows. Grass weeds all showed similar patterns of tolerance to heat with ARG being the most tolerant. Despite the higher tolerance to heat, high pre-harvest seed retention in ARG makes it more suited to effective control from residue burning (narrow windrows) than barley grass, which sheds most of its seeds well before harvest. Among brassica weeds, IHM showed good potential for control by burning harvest windrows as it is sensitive to both heat and HWSC methods.

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## References

Fleet B, Thongmee M, Preston C and Gill G (2014) Potential of harvest seed collection of annual ryegrass in the southern cropping region – UA00134. Report for GRDC. University of Adelaide, South Australia.

Fleet B and Gill G (2012) Seed Dormancy and Seedling Recruitment in Smooth Barley (*Hordeum murinum* ssp. *glaucum*) Populations in Southern Australia. *Weed Sci*. 60, 394-400.

Fleet B, Preston C and Gill G (2016) Does windrowing faba beans reduce seed set of Indian Hedge Mustard? - UA0049. Report for GRDC. University of Adelaide, South Australia.

Gill GS and Holmes JE (1997) Efficacy of Cultural Control Methods for Combating Herbicide-Resistant *Lolium rigidum. Pestic. Sci*. 51, 352-358.

Kleemann S, Martin J and Gill G (2016) Seedbank Biology of Emerging Weeds in the Southern Region – UA00156. Report for GRDC. University of Adelaide, South Australia.

Llewellyn RS, Ronning D, Ouzman J, Walker S, Mayfield A and Clarke M (2016) *Impact of Weeds on Australian Grain Production: the cost of weeds to Australian grain growers and the adoption of weed management and tillage practices* Report for GRDC. CSIRO, Australia.

Pitt JL, Vitrue JG and Feuerherdt LJ (2006) *Onion weed: Pest or perception. In Managing weeds in a changing climate: Australian weeds conference, 15th, 24-28 Sep 2006, Adelaide SA, eds Preston C, Watts JH and Crossman ND, 454-457.* Weed Management Society of South Australia, Adelaide SA.

Shergill L, Fleet B, Preston P and Gill G (2015) Incidence of Herbicide Resistance, Seedling Emergence, and Seed Persistence of Smooth Barley (*Hordeum glaucum*) in South Australia. *Weed Tech*. 29, 782-792.

Walsh M and Newman P (2007) Burning of narrow windrows for weed seed destruction. *Field Crops Research* 104, 24-30.

# Burning temperatures of harvest windrows and standing stubbles in low rainfall farming systems

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## Key messages

- **Cereal windrow burning achieved temperatures in excess of those required to achieve high levels of weed seed mortality, except in paddocks which had 11 mm of rainfall the week before.**
- **The open paddock burn with a high stubble load had a quicker, faster burn but still achieved the necessary temperatures of 450°C for longer than 60 seconds.**

## Why do the trial?

Farmers and advisers list weeds as one of the major constraints to improving the productivity and sustainability of southern Australian farming systems. Narrow windrow burning has been rapidly adopted across southern Australia as a weed management tool. The technique has been found to be very effective for controlling annual ryegrass and wild radish in WA. These weed species retain much of their seed by the time of crop harvest and a significant amount of weed seeds can be collected by the harvester and then concentrated into rows with the chaff and straw. High weed seed kill efficacy is generally achieved for annual ryegrass and wild radish at temperatures often achieved by burning narrow windrows.

Knowledge of both the threshold temperatures to kill weed seeds, and the temperatures achieved when burning crop residues in various formats are required to provide a guide to expected weed seed control of problematic weeds in low rainfall cropping systems. Unlike a whole paddock burn, this information will only relate to the fate of seed that enters the harvest windrow. The total efficacy of this method will be largely controlled by the proportion of weed seeds that can be collected by the harvester. Threshold temperatures to kill weed seeds are reported in the article '*Burning of weed seeds in low rainfall farming systems*'.

## How was it done?

SARDI staff on upper EP and the staff of the Upper North Farming Systems (UNFS) group measured temperatures during burning (windrows or whole paddock) of different crops in their region. The UNFS group located farmers in their region who were narrow windrow burning or burning whole paddocks, and the EP paddocks were monitored on the Minnipa Agricultural Centre (MAC).

Over the late summer/autumn of 2016-17, temperatures were measured when burning crops by using a hand held laser type thermometer (Kestrel delta T instrument) by holding the temperature gun at full arms-length pointing at the middle of the windrow. Temperatures were recorded every 10 seconds for 240 seconds, then recorded at 300 and 360 seconds.

Wind speed, direction and air temperature (either from BOM site or using a Kestrel delta T instrument) and the height of the standing stubble were also recorded. For the whole paddock burn the same protocol was used, measurements were taken in a stationary position and due to preserving personal safety, only one set of data were recorded until 210 seconds.

## What happened?

Nine paddocks were monitored for burning temperatures, most were cereal stubbles in windrows (Table 1).

Most paddocks with cereal windrows at MAC achieved temperatures greater than 450°C for longer than 60 seconds (Figure 1). The Compass barley in windrows in the airport paddock received 11 mm of rainfall in the week before, with 0.2 mm the day before burning, so despite having the highest stubble load at Minnipa, it did not achieve the target temperatures of higher than 450°C for greater than 60 seconds. Likewise, the S7 paddock burn was conducted 8 days after receiving 11 mm of rainfall at MAC and did not achieve the temperatures required for weed seed kill.

*Table 1. Paddock details, crop type, stubble and weather conditions at burning in autumn 2017.*

| Burning date | Crop | Crop yield (t/ha) | Paddock | Burn type | Stubble height (cm) | Stubble load (t/ha) | Relative humidity (%) | Wind speed and direction (km/h) | Temp (°C) |
|---|---|---|---|---|---|---|---|---|---|
| 20 March | Mace wheat | 3.0 | MAC S1 | windrows | 18 | 2-3 | 16 | 10 WNW | 30 |
| 28 April | Mace wheat | 3.1 | MAC S7 | windrows | 19 | 2-3 | 17 | 9 SSE | 19 |
| 26 April | Compass barley* | 4.0 | MAC Airport | windrows | 22 | 2.5-3.5 | 38 | 28 SSW | 16 |
| 26 April | Mace wheat* | 2.8 | MAC Airport | windrows | 19 | 2-3 | 38 | 28 SSW | 16 |
| 17 March | Trojan wheat | 2.6 | MAC S4 | windrows | 17 | 2-3 | 17 | 9 S | 29 |
| 17 March | Mace wheat | 3.6 | MAC N5S | windrows | 15 | 2-3 | 17 | 9 S | 29 |
| 10 May | Medic and barley grass | 3.7 DM hay cut | MAC N1 | large plots - paddock burn (9 m x 9 m) | 17 | 3-4 | 23 | 15 NNE | 19 |
| 10 May | Mace wheat | 2.9 | MAC N1 | windrows | 17 | 2-3 | 23 | 15 NNE | 19 |
| 9 May | UNFS Canola | 2.3 | Nottle Paddock 1 | windrows | 40 | 1-2 | 36 | 7 NNE | 20 |
| 9 May | UNFS Canola | 2.1 | Nottle Paddock 2 | windrows | 40 | 3-4 | 27 | 4 NNE | 21 |
| 5 May | UNFS Wheat | NA as leased | Hazels | windrows | 40 | 5-6 | 36 | 8 NE | 19 |
| 5 May | UNFS Wheat | NA as leased | Hazels | paddock burn | 40 | 5-6 | 36 | 8 NE | 19 |

**11 mm received between 20-27 April*

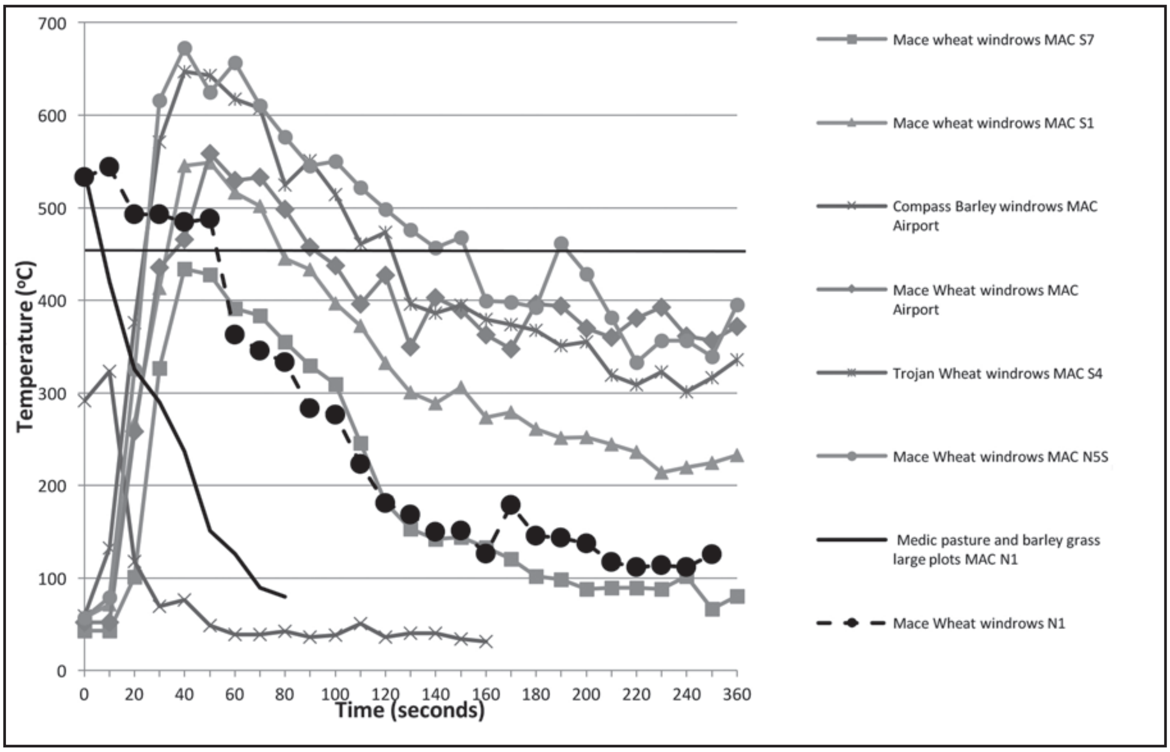


***Figure 1. Burning temperatures (°C) over time (seconds) of windrows (wheat and canola) prior to seeding in 2017 at Minnipa Agricultural Centre.***

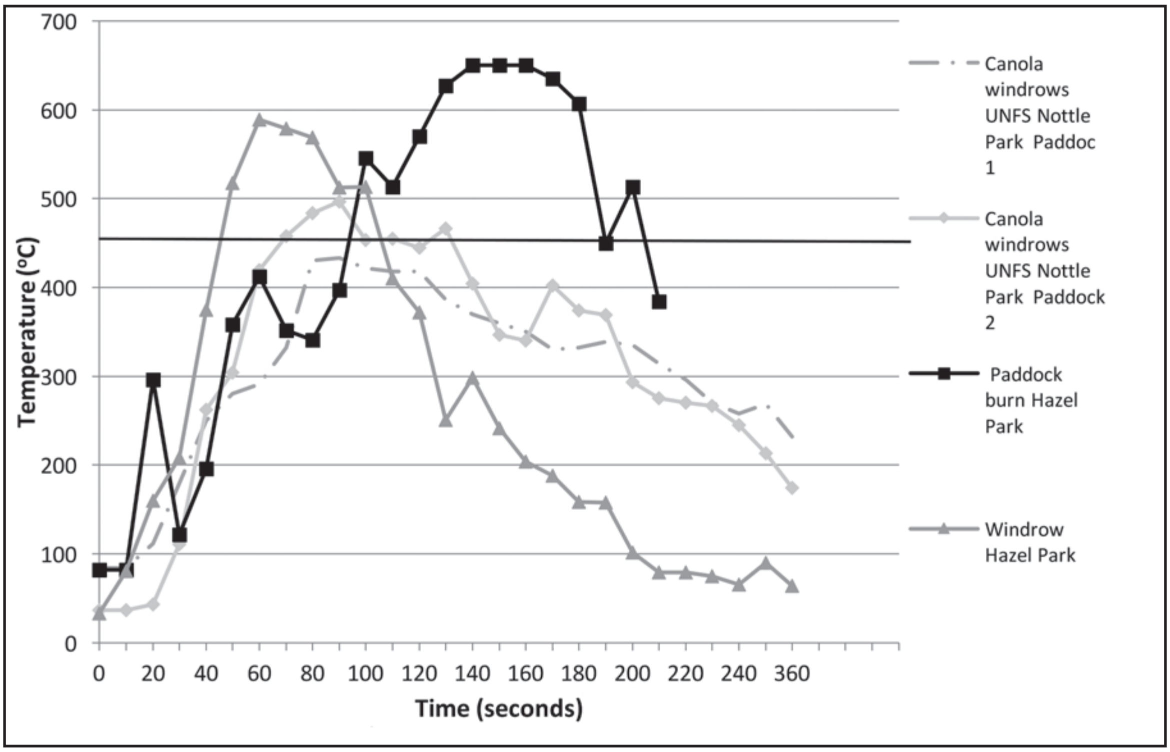


***Figure 2. Burning temperatures (°C) over time (seconds) of windrows (wheat and canola) prior to seeding in 2017 in the Upper North, SA.***

The medic pasture and barley grass plots (9 m x 9 m) were burnt as a whole paddock burn situation (replicated 8 times). The medic and grass plots did not achieve the high temperatures required for weed seed kill, however further measurements in other medic paddocks and at different dry matter levels are required to make more robust conclusions.

The UNFS canola paddock (Nottle) had been raked twice, so the windrows were low and scattered with very little standing stubble around the windrows, and these windrows didn't achieve the temperatures of greater than 450°C for longer than 60 seconds needed for weed seed kill (Figure 2).

Hazel's paddock was heavy wheat stubble with high numbers of grass weeds, especially ryegrass. The open paddock burn had flames that travelled fast and immediately behind the fire front cooled off relatively quickly; therefore any weed seeds on the soil surface that did not burn directly were not likely to suffer any damage.

Previous burning measurements in windrows at MAC taken in 2015 and 2016 show that with higher stubble loads after a good growing season, temperatures of 450°C for 60 seconds or greater are being achieved. A time interval of 40 seconds with temperatures of 450°C or greater would result in some mortality of seeds, but not a total weed seed kill.

## What does this mean?

Recent research under controlled conditions (using a kiln) on the temperatures required to kill weed seed species commonly found in SA cropping regions showed temperatures greater than 450°C for 60 seconds of exposure resulted in high mortality for most weed species (*Burning of weed seeds in low rainfall farming systems*, Fleet *et al.* EPFS Summary 2017).

The results from the paddock burning measurements, using a hand held temperature gun, showed that, when dry, in most situtations temperatures achieved when burning narrow harvest windrows were likely to achieve good control of the weed seeds collected in the harvest row. Total control of weed seeds across the paddock using these methods will depend on the proportion of the weed seeds that can be collected by the harvest operation.

## Acknowledgements

SAGIT for funding this research as part of the S416 – Burning of weed seeds in low rainfall farming systems project. Thank you to Ruth and Damien Sommerville, Matt Nottle, Barry Mudge, Hannah Mikajlo, Jake Hull, Wade Shepperd, Ian Richter, Rochelle Wheaton and Brett Hay for their involvement in data collection.

## References

Burning of weed seeds in low rainfall farming systems, Fleet B, Kleemann S and Gill G. Eyre Peninsula Farming Systems 2017 Summary.

# Capturing barley grass in broad acre paddocks

**Amanda Cook[1], Ian Richter[1], Jake Hull[1] and Bruce Heddle[2]**
[1]SARDI, Minnipa Agricultural Centre, [2]Farmer, Minnipa

RESEARCH

Weeds

**Searching for answers**

**Location**
Minnipa
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281mm
2017 GSR: 155 mm
**Soil Type**
Red loam
**Plot Size**
Paddock monitoring

**Location**
Yaninee
**Rainfall**
2017 Total: 274 mm
2017 GSR: 126 mm
**Paddock History**
2017: Medic pasture spray topped
2016: Grass free medic pasture
2015: Mace wheat
**Plot Size**
Paddock monitoring

**Location**
Condada
**Rainfall**
2017 Total: 233 mm
2017 GSR: 123 mm
**Paddock History**
2017: Hatchet wheat
2016: Mace wheat
2015: Grass free medic pasture
**Plot Size**
Paddock monitoring

## Key message

- **In 2017, approximately 50% of barley grass weed seed was already on the ground (dropped) before the first swathing opportunity.**

## Why do the trial?

Barley grass continues to be a major grass weed in cereal cropping regions on upper Eyre Peninsula (EP). Swathing a cereal crop involves cutting the cereal crop and weeds into windrows at between 20 and 40% grain moisture and allowing it to dry after cutting. Having the weed seeds cut and in the windrow before the seed heads shatter and before tillers fall over, may allow greater weed seed collection when using a chaff cart or windrows. Swathing early then harvesting for weed seed collection needs further evaluation as it may provide farmers with another tool for integrated weed management, especially for barley grass that matures and sheds seed before crops ripen.

## How was it done?

Four quadrats were taken at GPS-located sampling points before swathing. Crop and weeds were cut at 15-17 cm height (header cutting height). Crop and grass weeds were separated to measure weight and weed seed head length and calculate potential weed seed capture. Surface soil was also collected, and barley grass weed seeds were cleaned from the soil sample and weighed to calculate the weed seed which had dropped before swathing. To assess weed seed capture in chaff dumps after harvest, chaff was collected from paddock dumps to determine the species being collected at harvest by planting the chaff out in trays and assessing for weed germination every four weeks.

## What happened?

On upper EP the 2017 growing season rainfall was a decile 1 (well below average), with the first substantial rainfall event not until early July in cold conditions. Low plant tillering and continued dry seasonal conditions resulted in a very poor season.

Swathing wheat at Heddle's did not occur in 2017 due to poor crop growth and low bulk. However, data for barley grass seed drop in crop by harvest was still captured by monitoring two cereal crops weekly over a five week period from the beginning of harvest (17 October) at Oswald's and Cook's (Table 1). Both of these paddocks had grass weeds present as a result of changes in planned rotation due to the poor start to the 2017 season. Plant cuts and soils were collected to assess the amount of barley grass which could have been captured if early swathing of a cereal crop had occurred. Ryegrass was also present in Oswald's at low numbers, with most being greater than 15 cm in height so potentially able to be captured using harvest weed seed collection.

In the 2016 season, 65% of barley grass seed had already dropped to the ground by 27 October in Heddle's swathed paddock.

***Table 1. Wheat plants and barley grass seeds/m² from the beginning of harvest 2017 at Oswald's and Cook's.***

| | Date | Wheat (plants/m²) | Barley grass (plants/m²) | Barley grass seeds/m² above 15 cm | Barley grass seeds/m² below 15 cm | Barley grass seeds/m² already on/in soil | Total Barley grass seeds/m² under 15 cm | Barley grass seed/ m² for weed seed collection* (%) |
|---|---|---|---|---|---|---|---|---|
| Cook's | 17 Oct (grain moisture 24.6%) | 256 | 78 | 2500 | 1380 | 1350 | 2730 | 48 |
| | 25 Oct | 278 | 39 | 3350 | 1760 | 2830 | 4590 | 42 |
| | 1 Nov | 158 | 108 | 900 | 1070 | 1280 | 2370 | 28 |
| | 7 Nov | 214 | 31 | 120 | 160 | 1520 | 1680 | 7 |
| | 16 Nov | 242 | 44 | 8860** | 810 | 5890 | 6700 | 57** |
| Oswald's | 17 Oct (grain moisture 29.5%) | 177 | 192 | 6810 | 2370 | 3560 | 5930 | 53 |
| | 25 Oct | 236 | 458 | 6650 | 940 | 11400 | 12360 | 35 |
| | 1 Nov | 169 | 194 | 5074 | 1210 | 12390 | 13600 | 27 |
| | 7 Nov | 167 | 61 | 470 | 230 | 3152 | 3400 | 12 |
| | 16 Nov | 200 | 390 | 3180 | 1530 | 30200 | 31700 | 9 |

**(Barley grass seeds/m² above 15 cm)/(Barley grass seeds/m² above 15 cm + Total Barley grass seeds/m² under 15 cm) multiplied by 100*

***This sample was in a higher density weed area, with larger weeds and heads*

## What does this mean?

The grass weed seed collection showed the amount of barley grass seed which could potentially be collected using swathing of the crop was 50% when grain moisture was above 25%. Harvest generally started in the Minnipa area in late October/early November, and only 30-40% of barley grass seed was still in the heads or above 15cm during this time. The barley grass seed retention will decline with every successive week. If growers are aiming to collect grass seed using harvest weed seed management strategies (chaff carts or windrows) they need to harvest grassy paddocks as early as possible.

This research is ongoing for the next two seasons so more information and knowledge will be generated about weed seed management in current farming systems.


## Acknowledgements

Thank you to Bruce Heddle, Matt Cook and Oswald families for having the monitoring on their property. Thank you to Brett Hay, Katrina Brands and Rochelle Wheaton for helping to monitor the paddocks and processing the barley grass samples, and Ben Fleet for information regarding methodology for weed seed monitoring. Research funded by SAGIT S117.


SAGIT

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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Monitoring barley grass in broad acre paddocks

RESEARCH

**Amanda Cook[1], Scott Gillet[2], Terry Traeger[3], Ian Richter[1] and Jake Hull[1]**

[1]SARDI, Minnipa Agricultural Centre, [2]Wisdom Data and Mapping, Loxton, [3]Drone View Photography, Cleve

**Searching for answers**

**Location**
Minnipa Agricultural Centre
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281 mm
2017 GSR: 155 mm
**Soil Type**
Red loam
**Plot Size**
Paddock monitoring

**Location**
Yaninee
**Rainfall**
2017 Total: 274 mm
2017 GSR: 126 mm
**Paddock History**
2017: Medic pasture spray topped
2016: Grass free medic pasture
2015: Mace wheat

## Key message

- **UAV imagery with appropriate analysis has the potential to identify weed issues in paddocks quickly, reliably and cheaply over large areas.**

## Why do the trial?

Barley grass continues to be a major grass weed in cereal cropping regions on upper Eyre Peninsula (EP). The use of unmanned aerial vehicle (UAV) technology to identify and assess barley grass populations in paddocks and monitor potential resistant populations may be a useful tool for farmers. Barley grass weed density was monitored in three paddocks on upper EP (Minnipa Agricultural Centre (MAC), Heddle's at Minnipa and Wilkins' at Yaninee) using a UAV during the 2017 growing season at three different timings, with paddock transects conducted to verify grass weed density in paddocks.

## How was it done?

***In-crop paddock monitoring for grass weed populations***

Grass weeds were assessed in-crop or in pasture at ten GPS points along a transect for crop or weed density, with six counts taken at each sample point. This was used to verify the UAV data captured at three times during the cropping season. Extra sampling points in the paddock were targeted if more information was needed to verify the imagery. The paddock photos were captured on an iPad with 'Avenza Maps' linked to the location in the paddock.

***UAV imagery***

UAV data was captured during the 2017 cropping season on 14 August, 28 September and 3 October. The UAVs used were either a DJI Matrice 100 with both NIR and RGB sensors or a Mavic Pro with RGB sensors. The UAVs were flown at a height of 118 metres.

***Data analysis of UAV imagery***

To analyse weed locations at a whole paddock level using the UAV imagery, geospatial analysis tools were used to automate the selection of likely weed infestation areas. A map of the paddock with the UAV coverage was generated from ArcGIS Desktop as a geo-pdf to enable collection and analysis of field data. This is a map file which can be used in a range of devices. With this file loaded to the 'Avenza Maps' app on a tablet, photos and comments with GPS locations were collected. This data was then added to ArcGIS and used to interpret the UAV mapping.

The Spatial Analyst extension within ESRI's ArcGIS Desktop software was used to carry out a 'Maximum Likelihood' spatial classification. This classification uses small parts of the image selected by the user as 'training features' for deciding which category each pixel of the image most likely fits into. This classification method is based entirely on the spectral (colours through different bands of light) characteristics of the imagery. Training features were created which highlighted areas of; high weeds, low weeds/crop features, and bare ground (example photos are shown in Figure 2). The training features selected within the crop were mostly inter-row areas when selecting high weeds, and mostly crop rows when matching to less weeds.

## What happened?

Originally, we had planned to undertake monitoring in cereal paddocks, but due to the late start and poor opening rains on upper EP in 2017, two of the paddocks to be monitored (Minnipa and Yaninee) changed rotation from cereal to pasture. The MAC paddock monitored was MAC S4 which was sown to barley.

On upper EP the 2017 growing season rainfall was a decile 1 (well below average), with the first substantial rainfall event not until early July in cold conditions. The first flight time was 14 August, with crops only at the four leaf stage and lower than expected grass weed germination. Low plant tillering and continued dry seasonal conditions resulted in a very poor season. The UAV data captured was later than anticipated due to the late start and poor seasonal conditions.

The pasture paddocks (predominantly medics) were still monitored with the UAV to capture grass weed density and location in the paddock. These paddocks will be measured in the 2018 season in cereal crops. One paddock had suspected resistance to Group A herbicides as the grass weed patches were circular and spreading, and this was confirmed with herbicide resistance testing during the season. This paddock will provide an opportunity to see if UAV technology is an accurate monitoring tool for on-farm grass weeds.

***Issues with classification***

It was harder to detect areas high in barley grass numbers in the barley crop (Figure 1) than anticipated as the photos showed that a large percentage of the weeds were within the crop rows. It would be easier to define patches of grass weeds if they were mostly located in the inter-row. Study of the photos taken on site along with the matching UAV imagery provided better information for selecting training areas (Figure 2) to interpret the grass weed density.

Pasture areas provided much clearer weed signatures for training data analysis, especially earlier in the season. The pasture sites varied during the season with the amount and intensity of grazing. The Heddle's site was more intensively grazed which changed the appearance of grass weeds in the UAV imagery. Wilkins' paddock contained more obvious barley grass patches with intact seed heads. Training examples from the paddocks are shown in Figure 2.

## What does this mean?

UAV imagery may provide an opportunity to assist in targeted grass weed management. Current UAV technology is cheap, high resolution and quickly available for management decisions compared to other potential image sources, such as high resolution satellite. However the advantages must be balanced against the time and effort of collecting data over large areas, analysing the data and the variable image quality. To improve feature recognition, it would be worth trying UAV flights over a representative strip at half the usual height to provide a higher resolution strip which could be used in analysis.

As UAV technology improves with higher resolution data capture, other analysis techniques could also be explored, such as those based on shape recognition. The major attraction for this method of analysis is the short time taken to highlight representative image samples and if the samples could be used across multiple images (of other paddocks) this would make the technique even more efficient.

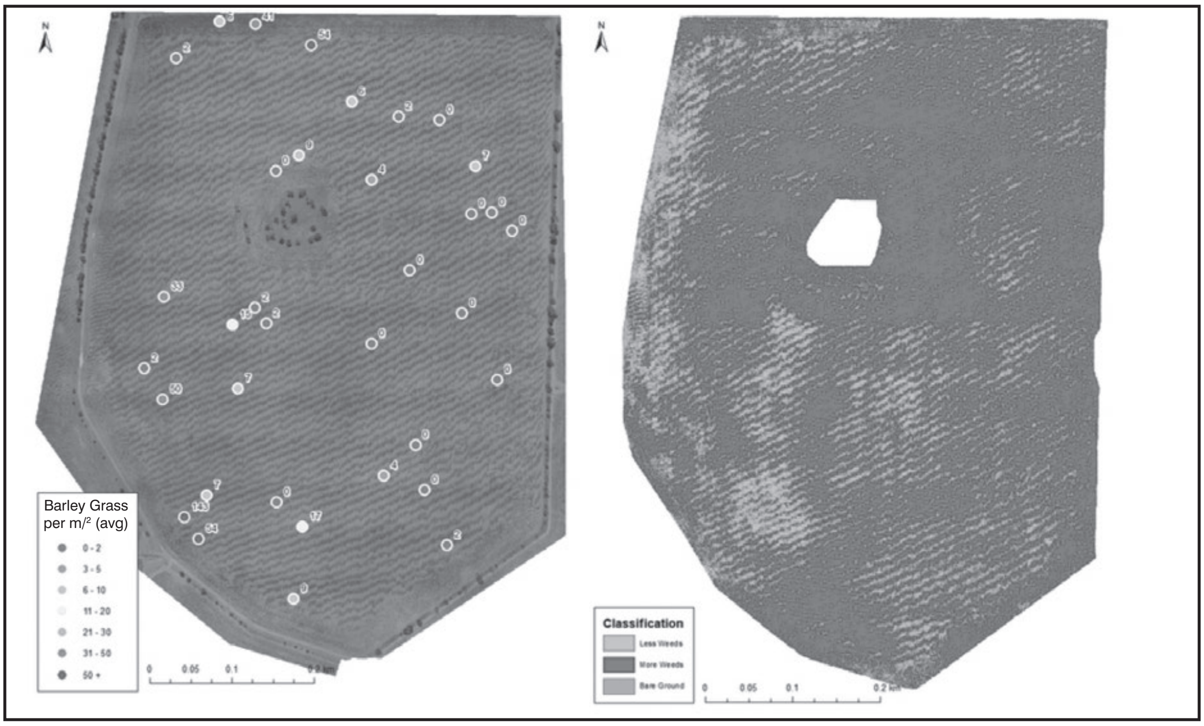
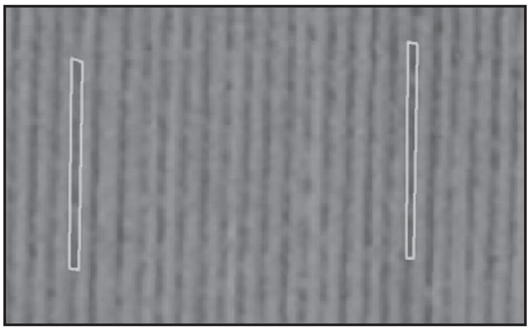
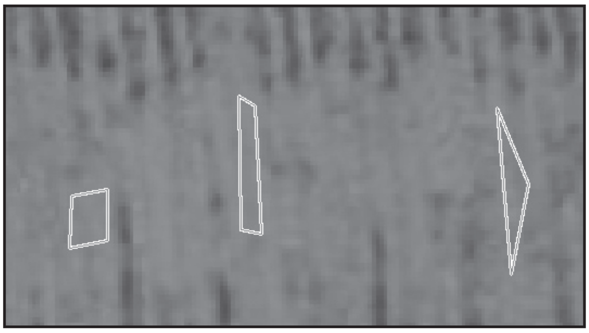
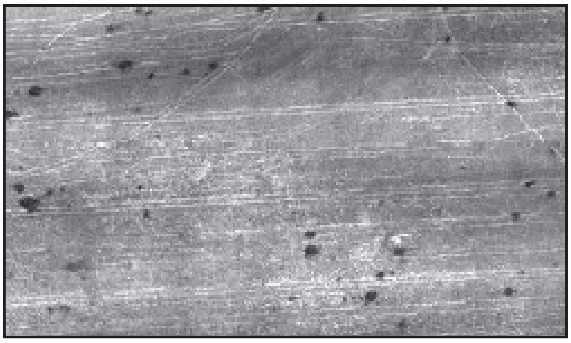



***Figure 1. Maps of Minnipa S4 (barley), (left) on ground sampling points and barley grass density, (right) weed density map from UAV in 2017.***

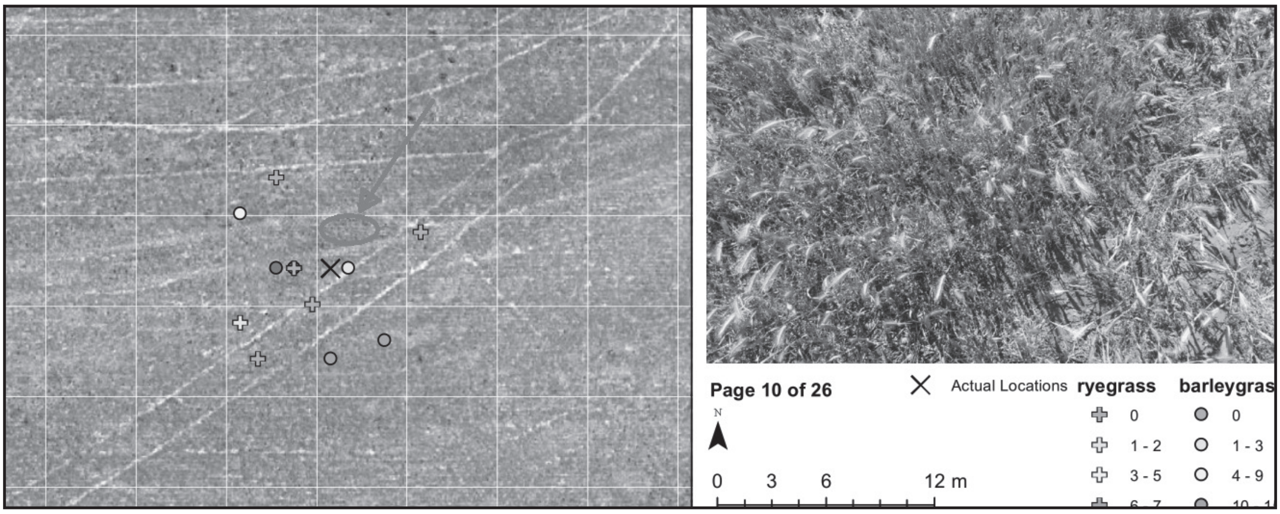




*MAC S4 paddock - Low weeds with crop (above left) and bare ground (above right)*



*Pasture – High grass weed density areas (above) visible early in the season*




*Pasture - Initial data map-book page showing the location of barley grass within the UAV imagery by combining information from the photo and imagery.*

***Figure 2. Examples of training features.***

This research is ongoing for the next two seasons so more information and knowledge will be generated about the use of imagery and data collection for weed management in current farming systems.

## Acknowledgements

Thank you to MAC, Bruce Heddle and Wilkins families for having the research and monitoring on their property. Thank you to Brett Hay, Katrina Brands and Rochelle Wheaton for helping to monitor the paddocks and processing the barley grass samples, and Ben Fleet for information regarding methodology for weed seed monitoring. Research funded by SAGIT S117.

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# Summer weeds survey of South Australian cropping districts

**Ben Fleet, Christopher Preston and Gurjeet Gill**
University of Adelaide, School of Agriculture, Food & Wine

SURVEY


## Key messages

- **Heliotrope was the most frequent summer weed surveyed.**
- **Frequency ranking of summer weed species varied greatly between districts.**
- **Dry summer fallow conditions in 2014/15 is likely to have reduced summer weed pressure, but not species composition.**

## Why do the trial?

Effective management of summer weeds can greatly improve subsequent crops by preserving stored soil moisture and nitrogen, improving crop establishment and reducing levels of weed vectored insects pests and disease (Cameron & Storrie, 2014). Information on summer weed species will both direct growers into targeted management of problem summer weeds in their cropping region and help direct future research into summer weeds.

## How was it done?

A random paddock survey was conducted on summer weeds across South Australian (SA) cropping regions during February to March in 2015 and 2016. The Lower North (LN), Mid North (MN), Upper North (UN), Yorke Peninsula (YP), Mallee, Upper South East (USE), and Lower South East (LSE) cropping districts were surveyed in 2015. The Upper Eyre Peninsula (UEP) and Lower Eyre Peninsula (LEP) were surveyed in 2016. In total 298 paddocks were surveyed and a breakdown of total surveyed paddocks in each region is displayed in Table 1. Sites were selected at approximately 10 km intervals. At each site, weed species were identified along an 80-100 m long transect. Weed density was assessed visually and rated as either low (0-10 plants/$m^2$), medium (11-50 plants/$m^2$) or high (>50 plants/$m^2$). Details of crop residue, soil type, NDVI (most sites) and comments on growth stage were recorded at each site. Any species that could not be identified on site had photos taken for later identification. Analysis of weed frequency was done using Microsoft Excel 2013.

## What happened?

The frequency ranking of different summer weeds varied significantly across SA cropping regions. Heliotrope was the most prevalent summer weed species across all surveyed regions of SA and in eight of the nine individual cropping districts surveyed (Tables 1 and 2).

Roly poly, Afghan melon and Clammy goosefoot were common summer weeds across most of the cropping regions. Whereas some weeds appear to be more localised in their distribution such as Tares (LN); Cutleaf mignonette (YP); Tar vine (UN); Skeleton weed, Small burr grass and Innocent weed (Mallee); Afghan thistle (UEP) and Wild radish (USE).

Sowthistle had the highest frequency of occurrence in the LSE region and it was also quite common in the LN and MN. Sowthistle was found at <10% of survey sites on the YP, which maybe a surprise given the increasing prevalence of this weed in lentil crops.

Panic grass was a regular occurrence in LN, MN, UN, and LSE districts where it has now established itself as a consistent summer weed.

While mallow was a regular occurrence in many cropping regions, it had a higher frequency in LN, MN and LEP cropping districts. Caltrop was only found at a regular frequency (>10%) in three regions (UN, Mallee and USE). Lincoln weed was only found to occur on the YP, UEP and LEP. Some areas had a much lower diversity of weed species (e.g. YP) than other others (e.g. USE and UN).

## What does this mean?

The 2014/15 summer fallow period was quite dry for many cropping regions surveyed, which could have reduced summer weed pressure (density) and plant size, but weed species composition is still likely to be representative of the general trend.

*Table 1. The frequency of summer fallow weed species for each South Australian cropping region (for all species found at more than 10% of sites). Frequency of sites given as a percentage and the number of paddocks surveyed for each district is in brackets.*

| Lower North (25) | Mid North (33) | Yorke Peninsula (34) | Upper North (22) | Mallee (48) | Upper Eyre Peninsula (58) | Lower Eyre Peninsula (37) | Upper South East (14) | Lower South East (19) |
|---|---|---|---|---|---|---|---|---|
| Heliotrope 84% | Heliotrope 68% | Heliotrope 47% | Heliotrope 68% | Heliotrope 67% | Heliotrope 48% | Heliotrope 51% | Heliotrope 71% | Sowthistle 21% |
| Sowthistle 44% | Panic grass 35% | Cutleaf Mignonette 24% | Stinking Love Grass 27% | Afghan Melon 46% | Afghan Melon 38% | Lincoln Weed 27% | Afghan Melon 36% | Clammy Goosefoot 16% |
| Panic grass 32% | Clammy Goosefoot 32% | Prickly lettuce 21% | Rolypoly 27% | Rolypoly 29% | Lincoln Weed 34% | Afghan Melon 24% | Clammy Goosefoot 36% | Heliotrope 16% |
| Mallow 28% | Mallow 26% | Lincoln Weed 15% | Panic grass 23% | Caltrop 27% | Rolypoly 29% | Medic 24% | Panic grass 29% | Panic grass 16% |
| Goosefoot 24% | Sowthistle 26% | Afghan Melon 12% | Caltrop 18% | Skeleton Weed 23% | Fleabane 28% | Mallow 22% | Stinking Love Grass 21% | Spear Thistle 16% |
| Rolypoly 20% | Wireweed 26% | Rolypoly 12% | Clammy Goosefoot 18% | Small burr Grass 19% | Caustic Creeper 16% | Onion Weed 19% | Caltrop 21% | Couch Grass 11% |
| Afghan Melon 16% | Salvation Jane 18% | | Tar Vine 18% | Prickly Paddy Melon 17% | Prickly Paddy Melon 16% | Stinking Love Grass 14% | Lincoln Weed 21% | Mallow 11% |
| Wireweed 16% | Caustic Creeper 15% | | Salvation Jane 18% | Wild Turnip 17% | Stinking Love Grass 14% | Fleabane 14% | Wild Radish 21% | Ox Tongue 11% |
| Prickly lettuce 12% | Afghan Melon 12% | | Afghan Melon 14% | Onion Weed 15% | Onion Weed 14% | Sowthistle 14% | Capeweed 21% | Fathen 11% |
| Tares 12% | Stemless thistle 12% | | Couch Grass 14% | Stinking Love Grass 13% | Prickly lettuce 14% | Wireweed 14% | Couch Grass 14% | |
| Salvation Jane 12% | | | Caustic Creeper 14% | Innocent Weed 10% | Silverleaf Nightshade 12% | Capeweed 14% | Caustic Creeper 14% | |
| Medic 12% | | | Mallow 14% | | Afghan Thistle 12% | Clammy Goosefoot 11% | Fleabane 14% | |
| | | | Wireweed 14% | | False Sow Thistle 10% | Rolypoly 11% | Mallow 14% | |
| | | | Salt bush 14% | | | | Prickly lettuce 14% | |
| | | | Storksbill 14% | | | | Stinkwort 14% | |
| | | | | | | | Salvation Jane 14% | |
| | | | | | | | Saffron Thistle 14% | |
| | | | | | | | Salt Bush 14% | |

***Table 2. The frequency of summer fallow weed species across South Australian cropping regions, 298 survey sites (for all species found at more than 5% of sites). Note that weed species are arranged in order of decreasing frequency.***

| Common name | Scientific name | Occurrence all SA (% of fields) |
|---|---|---|
| Heliotrope | *Heliotropium europaeum* | 57% |
| Afghan melon | *Citrullus lanatus* | 25% |
| Roly poly | *Salsola australis* | 18% |
| Lincoln weed | *Diplotaxis tenuifolia* | 14% |
| Sowthistle | *Sonchus oleraceus* | 14% |
| Clammy goosefoot | *Chenopodium pumilio* | 13% |
| Panic grass | *Panicum spp* | 13% |
| Stinking love grass | *Eragrostis cilianensis* | 11% |
| Fleabane | *Conyza bonariensis* | 11% |
| Mallow | *Malva parviflora* | 11% |
| Caltrop | *Tribullus terrestris* | 10% |
| Prickly paddy melon | *Cucumis myriocarpus* | 9% |
| Onion weed | *Asphodelus fistulosus* | 9% |
| Prickly lettuce | *Lactuca serriola* | 9% |
| Wireweed | *Polygonum aviculare* | 8% |
| Caustic creeper | *Chamaesyce drummondii* | 8% |
| Medic | *Medicago polymorpha* | 7% |
| Salvation jane | *Echium plantagineum* | 7% |
| Silverleaf nightshade | *Solanum elaeagnifolium* | 6% |
| Skeleton weed | *Chondrilla juncea* | 6% |
| Couch | *Cynodon dactylon* | 5% |

## Acknowledgements

This research was funded by the Grains Research and Development Corporation (GRDC) as part of project UA00149. We would also like to acknowledge Ryan Garnett who assisted with the paddock surveys.

## References

Cameron J & Storrie A (2014), Summer fallow weed management, a reference for grain growers and advisers in southern and western grain regions of Australia. Grains Research and Development Corporation, Kingston, ACT Australia.

# New uses of old herbicides for the control of barley grass in cereals

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

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



**Searching for answers**

**Location**
Minnipa Agricultural Centre, paddock S1

**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 281 mm
2017 GSR: 155 mm

**Yield**
Potential: 2.1 t/ha (B)
Actual: 0.8 t/ha (B)

**Paddock History**
2016: Mace wheat
2015: Gunyah peas
2014: Mace wheat

**Soil Type**
Red loam

## Key messages

- **Potential of older herbicides from broadacre and horticultural industries to control barley grass in barley was evaluated in a field trial at Minnipa in 2017.**
- **Over-reliance on group B herbicides for post-emergent control of barley grass has already resulted in high incidence of resistance to SU herbicides, and resistance to imidazolinone herbicides is also likely to occur in the future.**
- **Extremely dry conditions at Minnipa at the start of the 2017 growing season were unsuitable for the activity of pre-emergent herbicides on barley grass. Even under these challenging conditions, an experimental herbicide (Experimental-1) at the high rate provided effective pre-emergent control of barley grass.**

## Why do the trial?

Barley grass is becoming a more problematic weed in agriculture as a result of no-till cropping and the high dependence on cereals in the rotation. These practices have selected for increased dormancy in barley grass populations in continuously cropped fields in southern Australia (Fleet and Gill 2012). This dormancy is typically broken by cold stratification and such cold conditions are usually experienced after the start of winter. This means that barley grass now typically emerges after the crop has been sown. The later germination of barley grass means that growers typically use post-emergent herbicides to control it in broad-leaved crops. Unfortunately, there are few post-emergent herbicides available to control barley grass in cereal crops.

In cereals, only Group B herbicides can be used for post-emergent control of barley grass. This over-reliance on sulfonylurea herbicides has increased resistance in grass weeds in South Australia (SA) and Victoria (Peter Boutsalis, pers. comm.). Growers have responded by sowing Clearfield cereals and using imidazolinone herbicides to control these weeds. In recent years, resistance to the imidazolinone herbicides has been identified in brome grass in SA and Victoria and the problem could also develop in barley grass. There is an urgent need to identify alternative modes of actions for barley grass control in cereals.

A survey of existing herbicides identified few alternative modes of action for post-emergent use in cereals. Therefore, this study concentrated on several herbicide modes of action for pre-emergent control of barley grass. In addition, a post-emergent pot trial was also conducted. Feedback from potential registrants indicated that the ability to control annual ryegrass will be essential in developing a local registration of any new herbicides, so annual ryegrass was included in pot trials.

## How was it done?

A field experiment was established at Minnipa, SA to investigate the control of barley grass and crop safety with various herbicide mixtures. Herbicides were applied pre-sowing on 26 May 2017 with three replicates. Barley cv. Spartacus was sown on the same day using a plot seeder set up with knife points and press wheels. Barley grass seed heads and barley crop heads were assessed on 19 October 2017.

At the Minnipa field trial, investigations were undertaken on Experimental-1, Experimental-2 and Experimental-3 alone and in mixtures for control of barley grass in barley (Table 1).

## What happened?

Experimental-3 and their mixtures caused damage to barley and reduced the number of crop heads (Table 1). Experimental-2 caused severe bleaching of barley and reduced its plant density, which was consistent with previous field trials. The extremely dry growing conditions at Minnipa in 2017 are likely to have masked this damage. In contrast, Experimental-1, Sakura and Trifluralin were safe on barley.

*Table 1. Barley heads and barley grass panicles following pre-emergent herbicide applications at Minnipa 2017. Barley heads in Nil were 171 head/m², barley grass panicles in Nil were 61 panicles/m².*

| Treatment | Barley heads (% nil) | Barley grass panicles (% nil) | Yield (t/ha) |
|---|---|---|---|
| Nil | 100 ab | 100 ab | 0.89 ab |
| Sakura (118) | 102 ab | 73 b | 0.86 ab |
| Trifluralin 480 (3.0) | 95 ab | 110 ab | 0.90 ab |
| Trifluralin 480 (3.0) + Diuron 900 (500) | 98 ab | 82 b | 0.91 ab |
| Sakura (118) + Trifluralin 480 (3.0) | 81 bc | 42 bc | 0.80 b |
| Experimental-1 (2.0) | 101 ab | 58 bc | 0.96 ab |
| Experimental-1 (4.0) | 102 ab | 26 c | 1.07 a |
| Experimental-1 (2.0) + Trifluralin 480 (3.0) | 91 b | 71 b | 0.89 ab |
| Experimental-2 (1.56) | 83 bc | 125 a | 0.60 b |
| Experimental-2 (1.56) + Diuron 900 (500) | 93 ab | 80 b | 0.58 b |
| Experimental-2 (1.56) + Trifluralin 480 (6.0) | 79 bc | 65 bc | 0.70 b |
| Experimental-3 (4.0) | 57 c | 79 ab | 0.44 c |
| Experimental-3 (4.0) + Diuron 900 (500) | 51 c | 94 ab | 0.42 c |
| Experimental-3 (4.0) + Trifluralin 480 (3.0) | 64 c | 93 ab | 0.51 c |
| Experimental-2 (1.56) + Trifluralin 480 (3.0) | 90 b | 71 b | 0.65 b |
| Boxer Gold (1.5) + Trifluralin (1.5) | 103 ab | 120 ab | 0.90 ab |
| Boxer Gold (2.5) | 113 a | 54 bc | 0.92 ab |
| Experimental-1 (2.0) + Boxer Gold (1.5) | 112 ab | 64 bc | 0.92 ab |
| Arcade (3.0) | 87 b | 96 ab | 0.81 b |
| Experimental-1 (2.0) + Sakura (118) | 90 b | 80 b | 0.82 b |

*Different letters in each column indicate treatments significantly different from each other ($P<0.05$). Note these herbicide treatments are for experimental purposes and may not be registered in barley.*

Experimental-1 at the high rate provided the greatest reduction in barley grass seed set, with 74% reduction in panicles and was the only treatment to provide acceptable weed control. The next best treatment was Sakura + Trifluralin, only achieving 58% barley grass control. Experimental-1 at the lower rate (2 L/ha), on its own or with a mixing partner, was not very effective. In 2017, rainfall was decile 1 with GSR at Minnipa being more than 100 mm below the long-term average. Such dry conditions proved very difficult for pre-emergent herbicides to work effectively. These dry conditions also minimised crop yield increases in response to good weed control. Conditions in May and June were particularly dry and even proven barley grass herbicides like Sakura struggled to perform. It is of great promise that Experimental-1 at the high rate (4 L/ha) performed well in tough conditions. This treatment was also the best performer in field trials under more favourable conditions in 2016.

Barley yield was 0.89 t/ha in the nil. The best treatment and the only treatment significantly different to the control was Experimental-1 (4 L/ha) with barley grain yield of 1.07 t/ha. This treatment also provided the most effective barley grass control.

## What does this mean?

This trial indicates Experimental-1 can provide consistently good control of barley grass in cereals. However, it will need to be used at its high rate or an effective mixing partner will be required. Both Experimental-2 and Experimental-3 were too damaging to the crop and had insufficient activity on barley grass.

## Acknowledgements

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## References

Fleet, B. and Gill, G., 2012. Seed dormancy and seedling recruitment in smooth barley (*Hordeum murinum* ssp. *glaucum*) populations in southern Australia. Weed Science 60: 394-400.

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

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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
2015 Total: 333 mm
2015 GSR: 258 mm
**Yield**
Potential: 2.1 t/ha (B)
Actual: 0.8 t/ha (B)
**Paddock History**
2016: Pasture legume trial
2015: Pasture legume trial
2014: Mace wheat
**Soil Type**
Red loam
**Plot Size**
27 m x 9 m 3 split plots (2015)
9 m x 9 m x 4 reps (2016)

## Key messages

- **At present, group A herbicide resistance in barley grass is relatively low at a district level on the Eyre Peninsula (EP). However, group A resistant populations of barley grass can be much more common in other areas of the state. Growers need to act now to integrate multiple control tactics to prolong the effectiveness of these cheap and effective herbicides.**
- **Even without using group A herbicides, it is 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 essential.**

## Why do the trial?

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% o[illegible]docks to be resistant t[illegible]rbicides (≥ 20% sur[illegible]other 3% were de[illegible]nce (1% ≤ 20% [illegible]nce was much r[illegible] the UN than on [illegible]e survey results [illegible]ampling barley g[illegible]ompletely random [illegible]ound the survey distric[illegible]quite feasible that there could be individual farms in this area where resistance levels could be much higher.

As a result of the survey work, a field trial was established at the Minnipa Agricultural Centre (MAC) to investigate legume pasture options for controlling group A (ACCase inhibitors) resistant 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 versus 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 paddock (N1) heavily infested with barley grass. Soil cores were taken from the paddock and grown out in trays at Roseworthy Campus to assess the initial barley grass 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 after year one treatments. 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 three 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 (Treflan + Logran) and (b) a high efficacy and expensive option of pyroxasulfone 118 g/ha (Sakura).

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.

*Table 1. Pasture barley grass management treatments in 2015.*

| | |
|---|---|
| 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) @ 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) @ 2.4 L/ha (24 September) followed by hay cut (29 September). |
| 6 | **Medic (regen.) propyzamide** - applied at 1 L/ha Early Post Emergent (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). |

*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 (t/ha) | 2015 reduction in barley grass % reduction | 2016 barley grass in wheat (panicles/m²) | |
|---|---|---|---|---|
| | | | 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*** | 29.33 ***b*** | 17.5 ***cd*** |
| 5. Medic glyphosate + hay | 2.20 ***ab*** *(106.8%)* | 49 ***ab*** | 25.83 ***bc*** | 9.2 ***cd*** |
| 6. Medic propyzamide | 2.13 ***bc*** *(103.0%)* | 27 ***b*** | 50.0 ***a*** | 7.0 ***d*** |
| 7. Medic propyzamide + 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%* | |

Soil cores were taken prior to the 2017 growing season 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.

## What happened?

Initial barley grass seed bank at the experimental site at the start of 2015 season was 1432 seeds/m². 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).

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 a high seed bank, 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/m² to about 300 seeds/m². 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. In 2016 propyzamide was much more 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.

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 2). Sakura in wheat was able to control barley grass effectively even in pasture treatments that provided poor barley grass control in 2015. Although Sakura had high efficacy even in high weed density situations, using this herbicide repeatedly in such situations could accelerate resistance development.

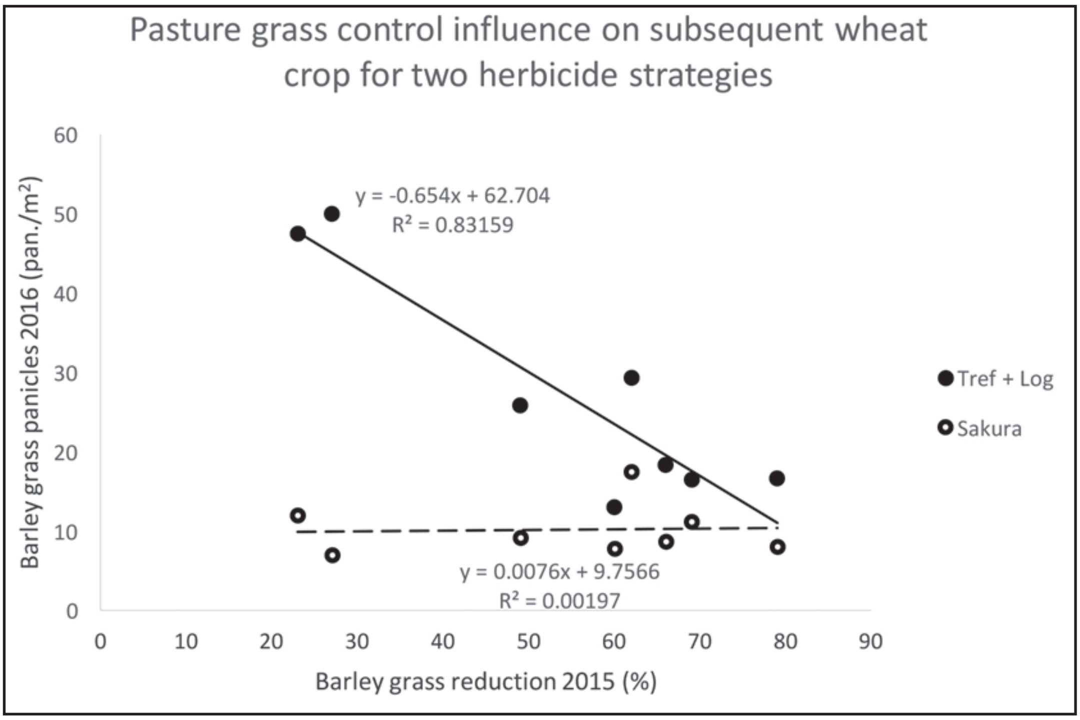


***Figure 1. Relationship between barley grass control in pasture (2015) and the amount of barley grass present in subsequent wheat crop (2016) for the two herbicide options investigated.***

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 the seed bank results shown in Table 3 and 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).

Seed bank results displayed in Table 3 and Figure 2 show that barley grass numbers in the wheat phase showed relatively small reduction or remained stable with the Treflan + Logran treatments.

*Table 3. Summary of results of percent Barley grass seed bank reduction for 2015 pasture treatments and 2016 pasture and wheat treatments, the higher the number the greater the barley grass seed set was reduced.*

| 2015 pasture treatments | Barley grass seedbank reduction % | | | |
|---|---|---|---|---|
| | 2015 | 2016 | | |
| | 1st Pasture | 2nd Pasture | Wheat (Tref + Log) | Wheat (Sakura) |
| 1. Vetch brown manure | 69 | 76 (94) | -21 (72) | -3 (76) |
| 2. Medic early spray-top | 66 | -48 (52) | -37 (56) | 21 (75) |
| 3. Medic mid spray-top | 60 | -10 (69) | -5 (70) | 20 (77) |
| 4. Medic hay cut | 62 | -517 (-180) | 18 (63) | -24 (44) |
| 5. Medic glyphosate + hay | 49 | 60 (82) | -4 (53) | 47 (76) |
| 6. Medic propyzamide | 27 | 43 (56) | 21 (39) | 55 (65) |
| 7. Medic propyzamide + spray-top | 79 | 58 (89) | -18 (68) | -5 (72) |
| 8. Medic grazed (control) | 23 | -948 (-686) | 32 (49) | 64 (73) |
| *Figures in brackets show 2 year barley grass seedbank reduction % (2015 + 2016)* | | | | |

These results highlight the ability of barley grass to reinfest after a single season with favourable conditions or a control failure. This is quite evident in the 2016 data when we look at Medic - hay cut (Treatment 4) and Medic grazed (Treatment 8) in Figure 2, where barley grass population increased in medic by 6 and 10 fold, respectively. When we compare Medic - hay (Treatment 4) with Vetch - brown manure (Treatment 1), seed banks were 640 and 333 seeds/m$^2$ after 2015. These are not dissimilar (Table 2), however in the 2016 season the Vetch brown manure treatment was successful in further driving down barley grass whereas a control failure in Medic - hay cut resulted in a 6 fold barley grass increase, which was nearly 3 fold higher than the starting barley grass seedbank.

There is great variability in the control of barley grass between seasons, demonstrating unreliability of some of these in-pasture control measures. This can be clearly seen in Table 3, where most pasture treatments were less effective in 2016 than in the 2015 season. This variation is evident with the spray-top treatments where achieving effective control as a stand-alone strategy can be very difficult. Alternatively, the use of propyzamide had limited effect in 2015 with a dry start to the season, but performed extremely well in 2016 when there was adequate soil moisture.

Vetch - brown manure proved to be a very effective strategy in driving down barley grass in both 2015 and 2016. While this tactic may not suit many growers due to lack of self-regeneration, it has proven effective in driving down barley grass and is a regular strategy used by growers in the UN cropping district of SA where group A herbicide resistant barley grass is more commonly found.

These results also demonstrate the variability of medic - hay cut in managing barley grass. However, glyphosate application (hay-freeze) prior to cutting for hay improved the effectiveness of this tactic. Management of regrowth is critical for effective results with hay cutting and this is demonstrated in the 2016 results. Herbicide application can be applied prior to cutting hay or after hay carting as long as regrowth is controlled prior to setting seed. Glyphosate prior to cutting could be more effective as barley grass can produce a mature seed head very quickly, possibly prior to hay being carted.

## What does this mean?

- At present, group A herbicide resistance is not widespread on the EP, but is expected to increase as has been the case in the Upper North.
- 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, weed infestations can rebuild quickly unless managed effectively.
- When using moderate efficacy-low cost herbicides (Treflan + Logran) for barley grass control in wheat, effective control of the weed in the previous pasture phase is essential.
- 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. In-crop herbicide options were able to prevent barley grass build-up but failed to cause a major reduction in the weed seed bank. Repeated use of Sakura in a high weed pressure situation would speed up resistance development to this valuable herbicide.

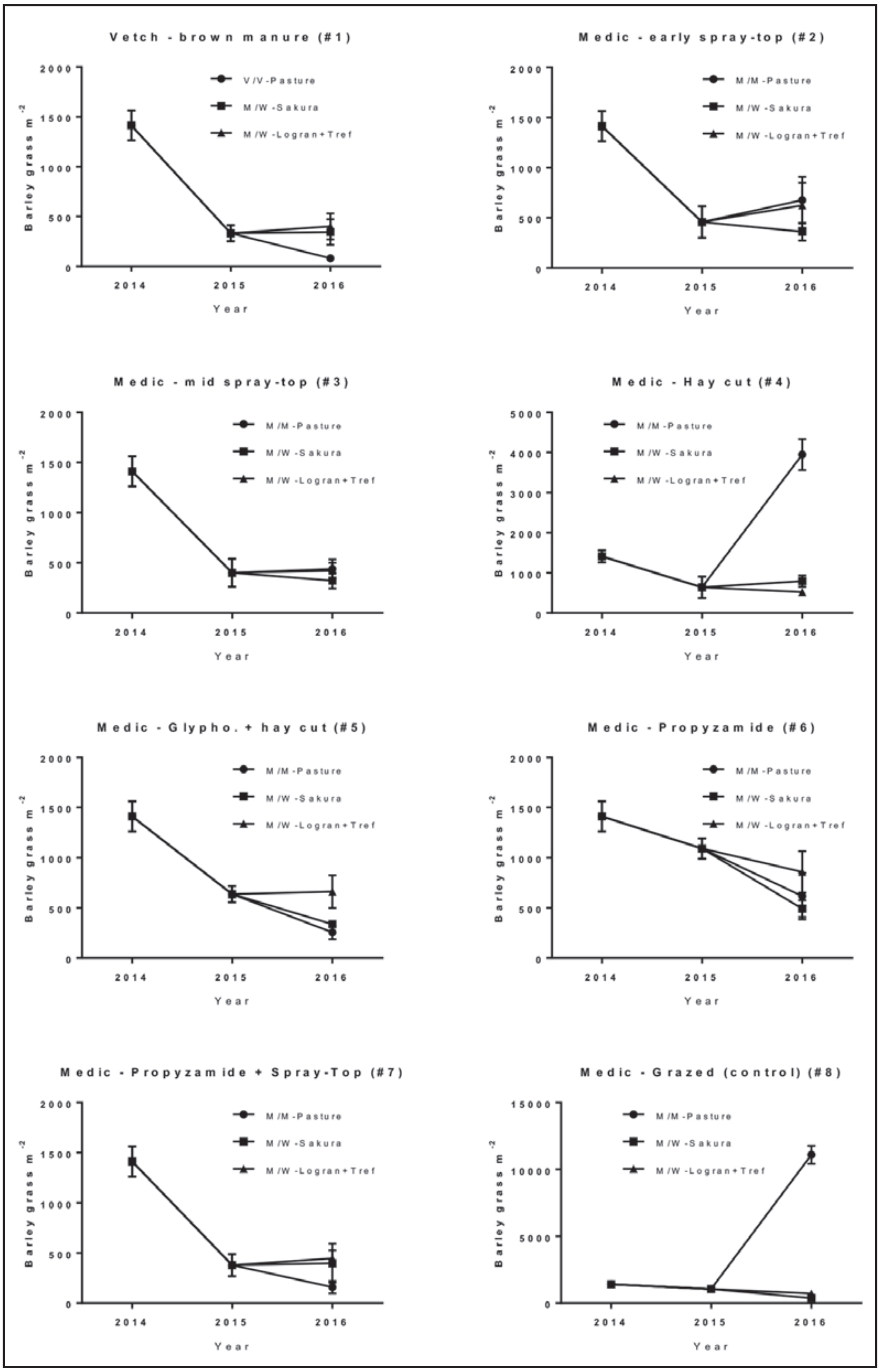


***Figure 2. Barley grass seed bank changes for each of eight initial pasture management strategies, the year represents the growing season immediately prior to seedbank assessment. In 2016 plots were split into three subplots repeated pasture treatment, wheat (+ Sakura), and wheat (+ Treflan Logran).***

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Sakura – registered trademark of Kumiai Chemical Industry Co. Ltd.

Logran – registered trademark of Syngenta Group Company.

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# Sowing early for crop competition

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RESEARCH

**Searching for answers**

**Location**
Roseworthy - University of Adelaide
**Rainfall**
Av. Annual: 394 mm
Av. GSR: 288 mm
2016 Total: 602 mm
2016 GSR: 448 mm
**Yield**
Actual: 8.8 t/ha (W)
**Paddock History**
2015: Lentils
2014: Wheat
2013: Canola
**Soil Type**
Sandy loam over medium calcareous clay - Red brown earth
**Plot Size**
10 m x 2 m x 4 reps

## Key messages

- **Sowing wheat early can improve crop competition against weeds.**
- **Crop competition can reduce grass weed seed set by up to 50%.**
- **It is important to get the pre-emergent herbicide strategy right and grow the right cultivar for the season length.**

## Why do the trial?

As grass weeds become increasingly resistant to post-emergent herbicides, more reliance is being placed on pre-emergent herbicides for weed control. One issue that arises with the use of pre-emergent herbicides is the emergence of weeds after the herbicides have dissipated. Obtaining early ground cover before the pre-emergent herbicide has dissipated will reduce the competiveness and seed production of later emerging weeds. This can be achieved by increasing the competiveness of crops, particularly cereals.

There are several ways to increase the competitive nature of cereal crops, such as increasing the seeding rate or reducing row spacings. However, we have been investigating an alternative approach to increasing the competitiveness of wheat crops. Sowing wheat later results in it growing more slowly as the soil temperature decreases going into winter. This means it takes longer for canopy closure to occur and this gives weeds a greater opportunity to use resources. Earlier sowing, when soil temperatures are warmer, results in more rapid growth and faster canopy closure. This provides an opportunity to increase the amount of competition against weeds without having to significantly change other aspects of the farming system.

Over the past three years, a series of trials have been undertaken at Hart, Roseworthy and Lake Bolac in collaboration with the Hart Fieldsite Group and Southern Farming Systems to look at the role of competition from early sowing to aid pre-emergent weed control. In the trials, wheat was sown about one month apart with several different pre-emergent herbicide options used. The results reported are 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 wheat cultivar Mace sown at 90 kg/ha, two times of sowing (6 May 6 and 1 June) and six pre-emergent herbicide treatments (Table 1).

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 100 kg/ha DAP (18:20:0:0) banded below the seed. Pre-sowing weed control was glyphosate (2.5 L/ha) + oxyfluorfen (90 mL/ha). Fungicide tebuconazole was applied on 23 September @ 290 mL/ha. Pre-emergent herbicides were applied with a 2 m pressurised hand boom and incorporated within a few hours of application. Boxer Gold was applied post-emergent 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.

## What happened?

TOS had no effect on annual ryegrass plant numbers, whereas herbicides reduced numbers significantly (P<0.001, Table 2). While all herbicides reduced plant numbers, Boxer Gold was the least effective herbicide at TOS1 and Sakura + Avadex Xtra was the most effective.

**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 followed by *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.*

Weeds

**Table 2. Annual ryegrass plant counts in August 2016, head counts in October 2016 and grain yield in Mace wheat sown on 6 May 2016 (TOS1) or 1 June 2016 (TOS2) at Roseworthy, SA.**

| Pre-emergent herbicide | Plant counts (August) ($m^2$) | | Head counts (October) ($m^2$) | | Mace wheat yield (t/ha) | |
|---|---|---|---|---|---|---|
| | TOS1 | TOS2 | TOS1 | TOS2 | TOS1 | TOS2 |
| Nil | 341 | 374 | 347 | 685 | 5.7 | 4.8 |
| Sakura | 77 | 40 | 60 | 71 | 7.3 | 8.8 |
| Sakura + Avadex XTRA | 18 | 13 | 4 | 21 | 7.5 | 8.8 |
| Sakura fb Boxer Gold* | 49 | 12 | 32 | 23 | 7.1 | 8.7 |
| Boxer Gold | 116 | 60 | 116 | 112 | 7.0 | 8.5 |
| Boxer Gold + Avadex XTRA | 94 | 89 | 67 | 167 | 7.5 | 7.8 |
| *TOS** | *ns** | | *P=0.05* | | *P<0.001* | |
| *Herbicide* | *P<0.001* | | *P<0.001* | | *P<0.001* | |
| *Interaction* | *ns* | | *P<0.001* | | *P<0.001* | |

**TOS = time of sowing; fb = followed by; ns = not significant.*

For annual ryegrass head counts in October there was an effect *($P<0.05$)* of both herbicide, TOS, and their interaction (Table 2). In contrast to annual ryegrass plant numbers, annual ryegrass seed heads in October were different between TOS (Table 2), with on average twice the number of annual ryegrass seed heads in the second TOS compared with the first TOS. Sakura + Avadex Xtra coupled with the early TOS was particularly effective at reducing annual ryegrass seed set, reducing seed heads by 99%. However, Boxer Gold tended to struggle with the high rainfall and long growing season in 2016.

There were differences between herbicide treatments, TOS and their interaction in wheat grain yield (Table 2), which was related to weed density and spring rainfall. Where herbicides had controlled annual ryegrass well, yield was higher for TOS2 compared with TOS1. However, in the absence of herbicide yield was higher for TOS1 compared to TOS2.

For both TOS herbicide treatment increased yield by 23 to 32% for TOS1 and by 63 to 83% for TOS2. Sakura and Sakura + Avadex Xtra tended to have the highest yields. Boxer Gold + Avadex Xtra produced a high yield from TOS1, but not TOS2.

In previous experiments in 2014 and 2015, average wheat yields were higher with the early TOS; by 42% in 2014 and by 45% in 2015. Both seasons were characterised by lower than average spring rainfall and higher than average spring temperatures. In 2016, there was higher than average rainfall in spring and cooler temperatures. In 2016, average wheat yield from the second TOS was higher at Roseworthy (12%) and Hart (36%), but not different at Lake Bolac. Choosing an appropriate wheat cultivar for the season length is essential in maximizing yield from early sown wheat.

## What does this mean?

Our experiments at three sites across three years have shown there is no advantage in annual ryegrass control in delaying sowing of wheat. Earlier sowing provides more competition for annual ryegrass and complements pre-emergent herbicides used. In particular, it can reduce the amount of annual ryegrass seed set, reducing populations in future years.

Where seasons are longer, it is necessary to choose a more persistent herbicide option. Sakura + Avadex Xtra is better than Boxer Gold under these conditions. Whether earlier sowing increases grain yield depends on seasonal conditions. In longer seasons, later sown wheat crops may benefit more from spring sowing. However, where spring rainfall is low, earlier sown wheat benefits. Matching wheat variety to season length and appropriate choice of pre-emergent herbicides is essential to get the best from early sowing.

## Acknowledgments

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# Managing clethodim resistant ryegrass in canola with crop competition and pre-emergent herbicides

RESEARCH

**Sam Kleemann[1], Gurjeet Gill[1], Chris Preston[1] and Sarah Noack[2]**

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**Searching for answers**

**Location**
Roseworthy and Hart, SA
**Rainfall**
Roseworthy
Av. Annual: 445 mm
Av. GSR: 330 mm
2017 Total: 466 mm
2017 GSR: 318 mm
Hart
Av. Annual: 425 mm
Av. GSR: 313 mm
2017 Total: 369 mm
2017 GSR: 192 mm
**Soil Type**
Sandy loam over medium calcareous clay - Red brown earth
**Plot Size**
1.5 m x 9 m x 4 reps

## Key messages

- **Two seasons of trials have shown that hybrid canola (Hyola559TT) was more competitive against ryegrass than open pollinated cultivars ATR-Bonito and ATR-Stingray; ATR-Stingray was the least competitive cultivar.**
- **Competition in canola is strongly correlated to crop vigour (i.e. biomass & leaf area) and is an easy and simple tool for integrated management of grass weeds.**
- **A combination of effective pre-emergent herbicides with more competitive canola cultivars combines two tactics to reduce ryegrass seed set (~40%).**
- **New pre-emergent herbicide options available for canola; Butisan is now available with Altiplano to be released soon.**

## Why do the trial?

Clethodim (Select) has been a major herbicide used for the control of annual ryegrass in canola and pulse crops. However, resistance to clethodim in ryegrass has been increasing in the southern region of Australia, which makes it more difficult for the growers to control this weed. Some growers have responded by using increased rates of clethodim, but weed control achieved can still be disappointing. As canola is more sensitive to clethodim than pulse crops, increasing clethodim dose can cause crop damage. Even though there are currently two different types of herbicide tolerant canola available in South Australia (SA) (TT, triazine tolerance; CLF, imidazolinone tolerance), each of these types has weaknesses for weed management and both have relied on clethodim to manage annual ryegrass.

Crop competition has long been known to be a useful tool in weed management. Practices such as decreasing row spacing, increasing seed rates, and growing more competitive varieties have all been demonstrated to reduce weed numbers. With an increasing number of canola varieties introduced to the market each season there is limited understanding of their ability to compete with weeds.

Field trials were undertaken in 2017 at Hart and Roseworthy in SA to demonstrate that crop competition, afforded by a hybrid canola in combination with pre-emergent herbicides, can reduce ryegrass seed set.

## How was it done?

The trials were established in a split-plot design to compare a triazine (TT) open-pollinated (OP) cultivar (ATR-Bonito) with a TT-Hybrid (Hyola559TT) under eight pre-emergent herbicide strategies (Table 1).

Seed rate was adjusted according to seed viability and size to obtain a target density of 35 plants/m$^2$, with ATR-Bonito (equivalent to 2.3 kg seed/ha) and Hyola559TT (equivalent to 2.9 kg seed/ha) sown on 3 May at Hart. Because of the adverse sowing conditions at Roseworthy, higher seed rates for ATR-Bonito (2.8 kg seed/ha) and Hyola559TT (3.4 kg seed/ha) were sown on 12 May. The replicated trials were sown using a standard knife-point press wheel system on 22.5 cm (9") row spacing. Fertiliser rates were applied as per district practice, with glyphosate applied for pre-sowing weed control. Pre-emergent herbicides were applied with a 2 m pressurised handboom within a few hours of sowing. Atrazine was applied post-emergent (treatments 5, 6, 7 and 8) to ryegrass at the 1-3 leaf growth stage.

*Table 1. Pre-emergent herbicide strategies used in canola competition trial at Hart and Roseworthy in 2017.*

| Herbicide treatment | Herbicides applied |
|---|---|
| 1 | Nil |
| 2 | Rustler (1 L/ha) pre |
| 3 | Butisan (1.5 L/ha) pre |
| 4 | Altiplano (3 kg/ha) pre |
| 5 | Atrazine (1.1 L/ha) pre + atrazine (1.1 L/ha) post |
| 6 | Rustler (1 L/ha) pre + atrazine (1.1 kg/ha) post |
| 7 | Butisan (1.5 L/ha) pre + atrazine (1.1 kg/ha) post |
| 8 | Altiplano (3 kg/ha) pre + atrazine (1.1 kg/ha) post |

*Table 2. Influence of canola variety and herbicide strategy on ryegrass density six weeks after sowing at Hart in 2017.*

| Herbicide treatment | T1 | T2 | T3 | T4 | *T5 | *T6 | *T7 | *T8 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Variety | Ryegrass density (plants/m²) | | | | | | | | |
| ATR-Bonito | 88 [a] | 12 [c] | 20 [bc] | 11 [c] | 38 [bc] | 25 [bc] | 14 [c] | 17 [bc] | 28 |
| Hyola559TT | 40 [b] | 11 [c] | 11 [c] | 17 [bc] | 15 [c] | 15 [c] | 17 [bc] | 15 [c] | 18 |
| Mean | 64 | 12 | 16 | 14 | 26 | 20 | 16 | 16 | |
| Interaction | *<0.01* | | | | | | | | |
| Herbicide treatment | *<0.001* | | | | | | | | |
| Variety | *<0.01* | | | | | | | | |

**Post atrazine not yet applied. Values in columns and rows with different letters are significantly different (P=0.05).*

Assessments included ryegrass control (reduction in plant and seed set), crop establishment, and grain yield. Data was transformed by a square root if required to stabilise variances. Data from the competition trials was analysed by 2-way ANOVA with cultivar and herbicide treatment as factors. Where the result of the ANOVA was significant, means were separated by Fisher's protected LSD test (P<0.05).

## What happened?

There was no effect of herbicide treatment on canola establishment at Roseworthy (~50 plants/m²). However higher establishment was observed for ATR-Bonito (28 plants/m²) compared to Hyola559TT (24 plants/m²) at Hart, respectively (data not presented). Higher crop establishment at Roseworthy relative to Hart resulted from the higher seed rate used at Roseworthy to compensate for the adverse sowing conditions.

At Hart there were differences between herbicide treatments, variety and their interaction on ryegrass control (Table 2). Only herbicide treatment was significant at Roseworthy (Table 3). Despite the low ryegrass infestation at Hart (<90 plants/m²), nearly 2-fold more ryegrass was present in plots sown to ATR-Bonito compared to Hyola559TT, whereas equal densities (83 plants/m²) were observed between varieties at Roseworthy. At both sites herbicides propyzamide, Butisan and Altiplano provided similar effective control (>74%) irrespective of variety. In comparison weed control in ATR-Bonito with atrazine was <50%. Atrazine requires adequate soil moisture for activation, and rainfall deficits in May and June at both field sites may have compromised the herbicide's activity.

At Roseworthy herbicide treatments propyzamide and propyzamide + POST atrazine were the most effective options providing >82% control relative to the nil 12 weeks after sowing (405 plants/m²; Table 4). Propyzamide is known for its moderate persistence and the benefit of its extended residual control was obvious during this season on the larger ryegrass population at Roseworthy.

At both Hart and Roseworthy herbicide treatment, but not variety, impacted the number of ryegrass spikes present at the end of the season (Table 5 and 6). However, herbicide responses were somewhat different between sites, with atrazine + POST atrazine providing the greatest reduction in seed production at Hart (95%), whereas propyzamide + POST atrazine (82% reduction) and Altiplano + POST atrazine (83% reduction) were the most effective treatments at Roseworthy. Differences in weed pressure were obvious between sites, and the more robust herbicide treatments (i.e. propyzamide or Altiplano + POST atrazine) prevailed at Roseworthy where ryegrass was present in large numbers. In contrast atrazine + POST atrazine was only effective on the smaller weed population at Hart, where rainfall conditions improved later in the season.

*Table 3. Influence of canola variety and herbicide strategy on ryegrass density six weeks after sowing at Roseworthy in 2017.*

| Herbicide treatment | T1 | T2 | T3 | T4 | *T5 | *T6 | *T7 | *T8 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Variety | Ryegrass density (plants/m²) | | | | | | | | |
| ATR-Bonito | 210 | 40 | 51 | 38 | 128 | 43 | 71 | 82 | 83 |
| Hyola559TT | 227 | 58 | 63 | 57 | 93 | 44 | 72 | 45 | 83 |
| Mean | 219 a | 49 c | 57 c | 47 c | 111 b | 44 c | 72 c | 64 c | |
| Interaction | *ns* | | | | | | | | |
| Herbicide treatment | *<0.001* | | | | | | | | |
| Variety | *ns* | | | | | | | | |

**Post atrazine not yet applied. Values in columns and rows with different letters are significantly different (P=0.05).*

*Table 4. Influence of canola variety and herbicide strategy on ryegrass density 12 weeks after sowing at Roseworthy in 2017.*

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Variety | Ryegrass density (plants/m²) | | | | | | | | |
| ATR-Bonito | 420 | 70 | 166 | 96 | 96 | 53 | 121 | 45 | 134 |
| Hyola559TT | 390 | 72 | 103 | 91 | 191 | 56 | 89 | 57 | 131 |
| Mean | 405 a | 71 d | 135 bc | 94 cd | 144 b | 54 d | 105 bc | 51 d | |
| Interaction | *ns* | | | | | | | | |
| Herbicide treatment | *<0.001* | | | | | | | | |
| Variety | *ns* | | | | | | | | |

*Values in columns and rows with different letters are significantly different (P=0.05).*

*Table 5. Influence of canola variety and herbicide strategy on ryegrass spike density at Hart in 2017.*

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Variety | Ryegrass seed heads (spikes/m²) | | | | | | | | |
| ATR-Bonito | 92 | 14 | 13 | 17 | 5 | 15 | 12 | 4 | 22 |
| Hyola559TT | 78 | 11 | 8 | 17 | 3 | 15 | 10 | 8 | 19 |
| Mean | 85 a | 13 bc | 11 bc | 17 b | 4 d | 15 b | 11 bc | 6 cd | |
| Interaction | *ns* | | | | | | | | |
| Herbicide treatment | *<0.001* | | | | | | | | |
| Variety | *ns* | | | | | | | | |

*Values in columns and rows with different letters are significantly different (P=0.05).*

*Table 6. Influence of canola variety and herbicide strategy on ryegrass spike density at Roseworthy in 2017.*

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Variety | Ryegrass seed heads (plants/m²) | | | | | | | | |
| ATR-Bonito | 591 | 194 | 238 | 278 | 171 | 90 | 184 | 77 | 228 |
| Hyola559TT | 442 | 178 | 162 | 195 | 245 | 97 | 146 | 100 | 196 |
| Mean | 516 a | 186 b | 200 b | 236 b | 208 b | 93 c | 165 bc | 88 c | |
| Interaction | *ns* | | | | | | | | |
| Herbicide treatment | *<0.001* | | | | | | | | |
| Variety | *ns* | | | | | | | | |

*Values in columns and rows with different letters are significantly different (P=0.05).*

*Table 7. Influence of canola variety and herbicide strategy on canola yield at Hart in 2017.*

| Herbicide treatment | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Variety | Canola yield (t/ha) | | | | | | | | |
| ATR-Bonito | 1.55 | 1.65 | 1.55 | 1.63 | 1.70 | 1.47 | 1.82 | 1.70 | 1.63 a |
| Hyola559TT | 1.41 | 1.42 | 1.36 | 1.36 | 1.51 | 1.35 | 1.50 | 1.38 | 1.41 b |
| Mean | 1.48 | 1.53 | 1.43 | 1.49 | 1.60 | 1.41 | 1.66 | 1.54 | |
| Interaction | *ns* | | | | | | | | |
| Herbicide treatment | *ns* | | | | | | | | |
| Variety | *<0.001* | | | | | | | | |

There was no effect of variety on ryegrass seed production at either Hart or Roseworthy. This is in stark contrast to previous studies where seed set was often reduced by as much as 40-50% with the more competitive hybrid versus OP variety. For example at Roseworthy in 2016 (Kleemann *et al*. 2016), Hyola559TT reduced seed set by 50% compared to ATR Stingray (OP). In these studies ATR-Bonito, whilst an OP variety, appeared to show more comparable early vigour and growth to hybrid Hyola559TT. This was evident from the similar NDVI values (measure of green vegetative growth) recorded from crop emergence through to flowering for both varieties (Figure 1).

Previous research (Lemerle *et al*. 2014) reported that hybrids were generally more competitive than OP varieties, but concluded that there is considerable variation in the competitiveness between varieties in their ability to suppress weed growth.

At Hart there was an effect of variety, but not herbicide or its interaction with variety on canola yield (Table 7). This is not entirely surprising given the weed interference at this site would likely have been negligible given the small population present, and that ryegrass on a per plant basis is far less competitive than many of the other grass weeds (i.e. brome and wild oats). Consequently, the small but significant yield difference between varieties (1.63 t/ha vs. 1.41 t/ha) is more likely a reflection of the shorter growing season at Hart, which would have favoured ATR-Bonito which is an earlier flowering type than Hyola559TT. In comparison the impact of weed interference on grain yield was significant at Roseworthy, and there was a significant effect of herbicide (P<0.001) on canola yield (Table 8). Not surprisingly yields were higher for all herbicide treatments relative to nil treatments because of the larger ryegrass population. In response to improved weed control, grain yields were highest for both varieties treated with propyzamide + POST atrazine (1.47 t/ha) and Altiplano + POST atrazine (1.46 t/ha).

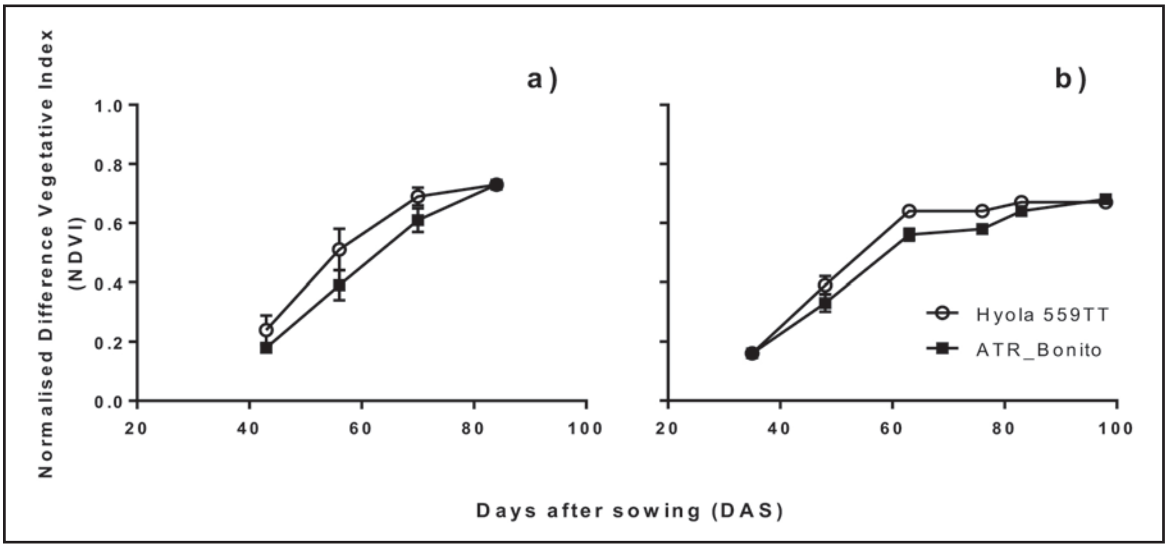


***Figure 1. NDVI (Normalised difference vegetative index) of canola varieties, ATR-Bonito and Hyola559TT measured during pre-flowering crop development at Hart (a) and Roseworthy (b). To avoid confounding effect of ryegrass on NDVI values only data from herbicide treatment 2, where ryegrass control was greatest, are presented.***

***Table 8. Influence of canola variety and herbicide strategy on canola yield at Roseworthy in 2017.***

| **Herbicide treatment** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **Mean** |
|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Canola yield (t/ha)** | | | | | | | | |
| ATR-Bonito | 0.35 | 1.18 | 1.01 | 1.07 | 1.31 | 1.47 | 1.17 | 1.51 | 1.13 |
| Hyola559TT | 0.63 | 1.17 | 1.13 | 1.04 | 1.27 | 1.47 | 1.34 | 1.41 | 1.18 |
| Mean | 0.49 [a] | 1.17 [bcd] | 1.07 [bc] | 1.05 [b] | 1.29 [d] | 1.47 [e] | 1.25 [cd] | 1.46 [e] | |
| Interaction | *ns* | | | | | | | | |
| Herbicide treatment | *<0.001* | | | | | | | | |
| Variety | *ns* | | | | | | | | |

*Values in columns and rows with different letters are significantly different (P=0.05).*

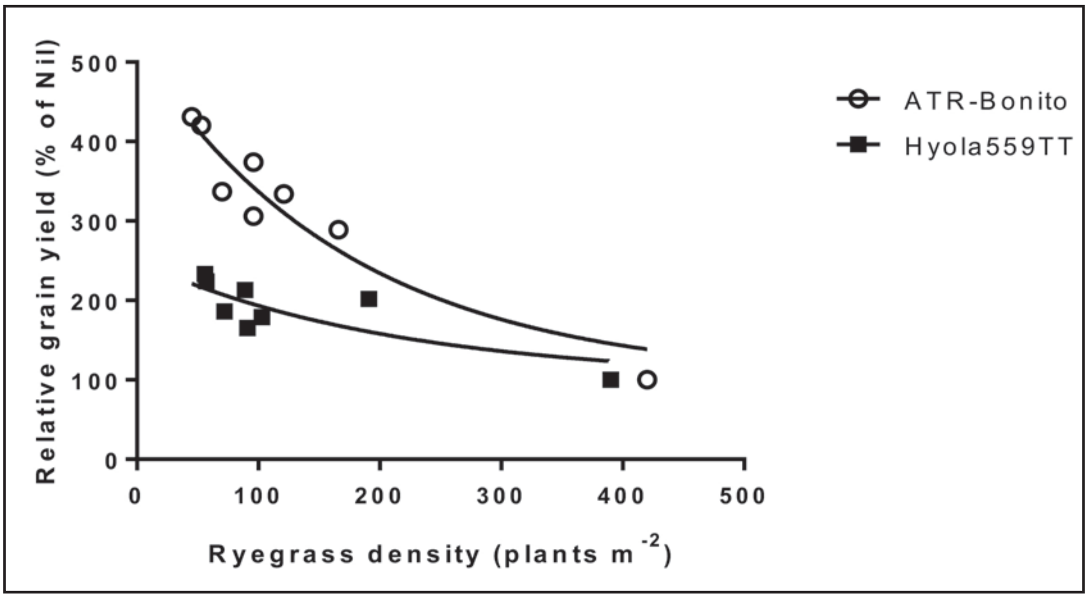


***Figure 2. Relationship between mean ryegrass density after application of herbicide treatments and relative grain yield of canola varieties ATR-Bonito and Hyola559TT at Roseworthy. Relative yield = (Treatment/Nil) × 100. Each line represents a one-phase decay exponential model: y = 518*exp(-0.0057*x) + 100, ($r^2$=0.91) for ATR-Bonito, and y = 250*exp(-0.0047*x) + 100, ($r^2$=0.64) for Hyola559TT. Each data point represents the mean of four replicates.***

Furthermore when the data from Roseworthy was shown as a percentage (relative yield) of the nil an exponential decay relationship between ryegrass density and grain yield was revealed (Figure 2). The yield of ATR-Bonito declined more sharply at low to moderate densities of ryegrass compared to Hyola559TT, and appeared to reach maximum yield loss at densities above 300 plants/$m^2$, where interspecific competition of ryegrass would have been high. These results appear consistent with previous studies which also showed that hybrid varieties could better maintain grain yield in the presence of weeds, and appear therefore more tolerant of weed competition than the less competitive OP conventional varieties.

## What does this mean?

At Hart the low ryegrass population resulted in smaller differences between canola varieties and the combined impact of herbicides. Whereas the same trial at Roseworthy, with much larger ryegrass infestation, differences in competitive ability between varieties and their interaction with herbicides were more apparent.

In both studies ATR-Bonito was shown to be far more competitive and comparable to the hybrid variety Hyola559TT. Previous studies using the OP variety ATR Stingray showed it is a weaker OP competitor compared to Hyola559TT. In support of previous research the hybrid appeared to better maintain grain yield in the presence of weeds, and was therefore more tolerant of weed competition than ATR-Bonito.

In light of the late break to the 2017 season, Rustler (ai propyzamide) along with new pre-emergent herbicides Butisan and Altiplano were extremely effective against ryegrass in canola.

## Acknowledgements

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Butisan is a registered trademark of BASF Aust. Pty Ltd.
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Select is a registered trademark of Arysta Life Sciences and Sumito Chemical Co. Japan.
Rustler is a registered trademark of Cheminova Aust. Pty Ltd.
Atrazine is a registered trademark of Cheminova Aust. Pty Ltd.

## References

Kleemann S, Gill G & Preston C (2016) Managing clethodim resistant ryegrass in canola with crop competition and pre-emergent herbicides. Hart trials results book 2016 p 74 - 79.

Lemerle D, Luckett DJ, Lockley P, Koetz E & Wu H (2014) Competitive ability of Australian canola (*Brassica napus*) genotypes for weed management. Crop & Past. Sci. 65: 1300-1310.

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# On-row sowing for brome grass competition on non-wetting sand

**Therese McBeath, Rick Llewellyn, Vadakattu Gupta, Bill Davoren, Willie Shoobridge and Stasia Kroker**
CSIRO Agriculture and Food, Waite.

RESEARCH

**Searching for answers**

**Location**
Karoonda - Loller Partners
**Rainfall**
Av. Annual: 337 mm
Av. GSR: 237 mm
2017 Total: 399 mm
2017 GSR: 236 mm
**Paddock History**
2016: Wheat
2015: Wheat
2014: Wheat
**Soil Type**
Dune sand
**Plot Size**
2 m x 20 m x 5 reps

## Key messages

- **For the fourth year running, on-row sowing proved it has potential as a brome grass management tool on non-wetting sands, reducing brome grass seed set by 55%.**
- **The use of trifluralin with metribuzin reduced the brome density in July but did not reduce seed set.**
- **On-row sowing resulted in more soil water and nitrogen supply potential near the crop, improved crop establishment and higher crop biomass.**
- **On-row sowing did increase root disease incidence, but there were low levels of disease for both on- and inter-row sowing in 2017.**

## Why do the trial?

Brome grass is the most costly weed to grain production in the Mallee region despite herbicide resistance being relatively low. For growers looking to sow earlier and reduce reliance on Group B herbicides, pre-emergence herbicides can be an important part of brome grass management strategies, but trifluralin often has low efficacy. Previous trials at the Mallee Sustainable Farming (MSF) Karoonda site looking at a range of pre-emergence herbicides have shown the potential for greater than 75% brome grass control from some pre-emergence options, but also the potential for variability under different early-season conditions. Improving crop competition can greatly improve herbicide efficacy. Other trials on non-wetting sandy soil at the Karoonda site have shown the potential for better crop establishment (e.g. 60% higher establishment in 2016) and large reductions in brome grass seed set suppression through seeding the crop on or near last year's crop row (McBeath *et al*. 2016).

## How was it done?

Following demonstrated benefits of increased water and nutrient harvesting along with reduced brome grass populations for on-row sowing on water repellent sands, on-row or inter-row seeding was tested with and without a pre-emergent herbicide package of trifluralin + metribuzin (Table 1). All plots were sown on 8 May into cereal stubble with 28 cm row spacing and received DAP (18:20:0:0) @ 50 kg/ha and urea @ 24 kg/ha on a water repellent dune soil. In addition 33 kg/ha potassium sulfate was applied pre-sowing and in-crop foliar application of Cu, Zn and Mn occurred at early tillering.

Measurements included disease risk, disease incidence, starting nitrogen (N) and water, microbial activity, N supply potential, crop emergence, biomass, weed density and biomass and crop yield.

## What happened?

***Pre-sowing soil water and crop establishment***

Measurements of sowing soil profile water indicated that the on-row position had an extra 18 mm soil water to 60 cm depth, with nearly twice as much water in the top 20 cm for on-row sowing (15 vs 8 mm).

***Table 1. Sowing and pre-emergent herbicide treatments.***

| Treatments | Sowing | Pre-emergent herbicide |
|---|---|---|
| 1 | On-row | Nil |
| 2 | Inter-row | Nil |
| 3 | On -row | trifluralin @ 1.5 L/ha + metribuzin @ 100 g/ha |
| 4 | Inter-row | trifluralin @ 1.5 L/ha + metribuzin @ 100 g/ha |

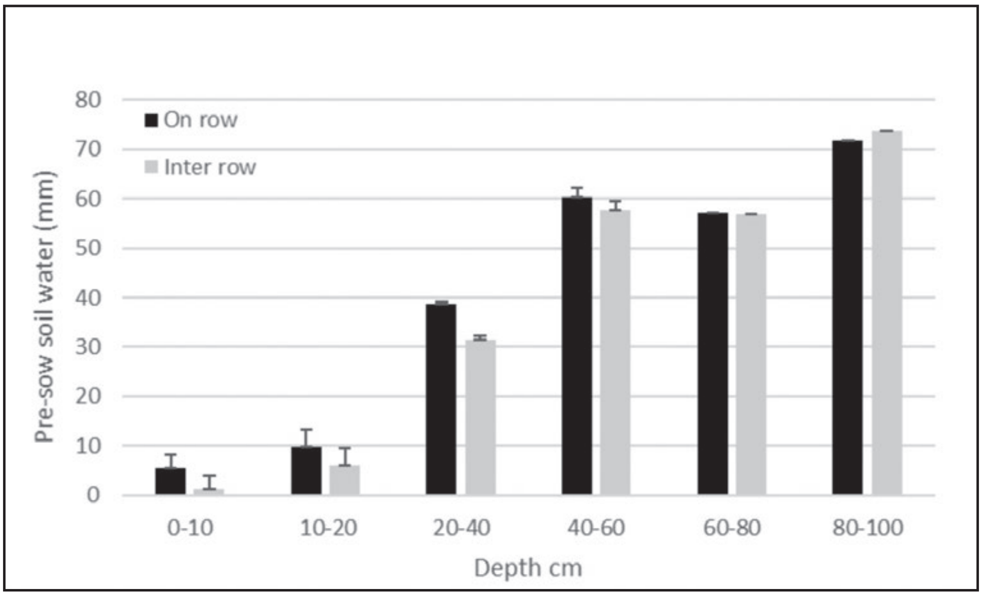


***Figure 1. Pre-sowing soil water (mm). At each sampling depth the on-row and inter-row sowing treatment was compared using a paired t-test. The 95% confidence interval for means that were significantly different are presented as error bars on the figure.***

***Table 2. Crop establishment in response to sowing row and herbicide treatment.***

| Treatment | Establishment 30 May (plants/m$^2$) | Establishment 21 June (plants/m$^2$) |
|---|---|---|
| On-row | 66 | 89 a |
| Inter-row | 44 | 68 b |
| *LSD (P=0.05)* | *20* | *11* |
| Minus pre-em | 55 | 91 a |
| Plus pre-em | 56 | 66 b |
| *LSD (P=0.05)* | *ns* | *11* |

**Significantly different treatments are annotated with a different letter. The interaction between sowing position and herbicide is not presented as it was not significant for any of the measurements.*

The benefit of extra topsoil water with on-row sowing appears to have increased crop establishment with 30% more plants for on-row sown plots (Table 2). Pre-emergent herbicide was found to reduce crop establishment (Table 2).

***Brome grass population, crop biomass and yield***

Both on-row sowing and pre-emergent herbicide treatments reduced the brome grass density in July but there was no interaction between the two treatments (Table 3). On-row sowing led to a 55% reduction in brome grass seed set compared to inter-row sowing. The pre-emergence herbicide did not significantly reduce seed set despite causing a reduction in early brome density. This can be partly explained by on-row sowing resulting in 70% more crop biomass at GS31 and 29% more at GS65 delivering an ongoing competition benefit. However, the greater biomass did not translate into a significant difference (P=0.09) in grain yield (Table 3).

***Nitrogen***

Pre-sowing mineral N levels in the surface 10 cm depth were similar at both the row positions, and similarly soil N to 1 m depth was the same for both row positions averaging 65 kg N/ha/m. However, higher levels of microbial biomass and over 30% more N supply potential on-row confirmed previous observations of the potential for higher soil fertility at the on-row position (Table 4). The higher microbial biomass on-row in the presence of wide C:N cereal crop residues has the potential to cause immobilisation (tie-up) of mineral N (average 17 kg/ha) including that from fertiliser early in the growing season. Although seedlings sown in the inter-row position avoid microbial immobilisation of nutrients, they may require more N from fertiliser to compensate for the lower N supply potential including N released from the microbial biomass during the growing season.

***Disease***

Soilborne pathogen inoculum levels for the three major pathogens (e.g. *Rhizoctonia solani* AG8, Ggt and *Fusarium pseudograminearum*) were generally higher on-row compared to inter-row which reflected in disease incidence, but the incidence was low for both treatments on the relative scale (0.6-1.4 on a scale of 0-5) (Table 5).

*Table 3. Crop biomass at first node (GS31), and anthesis (GS65), grain yield and grain protein in response to sowing treatments.*

| Sowing | July brome (plants/m²) | GS31 crop biomass (t/ha) | GS65 crop biomass (t/ha) | Maturity brome (seeds/m²) | Grain yield (t/ha) | Grain protein (%) |
|---|---|---|---|---|---|---|
| On-row | 15 [b] | 1.09 [a] | 5.35 [a] | 1960 [b] | 1.99 | 8.74 |
| Inter-row | 31 [a] | 0.64 [b] | 4.14 [b] | 4339 [a] | 1.66 | 8.61 |
| *LSD (P=0.05)* | *12* | *0.15* | *0.83* | *1660* | *ns* | *ns* |
| Minus pre-em | 31 [a] | 0.92 | 4.68 | 3240 | 1.74 | 8.44 [b] |
| Plus pre-em | 15 [b] | 0.81 | 4.81 | 3059 | 1.91 | 8.91 [a] |
| *LSD (P=0.05)* | *12* | *ns* | *ns* | *ns* | *ns* | *0.25* |

**Within a treatment factor significantly different treatments are annotated with a different letter. The interaction between sowing position and herbicide is not presented as it was not significant for any of the measurements.*

*Table 4. Microbial biomass carbon (C), mineral N and N supply potential on-row and inter-row at the time of sowing during May 2017.*

| Sowing | Microbial biomass | N supply potential (kg N / ha) | | Mineral N |
|---|---|---|---|---|
| | (kg C/ha) | <decile 5 | >decile 5 | (kg N/ha) |
| On-row | 231 | 30 | 46 | 21 |
| Inter-row | 183 | 22 | 35 | 18 |
| *LSD (P=0.05)* | *29* | *3* | *5* | *ns* |

*Table 5. Soilborne disease risk ratings for Take all (Ggt), Rhizoctonia (RsAG8) and Fusarium crown rot in soil measured in the on-row and inter-row sowing position at the time of sowing in 2017 and a combined disease incidence rating measured at first node (GS31).*

| Sowing Treatment | Disease risk from pathogen inoculum | | | Disease incidence Root rating (0-5 scale) |
|---|---|---|---|---|
| | Rhizoctonia | Take all (Ggt) | Fusarium crown rot | |
| On-row | High | Medium | High | 1.4 ± 0.2 |
| Inter-row | Low | Low | Low | 0.6 ± 0.1 |

## What does this mean?

Four years of on-row sowing on non-wetting sands showed consistent effects of increased sowing surface soil moisture, crop establishment, crop biomass and crop-brome competition reducing brome grass seed set. Our next steps are to consider the profit-risk outcomes and practicalities of implementing on-row sowing at the paddock scale in Mallee environments. The extent to which these effects will express on other types of sand and modifications that might assist with capturing a consistent yield effect (at $P<0.05$) remain to be explored.

## Acknowledgements

We thank Loller Partners (Karoonda) for hosting the field site and additional technical input from Damian Mowat, Jeff Braun and Michael Moodie. This research is funded by GRDC and CSIRO Agriculture and Food (project MSF00003).

## References

McBeath *et al.* (2016) Sowing strategies to improve the productivity of crops in low rainfall sandy soils. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Sowing-strategies-to-improve-the-productivity-of-crops-in-low-rainfall-sandy-soils

# Weed management strategies to address herbicide resistance in the Victorian Mallee

RESEARCH

Weeds

**Roy Latta**
Research and Development Specialist, Moodie Agronomy

**Try this yourself now**

**Location**
Yaapeet, VIC Mallee - Troy Fisher
**Rainfall**
Av. Annual: 350 mm
Av. GSR: 230 mm
2017 Total: 369 mm
2017 GSR: 203 mm
**Yield**
Treatment 5
Potential 2017: 4.0 t/ha (W)
Actual: 2017: 2.8 t/ha
**Paddock History**
2014 - 2016: Various
**Soil Type**
Neutral to alkaline sandy clay loam
**Plot Size**
10 m x 3 m x 4 reps

## Key message

- **Annual ryegrass populations with identified low to medium herbicide resistance levels to herbicide groups A, B and M were controlled with alternative crops and/or best practice chemical and management strategies.**

## Why do the trial?

It is generally recognised that there are progressive increases in weed herbicide resistance associated with current farming systems. With this in mind a four-year research project was established at Yaapeet in 2014 to demonstrate and validate options for depleting weed seed banks over successive seasons.

## How was it done?

The four-year study measured annual ryegrass populations through five rotations. Rotation 1 and 2 had a single phase of four years of wheat and rotations 3, 4 and 5 had each phase of each rotation in every year, two wheat, one canola and one field pea treatment. The annual ryegrass densities presented are from the phase of each rotation that finished in wheat in 2017. Grain yields presented are means of each component of each rotation over the four years.

District practice weed control chemistry for each crop was applied. Tri-allate was also applied to wheat treatments in Rotations 2, 3 and 4 (Tables 1 and 2). Hay cutting and brown manure were used as annual grass management strategies. Herbicide resistance levels in the annual ryegrass population measured at the commencement of the study identified a medium resistance level to Group A and low resistance to Groups B and M herbicides.

In all four years Corack and Grenade CL wheat varieties were sown at 50 kg/ha, StingrayTT and 43C80CL canola varieties at 2 kg/ha and Wharton field peas at 100 kg/ha. DAP (18:20:0:0) at 52 kg/ha was applied at seeding coupled with 50 kg/ha of urea on canola. A further 50 kg/ha of urea was applied mid-season to canola and the cereals that did not follow a pulse in the rotation. Sowing was carried out post weed emergence, late May-early June, in all four years following a double knockdown. Pre-emergence herbicides were applied immediately prior to sowing and post-emergent herbicides were applied at 8 and 14 weeks (application 2) post seeding. All crops received best practice broad-leaved weed control along with pesticides and fungicides as required.

Gross margin estimates were based on a single year's representative data derived from the 2015 PIRSA Farm Gross Margin Guide.

## What happened?

Growing season rainfall (April–October) in the four years was approximately 150, 100, 250 and 200 mm in 2014, 2015, 2016 and 2017 respectively.

The use of alternative crops with selective grass control (Rotations 3, 4 and 5) and the pre-emergent Group J (Rotation 2) and post-emergent Group B (Rotations 2 and 3) all reduced annual rye grass plant numbers compared to Rotation 1 (Table 3). The continued increase in Rotation 1 annual ryegrass densities resulted in hay becoming the only viable option in 2017.

Rotation 2, with three of the four years in wheat, produced more grain than Rotation 1, also with three years wheat. Total grain production from Rotations 3, 4 and 5 with two years of wheat and one year of field pea and canola was less than Rotation 2 but similar to Rotation 1. Field pea and canola yields were similar irrespective of variety or rotation. Hay production reflected the season, Rotation 1 2017 (200 mm), Rotation 2 2015 (100 mm).

Gross margin calculations indicated that Rotation 1 returned $280/annum, 2 $380, 3 $225, 4 $246 and 5 $300/annum.

*Table 1. The five crop rotations and annual grass control pre- and post-emergent herbicide groups and/or management strategies applied over the four year study.*

| No | 2014 | Herbicide groups applied | | 2015 | Herbicide groups applied | |
|---|---|---|---|---|---|---|
| | | Pre-emerg | Post-emerg | | Pre-emerg | Post-emerg |
| 1 | Wheat | D M | | Wheat | D M | |
| 2 | Wheat CL | D J M | B | Wheat | D J M | Hay |
| 3 | Wheat | D J M | | Field Pea | D M | M BM** |
| 4 | Wheat | D J M | | Field Pea | D M | A*A*** |
| 5 | Field Pea | D M | A* | Wheat | D M | |
| **No** | **2016** | | | **2017** | | |
| 1 | Wheat | D M | | Wheat | D M | Hay |
| 2 | Wheat | D J M | | Wheat | D J M | |
| 3 | Canola TT | D J M | A* | Wheat CL | D J M | B |
| 4 | Canola Imi | D J M | A*B | Wheat | D J M | |
| 5 | Canola Imi | D J M | A*B | Wheat | D M | |

**Includes both a fop and dim Group A herbicide, ** BM Brown manure treatment, *** Second application a Group A fop only*

*Table 2. Herbicide trade names and rates of each chemical group applied.*

| Group | Chemical (a.i.) | Trade name | Application rate |
|---|---|---|---|
| D | Trifluralin 480 g/L | Trifluralin | 1.5 L/ha |
| J | Tri-allate 500 g/L | Avadex | 2 L/ha |
| M | Glyphosate 450 g/L | Glyphosate | 1.5 L/ha |
| A | Clethodim 360 g/L | Select | 500 ml/ha |
| A | Haloxyfop 520 g/L | Verdict | 35 ml/ha |
| B | Imazamox 33 g/L & Imazapyr 15 g/L | Intervix | 600 ml/ha |

*Table 3. Four year crop rotations and mature annual rye grass densities (plants/m²).*

| No | Rotation and annual ryegrass (plants/m²) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | | 2015 | | 2016 | | 2017 | |
| 1 | Wheat | 29 | Wheat | 9 | Wheat | 22 | Wheat Hay | 128 |
| 2 | Wheat CL | <1 | Wheat Hay | 0 | Wheat | 2 | Wheat | 1 |
| 3 | Wheat | 2 | Field Pea BM | 0 | Canola TT | 0 | Wheat CL | 0 |
| 4 | Wheat | 2 | Field Pea | 0 | Canola Imi | 0 | Wheat | 0 |
| 5 | Field Pea | <1 | Wheat | 8 | Canola Imi | 0 | Wheat | 0.25 |

*Table 4. Total 2014 to 2017 grain and hay yields (t/ha) from the five crop treatments.*

| No | Rotation | Wheat | Field pea | Canola | Hay |
|---|---|---|---|---|---|
| 1 | Wheat-Wheat-Wheat-Wheat Hay | 5.7 | | | 2.9 |
| 2 | Wheat CL-Wheat Hay-Wheat-Wheat | 7.7 | | | 2.0 |
| 3 | Wheat-Field Pea BM-CanolaTT-WheatCL | 4.0 | 0 BM* | 0.8 | |
| 4 | Wheat-Field Pea-Canola Imi-Wheat | 4.2 | 0.8 | 0.8 | |
| 5 | Field Pea-Wheat-Canola Imi-Wheat | 4.5 | 0.8 | 0.8 | |

**BM Brown manure treatment*

## What does this mean?

At the commencement of the study the Plant Science report showed the annual ryegrass population had a 50-60% survival rate to Achieve (dim) and Verdict (fop). However, there was no measured resistance to a high rate of Select (dim). The results confirmed this outcome with no plant survival following Select applied at 500 ml/ha in 2015 and 2016.

The reported low resistance to Groups B and M, suggesting significant stunting but some recovery, was not clearly evident. The laboratory measured 75% survival rate to Group B was significantly lower in the study, Rotation 1 2014, at 50% at most. There was no evidence of 20% Group M resistance with total annual ryegrass control following brown manuring.

There is no evidence that there remains a population of Groups A, B or M herbicide resistance for annual ryegrass following Rotations 3 and 4. Concurrent break crops incorporating Groups A, B and M chemicals have resulted in subsequent annual ryegrass free wheat crops. The late May sowings following a double knock down and the herbicides that were applied at an early timely weed growth stage may have assisted.

Yields (and comparative gross margins) were influenced by the 2015 100 mm growing season rainfall and sowing dates. Field pea and canola completely failed in that season, plus the later than optimum sowing dates reduced the broad-leaved crops' potential yield in all years. Rotation 2 total grain production did not include 2015 when it was cut for hay, whereas Rotation 1 was cut for hay in 2017, a higher grain production season. For these reasons, yields (and the gross margins) give only an indication of the comparative performance of each rotation. However, they do suggest improved reliability from the wheat phase in the system. Rotation 5 with higher grain yields and lower input costs outperformed Rotations 3 and 4.

## Acknowledgements

This research project was funded by the Australian Government through the Mallee Catchment Management Authority.

Avadex - registered trademark of Nufarm.
Select - registered trademark of Arysta Life Sciences and Sumitomo Chemical Co. Japan.
Verdict - registered trademark of the Dow Chemical Company or an affiliated company of DOW.
Intervix - registered trademark of BASF.

# Onion weed wick wiper demonstration

**Craig James**
Advanced Agricultural Services

DEMO

**Try this yourself now**

**Location**
Minnipa - Warwick Hutchings
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 390 mm
2016 GSR: 268 mm
**Paddock History**
2016: Pasture
2015: Wheat
2014: Pasture
**Soil Type**
Red brown calcareous loam
**Plot Size**
15 m x 1.8 m 1 rep

## Key messages

- **Wick wiping has the potential to be used as a tool to reduce Onion weed biomass and delay its seed set until later than the medic pod set in pastures.**
- **The combination of wick wiping in pastures and successive management in cropping rotations has the potential to significantly reduce or eliminate onion weed in dryland farming systems.**
- **Two-way wick wipe applications had the greatest and longest effect on onion weed biomass.**
- **Mechanical control prior to the following season's plantings may still be required to prevent larger plants from regrowing.**

## Why undertake this demonstration?

This paddock demonstration was undertaken to assess level if wick wiping had a place in the control of Onion weed (*Asphodelus fistulosus*) and if so, to identify areas that warrant further research. The demonstration was done to address a number of questions of growers on upper Eyre Peninsula:

- To observe the potential use of wick wiping for suppressing and/or controlling Onion weed in medic pastures to increase the quality of feed on offer.
- To reduce the need for tillage of fragile soil types often infested with Onion weed.

Onion weed prefers growing on calcareous soils, which are widespread on upper Eyre Peninsula. Onion weed lowers the feed on offer in medic pastures by up to 75% (James, pers. comm.). Current control methods involve the use of either non-selective Group L bipyridyls or Group B sulfonylureas (SUs) herbicides and or mechanical disturbance. On these soils, SUs pose residual problems and mechanical disturbance can leave soils exposed to wind erosion.

Previous trials assessing the efficacy of an array herbicides in controlling Onion weed in medic pastures found that both Group L and K herbicides to be relatively effective, but equally damaging to accompanying medics (Dzoma and Bates, 2016, *Onion weed control in medic pastures - a herbicide evaluation*, Eyre Peninsula Farming Systems Summary 2015 p175). Wick wipers offer the opportunity to apply SUs in a selective manner to Onion weed and other taller weed species in pasture, without contacting and damaging the shorter medic pastures.

## How was it done?

Herbicide treatments were applied with a Smucker wick wiper, 1.8m wide, mounted on a quad bike and fed by a Delavan 12v 15 L/min pump on 8 September 2016, to a regenerated medic pasture paddock area with mostly even mature onion weed and infestation (Table 1).

## What happened?

The site was initially monitored for visual damage on 15 October 2016. The number of Onion weed plants remaining and how many of these were setting seed was assessed on 16 March 2017, these results were compared to the control treatment (Figure 1).

All herbicides reduced the number of plants and also the number of plants setting seed at the time of monitoring in March 2017, compared to the control.

## What does this mean?

This demonstration was for investigative reasons only and any observations noted here are therefore subjective.

From the above observations it can be suggested that all the herbicide regimes applied selectively via a wick wiper can significantly lower the Onion weed numbers in medic pastures and lower the biomass of those that remain.

*Table 1. Onion weed wick wiper demonstration herbicide and application regime in 2016 at Minnipa.*

| Treatment (mixed with water to a total of 12 L) | Speed (km/h) | Application |
|---|---|---|
| Nil - control | | |
| 15 g metsulfuron methyl 600ac and 3 L glyphosate 470ac | 10 | One direction |
| 15 g metsulfuron methyl 600ac and 3 L glyphosate 470ac | 15 | One direction |
| 15 g metsulfuron methyl 600ac and 3 L glyphosate 470ac | 10 | Back and forth |
| 30 g metsulfuron methyl 600ac and 6 L glyphosate 470ac | 10 | One direction |
| 30 g metsulfuron methyl 600ac and 6 L glyphosate 470ac | 15 | One direction |
| 30 g metsulfuron methyl 600ac and 6 L glyphosate 470ac | 10 | Back and forth |
| 30 g chlorsulfuron 750ac and 3 L glyphosate 470ac | 10 | One direction |
| 30 g chlorsulfuron 750ac and 3 L glyphosate 470ac | 15 | One direction |
| 30 g chlorsulfuron 750ac and 3 L glyphosate 470ac | 10 | Back and forth |
| 60 g chlorsulfuron 750ac and 6 L glyphosate 470ac | 10 | One direction |
| 60 g chlorsulfuron 750ac and 6 L glyphosate 470ac | 15 | One direction |
| 60 g chlorsulfuron 750ac and 6 L glyphosate 470ac | 10 | Back and forth |

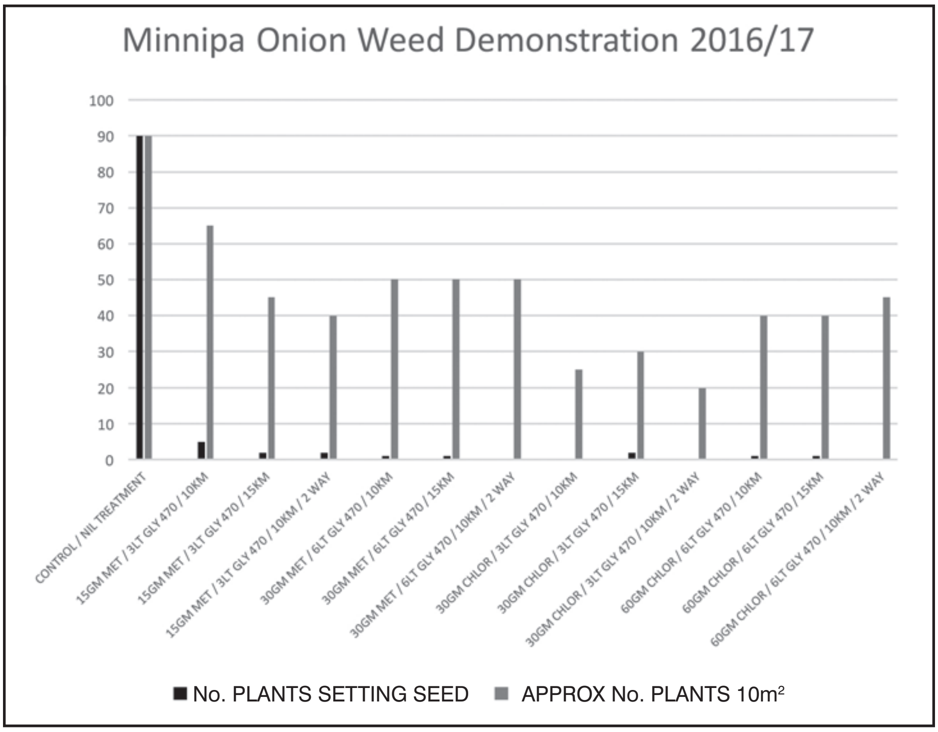


***Figure 1. Approximate number of Onion weed plants/m$^2$ and number of plants setting seed on 16 March 2017, following treatments on 8 September 2016.***

More interestingly, seed set of Onion weeds that did survive the treatments was delayed well past February, which affords the opportunity to treat the remaining weeds with a non-selective herbicide such as paraquat. A summer treatment of paraquat following an in-pasture wick wipe should result in minimal Onion weed seed set during the pasture phase of the rotation.

Not shown in the data is the observation of the persisting impact on Onion weed provided by two-way wipes, suggesting application efficacy is critical as seen in Figure 2.

***Other observations made during the demonstration include:***

- Rough and uneven paddocks will make wick wiping difficult, as will sticks and rocks.
- Standing stubbles result in herbicide being randomly flicked off the wick onto non-target plants.
- The amount of non-target damage could be minimised by heavily grazing the pasture to be treated.
- Wick wiping may provide an opportunity to prevent Onion weed from setting seed in pastures whilst increasing the desirable levels of feed on offer. Considering that onion weed can be controlled in the other phases of the rotation this innovative approach should go a long way to reducing this unwanted plant.

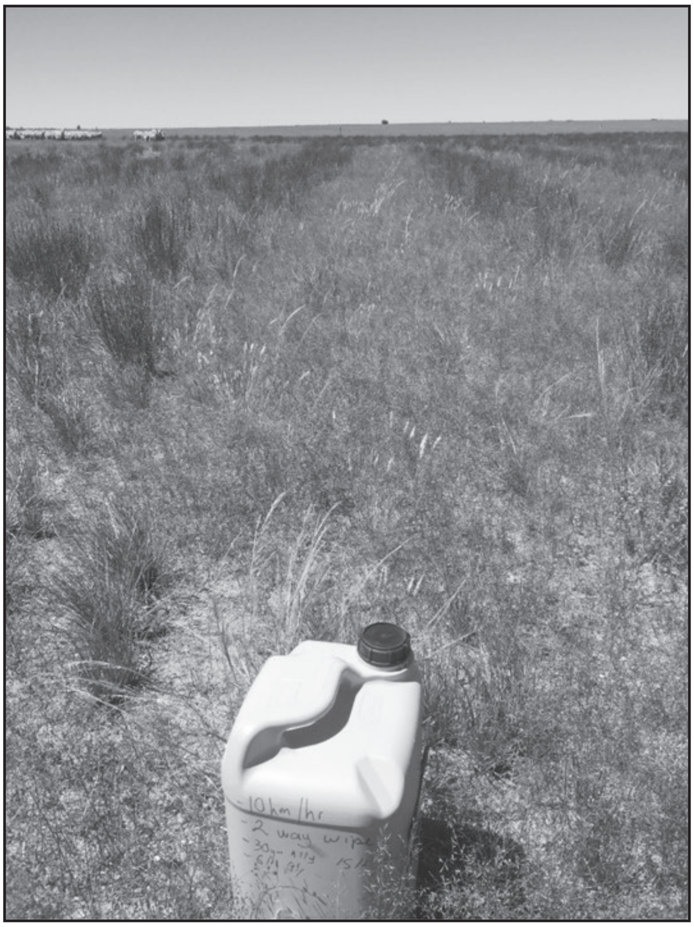

***Figure 2. Two-way wipe of 30g metsulfuron methyl and 6 L glyphosate in 12 L of water at Cowell demonstration site.***

- Wick wiping in pastures should also have the overall benefit of suppressing/controlling other undesirable weeds that are taller than pasture species, such as Horehound, silver-leaved nightshade, thistles etc.

***Replicated trials are required to:***

- Investigate differing application methods.
- Measure biomass counts of medic between various treatments.
- Confirm the most effective herbicides and adjuvant mixtures.
- Test to ensure SU residues don't accumulate in the soil through treated plant root systems, dead or alive.
- Further quantify seed set prevention to ensure it was not a one off seasonal effect.

## Acknowledgements

The author wishes to thank the EPNRM for funding the Minnipa project, Bruce Heddle for field and assistance with equipment and Warwick Hutchings for use of his land.

Government of South Australia

Eyre Peninsula Natural Resources Management Board

# Section 3

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

# Cereals



# Elliston and Wharminda district wheat trials 2017

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

RESEARCH

**Try this yourself now**

**Location**
Elliston
Nigel & Debbie May
**Rainfall**
Av. Annual: 427 mm
Av. GSR: 353 mm
2017 Total: 431 mm
2017 GSR: 280 mm
**Yield**
Potential: 6.7 t/ha
2017 trial Av. 2.6 t/ha
**Paddock History**
2016: Medic pasture
2015: Wheat
2014: Canola
**Soil Type**
Dark silt sand
**Plot Size**
1.8 m x 10 m x 3 reps
**Yield Limiting Factors**
Late sowing date

**Location**
Wharminda - Tim Ottens
Wharminda Ag Bureau
**Rainfall**
Av. Annual: 338 mm
Av. GSR: 253 mm
2017 Total: 344 mm
2017 GSR: 176 mm
**Yield**
Potential: 1.6 t/ha
2017 trial Av. 1.1 t/ha
**Paddock History**
2016: Medic pasture
**Soil Type**
Sand
**Plot Size**
1.8 m x 10 m x 3 reps
**Yield Limiting Factors**
Late sowing date, low GSR

## Key messages

- **The season of 2017 started late and dry, having a strong influence on which varieties yielded well. A long soft finished allowed crops to get over the line.**
- **Corack, Mace and Scepter were consistent in high yields across both Elliston and Wharminda.**
- **Selecting mid-early varieties is important when sowing late as both yield and quality are affected.**

## Introduction

These variety trials were undertaken to fill the gaps in regions where National Variety Trials were not undertaken and therefore did not provide information for the season. They continue to be highlighted as a subject of relative importance as they allow local growers to identify and evaluate any issues or successes from the season. The growing season of 2017 was widely late and dry. Despite this the trials yielded reasonably well and displayed helpful varietal differences. Both trials contained fifteen varieties each replicated three times.

### *Elliston*

### Crop agronomy

Roundup (2 L/ha), Boxer gold (1.5 L/ha), Treflan (1.5 L/ha), Avadex (1.6 L/ha) and Chlorpyrifos (500) (0.5 L/ha) were applied immediately prior to sowing on 21 June. DAP treated with Impact (0.4 L/ha) was applied at 80 kg/ha. Seed was sown slightly deeper than usual onto moisture resulting from May rainfall events. Rain followed shortly after and the crop emerged on 1 July.

On 14 August at GS23 Velocity (0.5 L/ha), Bromicide (0.5 L/ha), Lontrel 300 (0.15 L/ha), Le Mat (0.085 L/ha) and Smartrace Triple (3 L/ha) were sprayed to combat broadleaved weeds, RLEM and possible micronutrient deficiencies.

### What happened?

Once the season broke, rainfall was steady and provided enough moisture for good growth and a short but steady finish. Spring temperatures were kind with no days over 30°C in September and 33, 35 and 30°C on the 16, 17 and 24 October allowing a steady finish for the late sown crop. This cool finish also resulted in low screenings and reasonable test weights (Table 2).

Corack, Scepter and Cosmick yielded the highest at Elliston in 2017. Clearfield varieties yielded considerably well but still had a yield penalty. The longer season varieties that yielded well in 2016 saw the lowest yields in 2017 due to late sowing date and insufficient season length to mature to their full potential.

***Table 1. Elliston rainfall (mm) for 2017, Bureau of Meteorology, 2018.***

| Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 97.2 | 9.8 | 6.6 | 2.6 | 16.2 | 13.0 | 102.0 | 88.8 | 36.4 | 24.0 | 20.0 | 34.2 |
| Growing season rainfall (May-October*) | | | | | | 280 | | | | | |
| Annual rainfall | | | | | | 431 | | | | | |

**April not included in GSR due to minimal rainfall and late time of sowing*

***Table 2. Elliston district wheat trial grain yield (t/ha) and quality results, 2017.***

| Variety | Yield (t/ha) | Test weight (kg/hL) | Screenings (%) | Protein (%) |
|---|---|---|---|---|
| Corack | 2.97 | 81.6 | 0.8 | 11.4 |
| Scepter | 2.89 | 81.8 | 1.3 | 11.4 |
| Cosmick | 2.78 | 80.4 | 2.6 | 12.1 |
| Axe | 2.70 | 81.5 | 0.7 | 12.3 |
| Wyalkatchem | 2.67 | 80.3 | 0.8 | 12.2 |
| Mace | 2.65 | 80.5 | 2.1 | 11.9 |
| Hatchet CL | 2.60 | 81.3 | 2.0 | 12.9 |
| Kord CL | 2.58 | 82.0 | 0.5 | 12.3 |
| Emu Rock | 2.54 | 80.5 | 2.2 | 12.4 |
| Grenade CL | 2.52 | 80.8 | 0.6 | 12.5 |
| Shield | 2.49 | 78.7 | 2.8 | 12.4 |
| Trojan | 2.47 | 82.4 | 1.3 | 12.5 |
| Scout | 2.38 | 81.8 | 0.8 | 12.2 |
| Yitpi | 2.32 | 79.3 | 0.4 | 12.7 |
| Cutlass | 2.07 | 78.5 | 1.4 | 12.5 |
| **Site average** | **2.58** | **80.8** | **1.3** | **12.2** |
| *LSD (P=0.05)* | *0.18* | | | |
| CV (%) | 4.2 | | | |

***Table 3. Elliston district wheat yields as a percentage of Yitpi (2013-2017).***

| Variety | 2017 | 2016 | 2015 | 2014 | 2013 | % mean |
|---|---|---|---|---|---|---|
| Axe | 116 | 80 | 109 | 95 | 87 | 97 |
| Cobra | NA | NA | 111 | 109 | NA | 110 |
| Corack | 128 | 107 | 82 | 108 | 93 | 104 |
| Cosmick | 120 | 104 | 109 | NA | NA | 111 |
| Cutlass | 89 | 99 | NA | NA | NA | 94 |
| Emu Rock | 109 | 99 | 99 | 98 | NA | 101 |
| Grenade CL | 109 | 90 | 111 | 106 | NA | 104 |
| Hatchet CL | 112 | 79 | 91 | NA | NA | 94 |
| Kord CL Plus | 111 | 85 | 132 | 102 | 104 | 107 |
| Mace | 114 | 99 | 197 | 117 | 121 | 130* |
| Phantom | NA | NA | 113 | 117 | NA | 115 |
| Scepter | 125 | 89# | NA | NA | NA | 107 |
| Scout | 103 | 98 | 101 | 104 | 92 | 100 |
| Shield | 107 | 101 | 115 | 107 | NA | 108 |
| Trojan | 106 | 95 | 81 | 108 | NA | 98 |
| Wyalkatchem | 115 | 106 | 111 | 112 | 113 | 111 |
| Yitpi | 100 | 100 | 100 | 100 | 100 | 100 |
| **Yitpi (t/ha)** | **2.32** | **5.49** | **0.47** | **2.87** | **1.41** | |

**Mace is seen to have an exceedingly high average. Whilst being a strong performing variety, 2015 saw low yields where mace yielded at 197% of Yitpi (at 0.93 t/ha). This has skewed the % mean. Without 2015, Mace yielded 113% of Yitpi over the 4 remaining years.*

*#Scepter yield affected by disease 2016*

Protein was high across the board with most varieties achieving H2 grain quality. It appears protein dilution occurred, and nitrogen may have been lacking in higher yielding varieties (Table 2).

Table 3 shows the variety yields as a percentage of Yitpi over the last 5 years. Early and Clearfield varieties that didn't perform well in the decile 9 year of 2016, performed well in 2015 and 2017, both short, dry years. Mace, Wyalkatchem and Shield have all yielded well over this period of time, regardless of the seasonal conditions. Imi tolerant varieties, normally thought to possess a yield penalty have maintained a relatively high percentage through their ability to perform in dry seasons.

## *Wharminda*

## Crop agronomy

At Wharminda, the site was situated on sand with some non-wetting issues, following a medic pasture. Chemical applications of Roundup (2 L/ha), Hammer (0.045 L/ha), Avadex (1.6 L/ha), Treflan (1.5 L/ha) and Boxer gold (1.5 L/ha) was applied immediately prior to sowing on 11 July. 80 kg/ha of DAP treated with Impact (0.4 L/ha) was applied in furrow at sowing. Germination was poor and uneven due to low rainfall and non-wetting sands. No further inputs followed, and the trial was harvested on 10 November.

## What happened?

Wharminda was a low yielding site in 2017 with a site average of 1.07 (t/ha) (Table 5). Despite the late time of sowing and low rainfall the site yielded higher than expected and top varieties Mace, Corack and Scepter yielded well with good grain quality in a tight season. Similarly to Elliston, a soft finish was seen with no days over 30°C in September and only 3 in October (16, 17 and 24). This allowed plants to flower and fill grain with relatively low levels of abiotic stress as is reflected by relatively low screenings and good test weights (Table 5). It can also be seen that some longer varieties produced a high percentage of screenings, as their required season length was cut short. This highlights the importance of varietal selection when sowing late.

Cereals

***Table 4. Wharminda rainfall (mm) for 2017, Bureau of Meteorology, 2018.***

| Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45.8 | 14.4 | 0 | 15.8 | 6.6 | 6.8 | 39.8 | 75.0 | 33.6 | 27.4 | 49.4 | 29.4 |
| Growing season rainfall (May-October*) | | | | | | 176 | | | | | |
| Annual rainfall | | | | | | 344 | | | | | |

**Rainfall measured from July as prior rainfall was insignificant*

***Table 5. Wharminda district wheat trial grain yield (t/ha) and quality results in 2017.***

| Variety | Yield (t/ha) | Test weight (kg/hL) | Screenings (%) | Protein (%) |
|---|---|---|---|---|
| Mace | 1.33 | 80.9 | 2.5 | 12.2 |
| Corack | 1.27 | 79.6 | 3.1 | 12.3 |
| Scepter | 1.22 | 80.2 | 4.0 | 12.3 |
| Emu Rock | 1.15 | 79.8 | 2.7 | 13.1 |
| Shield | 1.13 | 78.6 | 4.2 | 12.9 |
| Hatchet CL | 1.12 | 79.9 | 2.5 | 13.6 |
| Wyalkatchem | 1.11 | 79.1 | 2.5 | 12.7 |
| Axe | 1.05 | 80.5 | 1.2 | 13.5 |
| Kord CL | 1.04 | 79.1 | 4.2 | 12.9 |
| Scout | 1.00 | 80.5 | 4.1 | 12.4 |
| Cutlass | 0.97 | 78.6 | 5.5 | 12.8 |
| Cosmick | 0.94 | 77.7 | 8.1 | 12.4 |
| Yitpi | 0.91 | 79.9 | 2.4 | 13.1 |
| Grenade CL | 0.88 | 79.5 | 4.5 | 12.6 |
| Trojan | 0.88 | 79.5 | 7.8 | 12.9 |
| **Site average** | **1.07** | **79.6** | **4.0** | **12.8** |
| *LSD (P=0.05)* | *0.16* | | | |
| CV (%) | 9.2 | | | |

*Table 6. Wharminda district wheat yields as a percentage of Yitpi (2014-2017).*

| Variety | 2017 | 2016 | 2015 | 2014 | % mean |
|---|---|---|---|---|---|
| Axe | 115 | 53 | 87 | 114 | 92 |
| Cobra | NA | NA | 107 | 120 | 114 |
| Corack | 140 | 81 | 107 | 136 | 116 |
| Cosmick | 103 | 77 | 105 | NA | 95 |
| Cutlass | 107 | 101 | NA | NA | 104 |
| Emu Rock | 126 | 61 | 98 | 114 | 100 |
| Grenade CL Plus | 97 | 75 | 91 | 113 | 94 |
| Hatchet CL Plus | 123 | 42 | 84 | NA | 83 |
| Kord CL Plus | 114 | 75 | 85 | 109 | 96 |
| Mace | 146 | 84 | 108 | 129 | 117 |
| Phantom | NA | NA | 97 | 113 | 105 |
| Scepter | 134 | 91 | NA | NA | 113 |
| Scout | 110 | 81 | 100 | 115 | 101 |
| Shield | 134 | 83 | 96 | 123 | 109 |
| Trojan | 97 | 98 | 101 | 118 | 103 |
| Wyalkatchem | 122 | 81 | 109 | 122 | 108 |
| Yitpi | 100 | 100 | 100 | 100 | 100 |
| **Yitpi yield (t/ha)** | **0.91** | **3.72** | **3.56** | **2.87** | |

Table 6 displays the variety averages as a percentage of Yitpi over the last four years at Wharminda. Corack and Mace have yielded the most consistently over this time despite rainfall variability between seasons. A consistent yield penalty is seen for Clearfield varieties despite yielding well compared to Yitpi in the 2017 season, and of these Grenade CL Plus appears to be the most consistent.

## What does this mean?

Variety selection should be made by evaluating yields from more than one season, ideally a broad range of seasons such as the last five. Disease (root or leaf/stem), maturity, height, herbicide tolerance, sprouting tolerance and grain quality are all important characteristics to asses when selecting varieties to best fit your farming system.

For more extensive variety options and further information on any variety visit the National Variety Trials website at www.nvtonline.com.au, or refer to the articles in the EPFS Summary 2017 NVT Cereal Yield Performance Tables and the Cereal Variety Disease Guide.

## Acknowledgements

Many thanks to Nigel and Debbie May for the use of their land at Elliston and to Tim Ottens for the use of his land at Wharminda.

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Management of early sown wheat

**Kenton Porker[1], Brenton Spriggs[2], Sue Budarick[2] and James Hunt[3]**
[1]SARDI Waite, [2]SARDI Minnipa Agricultural Centre, [3]La Trobe University



**Try this yourself now**

**Location**
Minnipa Agricultural Centre, Paddock S2/8
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 282 mm
2017 GSR: 155 mm
**Yield**
Potential: 1.7 t/ha (W)
Actual: Highest yielding treatment, 2.5 t/ha
**Paddock History**
2016: Grass free pasture
2015: Wheat
2014: Wheat
**Soil Type**
Sandy loam
**Plot Size**
5 m x 1.4 m x 4 reps
**Yield Limiting Factors**
Drought, mice

## Key messages

- **Maximum yields were achieved when flowering occurred in late August.**
- **Fast developing winter variety Longsword sown in early April achieved similar yields to the best performing spring variety Cutlass sown in early May.**

## Why do the trial?

The aim of this trial is to determine which of the new generation of winter cultivars have the best yield and adaptation in different environments and what is their optimal sowing window.

Flowering time is critical for wheat yield and must occur within an optimal period. At Minnipa this period has been defined from the 22 August – 8 September (*Flohr et al*. 2017). Growers need to match variety developmental rate with sowing time in order to ensure flowering occurs during this period. For example, fast - medium developing spring wheat varieties (e.g. Scepter) need to be sown within the period from 29 April – 9 May to flower on time at Minnipa (*Flohr et al.* 2017).

Sowing earlier may require varieties that are slower developing, such as varieties with increased photoperiod sensitivity (e.g. Cutlass). For sowing prior to 20 April, winter varieties may be required. Winter wheats will not progress to flower until their vernalisation requirement is met (cold accumulation).

Previous research has shown currently available winter wheats (e.g. Wedgetail) are not well adapted to SA. The pre-release winter cultivars in this trial have diverse phenology and adaptation, the faster ones are likely to be best suited to low rainfall locations such as Minnipa. The first fast winter wheat cultivar, Longsword (RAC2341) was released in 2017 and is commercially available in 2018. Winter wheats have received little evaluation sown early in low rainfall environments.

## How was it done?

The trial was a two-way factorial time of sowing experiment incorporating eight varieties that differ in developmental controls across four times of sowing (TOS) on 23 March, 3 April, 18 April and 5 May.

1. Scepter (fast spring)
2. Cutlass (slow photoperiod responsive spring)
3. Longsword (previously coded RAC2341) (fast winter)
4. V09150-0 (fast-medium winter)
5. Kittyhawk (medium winter)
6. LPB14-0392 (intermediate fast winter-slow spring)
7. ADV11.9419 (slow winter)
8. ADV08.0008 (medium winter)

All varieties were planted with adjusted seeding rates aiming for a target plant density of 150 plants/m$^2$. Ten mm of irrigation at sowing was applied to ensure even establishment. 50 kg/ha of MAP fertiliser was applied in furrow, and the site was managed for pest and disease throughout the season. Plots were sown in six row 5 m plots at 22.8 cm row spacing, the two outside rows were removed at harvest and the middle four rows harvested to account for edge effects.

Measurements included plant emergence, establishment, timing of stem elongation, flowering time (measured as 50% of heads in the plot flowering), biomass at maturity, harvest index, grain yield and components.

## What happened?

The site received above average summer rainfall, however the period from April – July was extremely dry, with most of the in season rainfall occurring in August and September. Despite the dry start, the establishment was greater than 80 plants/m$^2$ in all sowing dates. Previous research has demonstrated there is no significant yield effect from different plant densities in the range of 50 – 150 plants/m$^2$ in winter wheats established early. There were no significant frost events during the flowering period, however maximum temperature exceeded 30°C on several occasions from 20 September (Figure 1).

There was a significant variety x sowing date interaction for grain yield at the site (P<0.001). Spring varieties Scepter and Cutlass flowered too early from sowing dates in March and April. Winter varieties had relatively lower yields at the March sowing date despite flowering at a similar time to the April sowings; this is likely due to the dry start reducing biomass and grain number. This provides insights into the ability of new winter wheats to tolerate vegetative drought and suggests March sowing may be too early (Figure 1).

Peak yields were achieved when flowering occurred during late August, around the 24 and 25 August. This is consistent with previous work identifying the optimal flowering period for Minnipa to be between 22 August – 8 September (Figure 1).

Cutlass and Longsword flowering in late August produced the highest yields. Across all sowing dates the fast developing Longsword was the highest yielding winter variety compared to pre-release cultivars and commercially available slower developing winter Kittyhawk at this site (Figure 2). Based on flowering dates Longsword will likely flower after the optimum period with sowing dates after 20 April and appears better suited to early–mid April plantings at Minnipa.

LPB14-0392 demonstrated a unique unstable flowering behaviour that requires further investigation. From March sowing it flowers too early (similar to spring varieties), however from April sowing it demonstrated it could flower within the optimum period and achieve yields comparable to Longsword. From early May sowing it was too late flowering along with other winter wheats.

All other winter varieties flowered too late from all sowing dates, although the slightly quicker winter variety V09150-01 flowered just after the end of the optimal period (9 September) from March sowing. This flowering behaviour may have a better fit in slightly later districts. Even though the line ADV11.9419 flowered much later in September it still achieved comparable yields to other winter types. The ability to maintain high relative yields outside of the optimum flowering window is a useful attribute in some regions and will be investigated further.

## What does this mean?

Prior to 2017 the new winter cultivars have had little exposure to the low rainfall environments and particularly at really early sowing dates (mid-March). In this trial the fast developing winter variety Longsword sown in early April achieved similar yields to the best performing spring variety Cutlass sown in early May. This data also highlights the importance of matching variety to sowing time to ensure flowering occurs at the optimum time. Maximum yields were achieved when flowering occurred in late August consistent with published optimum flowering times for Minnipa.

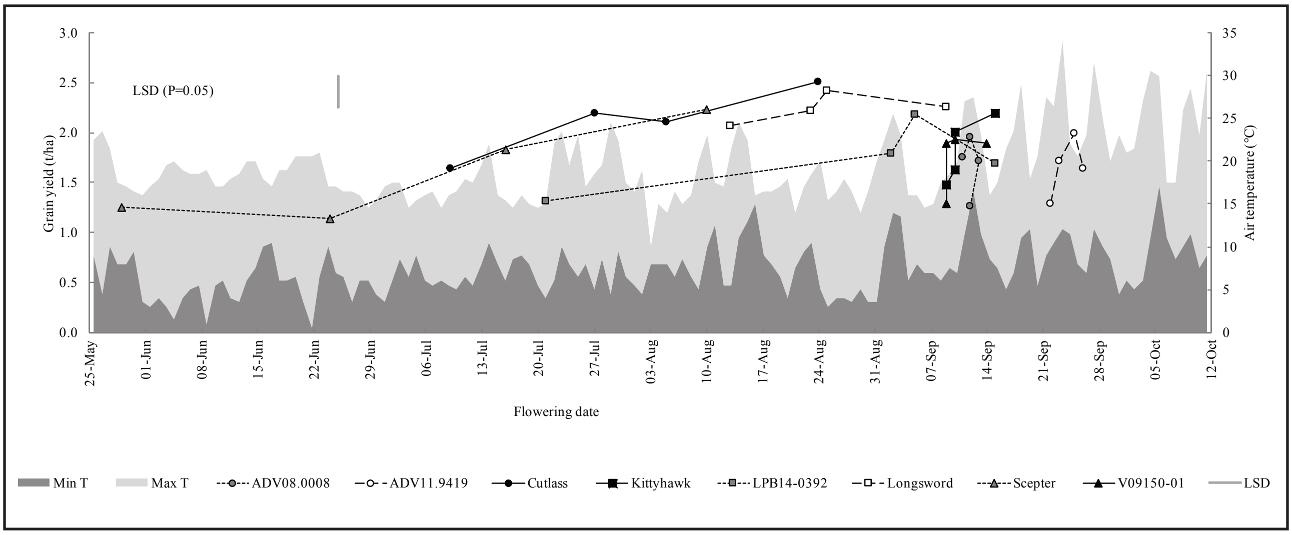


***Figure 1. Relationship between flowering date and grain yield for all varieties at Minnipa in 2017, each symbol corresponds to a different sowing date from TOS1 (Left) – TOS4 (Right).***

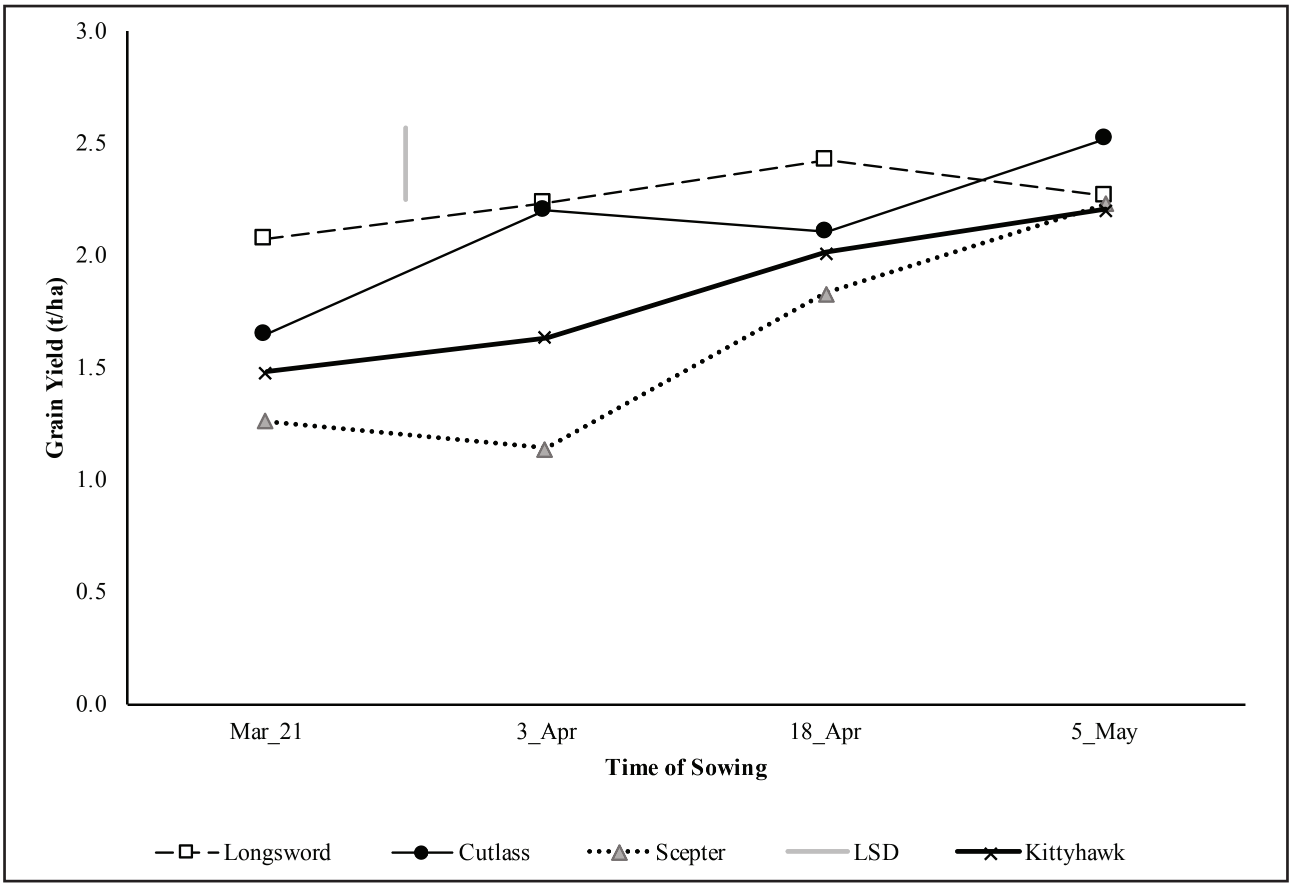


***Figure 2. The effect of time of sowing on grain yield in selected commercially available wheat varieties at Minnipa in 2017 (LSD P=0.05).***

While this trial is only from one year of data, it builds on evidence that faster developing winter varieties such as Longsword or varieties with different development controls like LPB14-0392 are needed for sowing dates prior to 20 April in the lower rainfall zones. The longer vegetative period of winter varieties also opens opportunities for grazing.

The project is in its first year and will be continued in 2018 and 2019. Yield and flowering time data is available from eight sites including Minnipa, Hart, Loxton, and Booleroo Centre in SA and Mildura, Horsham, Birchip and Yarrawonga in Victoria.

## Acknowledgements

The authors would like to acknowledge the Grains Research and Development Corporation (GRDC) for investment in the Management of Early Sown Wheat project (Project No 9175069).

Cereals

# New technologies for wheat crop monitoring on the Eyre Peninsula

**Danielle J. Allen[1], Andrew Ware[2] and Kenton Porker[1]**

[1]SARDI, Waite, [2]SARDI, Port Lincoln

RESEARCH

**Looking for answers**

**Location**
Paul Schaefer
Pinkawillinie
**Rainfall**
Weather station: Buckleboo (018172)
2017 Total: 357 mm
2017 GSR: 180 mm
**Yield**
Potential: 2.4 t/ha
Actual: 3.8 t/ha
**Paddock History**
2016: Medic pasture
**Soil Type**
Clay loamy sand
**Plot Size**
20 m x 20 m x 3 reps, with each plot split into subplots (10 m x 20 m)

**Location**
Jordan Wilksch
Karkoo
**Rainfall**
Weather station: Yeelanna (018007)
2017 Total: 358 mm
2017 GSR: 227 mm
**Yield**
Potential: 4.0 t/ha
Actual: 4.0 t/ha
**Paddock History**
2016: Canola
**Soil Type**
Loamy sand
**Plot Size**
20 m x 20 m x 3 reps, with each plot split into subplots (10 m x 20 m)

**Location**
Ben Pope
Warramboo
**Rainfall**
Weather station: Kyancutta (018044)
2017 Total: 309 mm
2017 GSR: 155 mm
**Yield**
Potential: 2.2 t/ha
Actual: 2.6 t/ha
**Paddock History**
2016: Wheat
**Soil Type**
Sand
**Plot Size**
20 m x 20 m x 3 reps, with each plot split into subplots (10 m x 20 m)

## Key messages

- **Soil moisture capacitance probes are a valuable tool for continuous monitoring of soil moisture throughout the soil profile.**
- **The soil moisture probe moisture follows the same pattern as APSIM extractable soil water, suggesting that the moisture probes are a good measure of the moisture in the soil at the paddock scale.**
- **Visible-near infrared spectroscopy is a rapid, cost-effective solution that can be used to predict plant and soil nitrogen, plant biomass, and soil particle size.**
- **Infrared spectroscopy can be used to assist with crop management decision making (e.g. N applications).**

## Why do the trial?

The aim of this project was to assess the usefulness of new technologies to support crop management decisions on the Eyre Peninsula. The technology evaluated as part of this project included recently installed soil moisture probes and an infrared spectroradiometer.

Wheat grain yields are subject to high annual variation as a result of many factors, particularly the availability of water and nitrogen resources in rain-fed cropping systems in semi-arid environments such as South Australia [1,2]. Within season and within paddock variability can contribute to uncertainty associated with crop potential and cropping inputs resulting in the need for continuous crop monitoring, including soil moisture content and crop nitrogen status.

There are many new tools such as soil moisture capacitance probes and infrared spectroscopy that can be utilised to collect and analyse crop performance data that are rapid, cost effective and non-destructive strategies. Other tools, e.g. APSIM, utilise a simulation model-based approach and rely on a range of input information (e.g. sowing date, nitrogen inputs) to predict various crop information, e.g. soil moisture and yield.

Soil moisture capacitance probes have recently been installed on the EP and are an attractive tool as they are of low-cost, time-efficient, require little attention once installed, and provide continuous data on soil moisture throughout the soil profile. These instruments will also have the ability to compare data with previous years and once enough data has been collected, may aid in crop choice decisions by assessing pre-sowing plant available water, potentially provide increased confidence in sowing time by assessing soil moisture reserves, and possibly assist with informed input decisions with the aim of lowering inputs in years of low moisture and increasing yield potential when favourable seasons occur [3].There is however, the question of whether a single probe can be relied upon for field-scale interpretations due to potentially large variability across the paddock and the distance from the probe that it is able to measure [4]. There are limited examples of the use of soil moisture probes in dryland cropping systems in South Australia, but interest and awareness in this technology is increasing.

**Location** Jason Burton
Rudall
**Rainfall**
Weather station: Rudall (018174)
2017 Total: 293 mm
2017 GSR: 190 mm
**Yield**
Potential: 2.2 t/ha
Actual: 2.7 t/ha
**Paddock History**
2016: Wheat
**Soil Type**
Sand
**Plot Size**
20 m x 20 m x 3 reps, with each plot split into subplots (10 m x 20 m)

---

**Location** Jamie Phillis
Ungarra
**Rainfall**
Weather station: Ungarra (018088)
2017 Total: 379 mm
2017 GSR: 240 mm
**Yield**
Potential: 3.9 t/ha
Actual: 3.4 t/ha
**Paddock History**
2016: Lentils
**Soil Type**
Sandy clay loam
**Plot Size**
20 m x 20 m x 3 reps, with each plot split into subplots (10 m x 20 m)

Infrared technology measures the wavelengths of light that are reflected from a particular surface (e.g. soil or crop canopy) and is similar to GreenSeeker/NDVI technology, except that it measures a wider range of light wave lengths. The use of infrared spectroscopy has been widely used in laboratories as a rapid, non-destructive and low-cost option for predicting plant and soil properties such as nitrogen and water stress [5,6], however it has had little application in field studies. This tool could be used to capture paddock variation throughout the paddock-scale to provide a better estimate of yield-driven variables, and also yield itself [1,7].

APSIM is a computer based crop simulator that is available commercially as Yield Prophet through BCG that enables crop paddock simulation and monitoring based on various input information (e.g. nitrogen inputs, sowing date, crop type, cultivar, sowing rate) [8,9].

By combining all three of these tools there is opportunity to improve the accuracy in decision making of in-crop N applications with measured soil moisture conditions on the EP.

## How was it done?

Five replicated field experiments were set up across the Eyre Peninsula in wheat paddocks as close to the soil moisture probes as possible. Each trial had three plots (20 m x 20 m) that were separated into subplots (10 m x 20 m). The locations were: Warramboo (B. Pope), Pinkawillinie (P. Schaefer), Rudall (J. Burton), Karkoo (J. Wilksch), and Ungarra (J. Phillis). The crop details for each site are presented in Table 1.

Soil physical and chemical properties and gravimetric water content were measured pre-sowing. Each site in this project had a soil moisture capacitance probe and a weather station that were used to monitor soil moisture and to obtain site-specific rainfall information throughout the season. The probes utilise telemetry systems that allow the data collected to be accessed via mobile devices or computers through the Eyre Peninsula Agricultural Research Foundation (EPARF) website (https://eparf.com.au/). Biomass cuts were taken at Z3.1 (stem elongation), Z6.5 (flowering) and Z9.4 (maturity) and were dried, ground and sent to the laboratory for N analysis. An infrared spectroradiometer (Spectral Evolution, SR-3500, USA) was used on a weekly basis on crop canopy and the soil surface in the field from Z3.1 to Z6.5 and on the dried and ground biomass and pre-sowing soil profile samples. Soil and canopy property prediction models were developed using the spectra in the range of 350–2500 nm and analysed using partial least squares regression (PLSR) in the Unscrambler (CAMO version 10.3) program. APSIM was used to develop crop simulation models to assess the predicted soil moisture content in relation to the moisture probes.

*Table 1. Crop details and sowing nitrogen applications in 2017.*

| Locality | Crop | Variety | Sowing date | Sowing rate (kg/ha) | N applied (kg/ha) | Mineral N @ sowing (kg/ha) | GSR (mm) | PAW (ext.) @ March 2017 | Grain yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|
| Rudall | Wheat | Mace | 16 May | 65 | 5 | 39 | 170 | 105 | 2.72 – no N<br>2.62 + 46 kg/ha N |
| Ungarra | Wheat | Mace | 1 July | 80 | 11 | 11 | 240 | 76 | 2.79 – no N<br>3.42 + 46 kg/ha N |
| Warramboo | Wheat | Mace | 30 May | 75 | 75 | 9 | 170 | 9 | 2.37 – no N<br>2.61 + 46 kg/ha N |
| Pinkawillinie | Wheat | Scepter | 7 May | 60 | 12 | 84 | 140 | 84 | 3.29 |
| Karkoo | Wheat | Trojan | 21 April | 75 | 41 | 67 | 186 | 55 | 3.68 – no N<br>4.02 + 46 kg/ha N |

Cereals

The soil moisture capacitance probes provided continuous uncalibrated monitoring of soil moisture throughout the soil profile to a depth of 1 m. The information collected illustrates the location of roots in the soil profile and where the soil moisture is being extracted as indicated by the 'stepping' in Figure 1. The summed soil moisture in relation to rainfall events, plant water use and evaporation is also presented (Figure 2).

The summed soil moisture generated by the probe was plotted in conjunction with the APSIM predicted extractable soil water (esw) using the same rainfall data collected from the weather stations at each location (Warramboo, Pinkawillinie and Karkoo). The plots illustrated that the probe moisture and esw follow a very similar pattern (Figures 3, 4, 5) indicating that the moisture probes may be a good estimation of soil moisture at paddock scale.

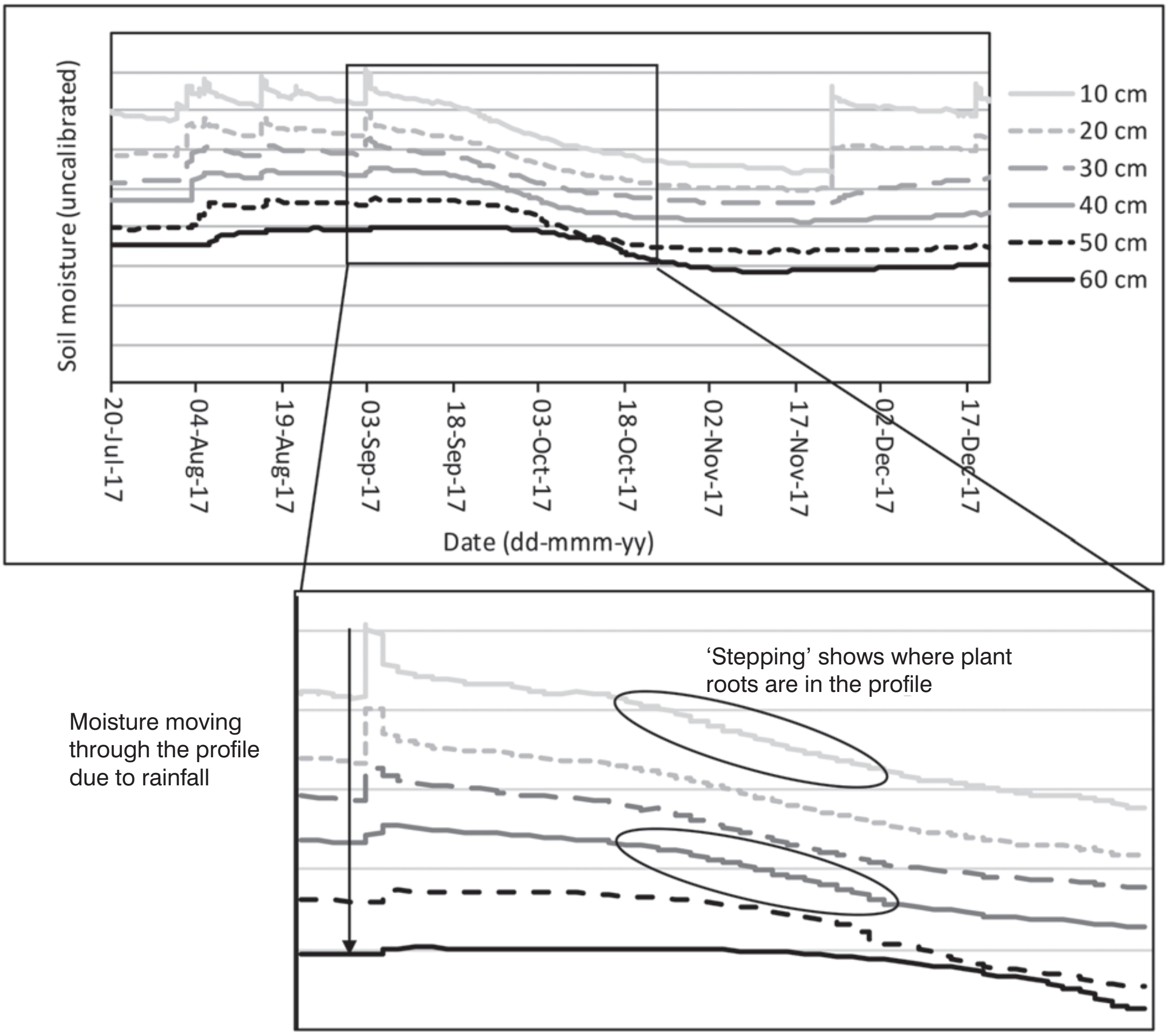


*Figure 1. Stacked soil moisture graph of the soil profile at Ungarra using the data collected from the soil moisture capacitance probe.*

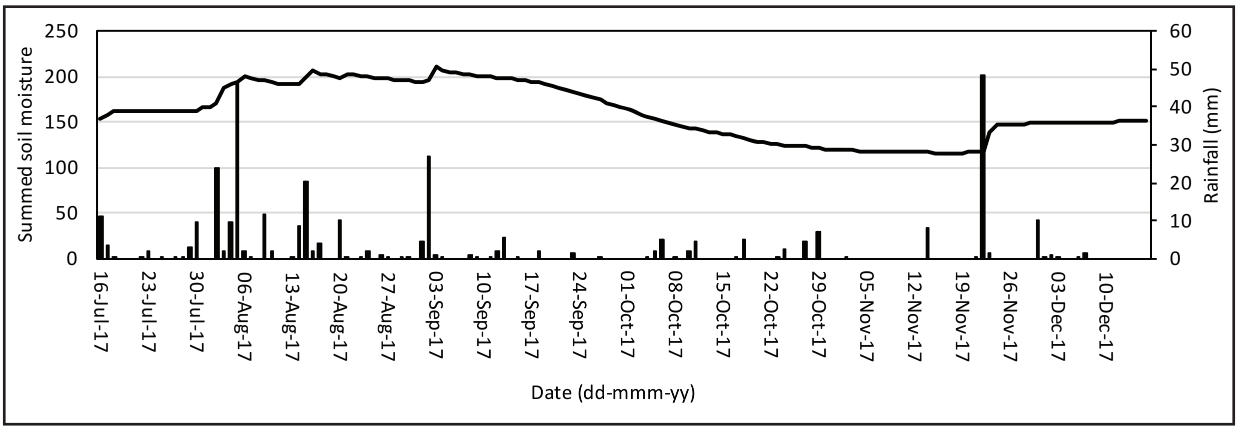


*Figure 2. Summed soil moisture and rainfall (mm) data from the Ungarra soil moisture probe.*

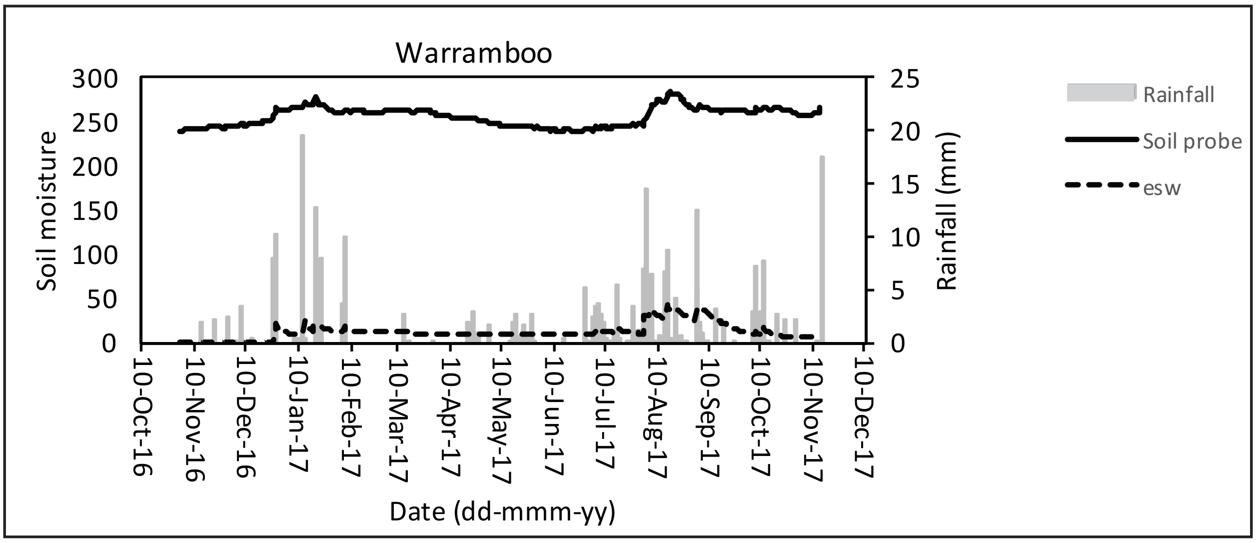


***Figure 3. Warramboo summed soil moisture, extractable soil water and rainfall. Extractable soil water based on an estimated starting soil moisture of 0% using APSIM.***

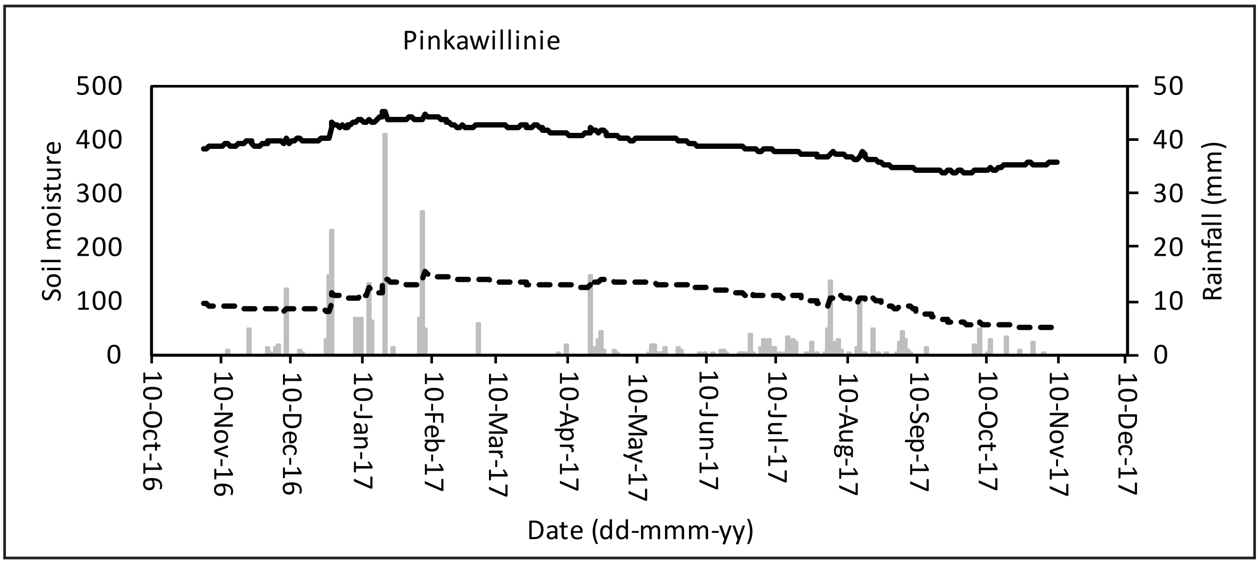


***Figure 4. Pinkawillinie summed soil moisture, extractable soil water and rainfall. Extractable soil water based on an estimated starting soil moisture of 30% using APSIM.***

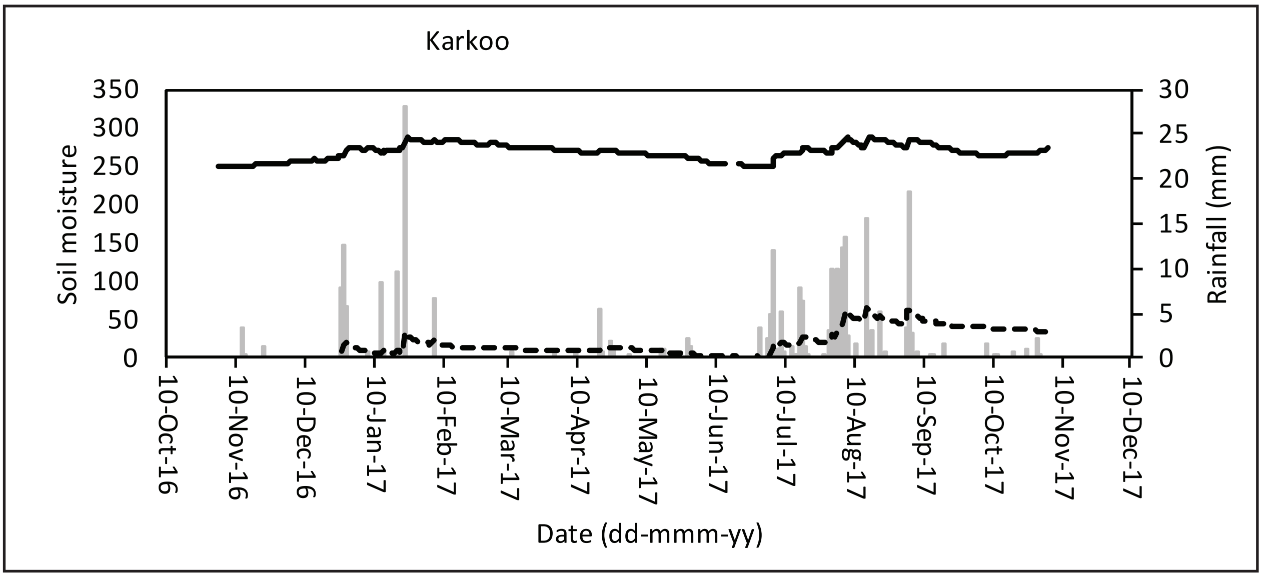


***Figure 5. Karkoo summed soil moisture, extractable soil water and rainfall. Extractable soil water based on an estimated starting soil moisture of 0% using APSIM.***

The soil moisture capacitance probes used in the EP have demonstrated to be a useful and time-efficient method for monitoring soil moisture throughout the soil profile at low cost (approx. $5000/ probe + ongoing telemetry fee) and may be a good alternative to manual moisture measurements.

***Infrared spectroscopy***
For this project the Spectral Evolution SR-3500 spectroradiometer was used to assess the ability of the instrument to predict plant nitrogen and biomass, and soil particle size and nitrogen in the Eyre Peninsula.

Using the dried and ground biomass samples, the PLSR model achieved a strong correlation of $R^2$ 0.96 for the prediction of plant nitrogen (%) (Figure 6) using information from Z3.1 (Pinkawillinie, Rudall, Warramboo) and Z6.5 (Pinkawillinie, Warramboo, Rudall, Karkoo, Ungarra) in the lab. When using field data, the model for Z6.5 achieved the highest correlation for plant N ($R^2$ 0.70) (Figure 7). The models that combined earlier growth stages also presented strong relationships between the reference and predicted data (Table 2). The correlation between laboratory reference and field predicted biomass (kg) was the strongest when using all of the assessed growth stages (Z3.1, Z4.3, Z6.5) $R^2$ 0.70 (Figure 8).

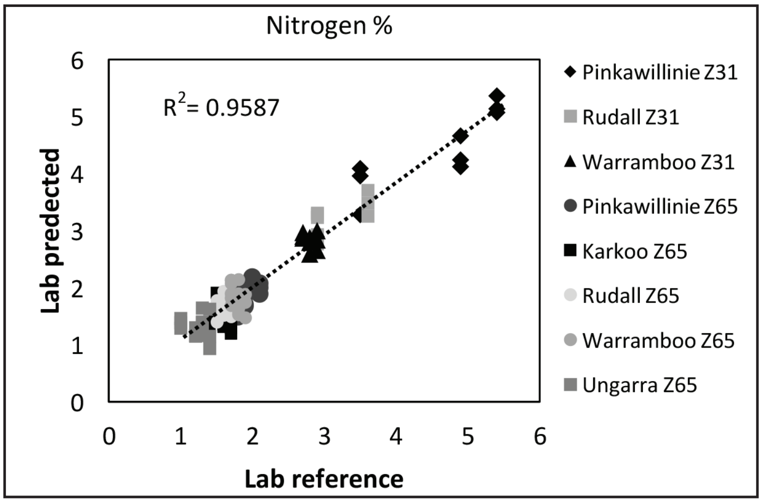


***Figure 6. Reference and predicted plant nitrogen content for ground laboratory samples across 3 sites for Z3.1 and 5 sites for Z6.5 using the SR-3500.***

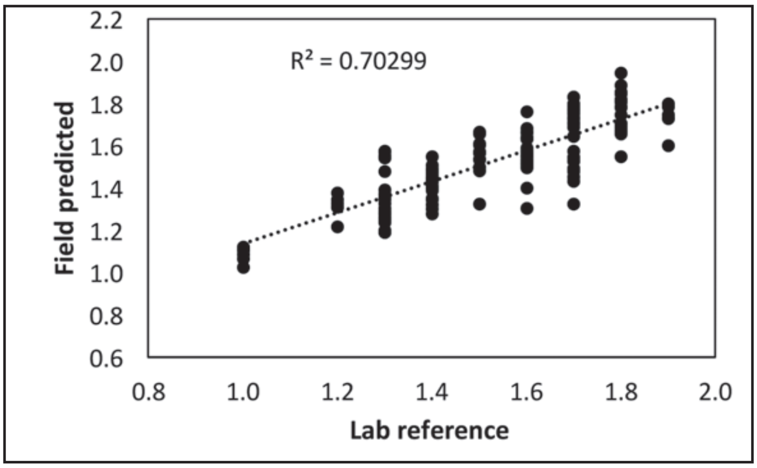


***Figure 7. Relationship between laboratory plant nitrogen content and predicted plant nitrogen using the SR-3500 for field measurements at 4 sites at Z6.5. Root mean Square Error (RMSE)=+/-0.120.***

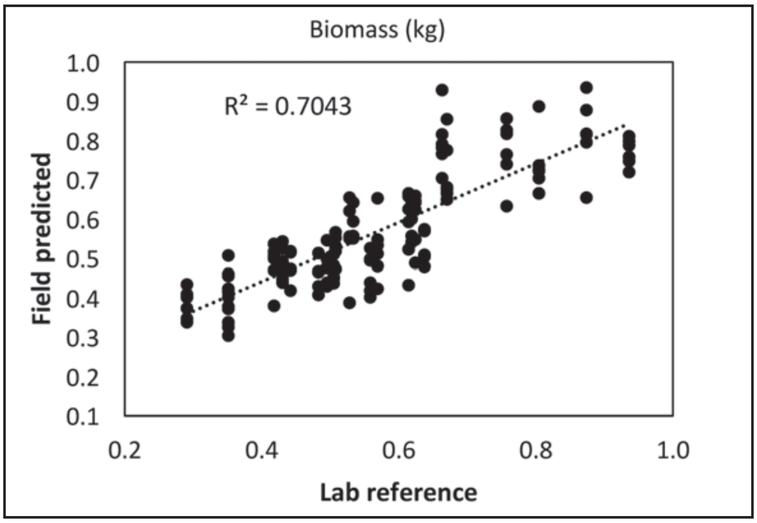


***Figure 8. Relationship between laboratory measured plant biomass and predicted biomass using the SR-3500 for 4 sites at Z3.1, Z4.3 and Z6.5. RMSE=+/-0.087.***

***Table 2. $R^2$ for relationship between reference and predicted plant nitrogen and biomass for various growth stage combinations using field scans from SR-3500 for the predictive models.***

| | Growth stage | $R^2$ |
|---|---|---|
| Nitrogen | Z3.1, Z4.3, Z6.5 | 0.69 |
| | Z3.1, Z4.3 | 0.63 |
| | Z6.5 | 0.70 |
| Biomass | Z3.1, Z4.3, Z6.5 | 0.70 |
| | Z3.1, Z4.3 | 0.60 |
| | Z6.5 | 0.55 |

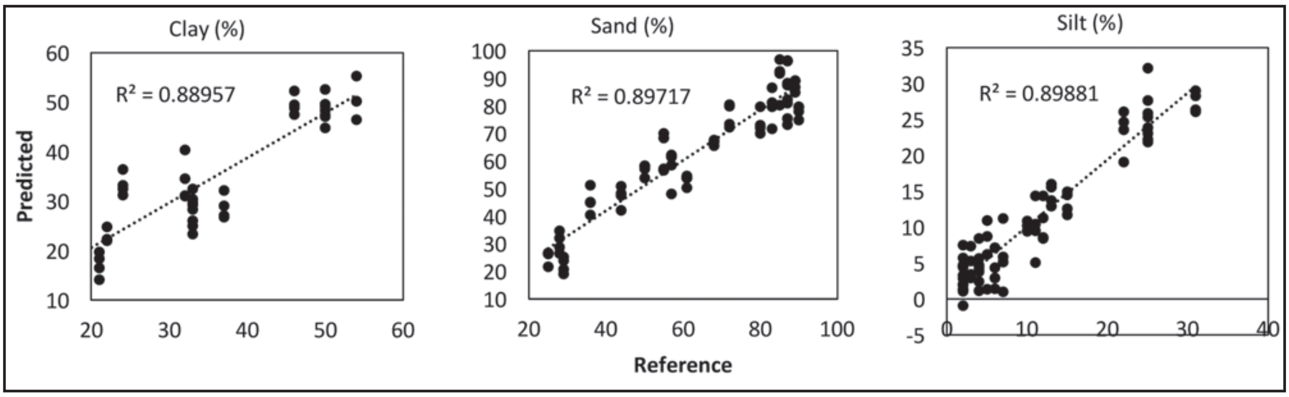


***Figure 9. Relationship between laboratory (reference) and predicted soil particle size (%) using the SR-3500. The results are based on the use of dried and ground soil samples from depths 0-10 cm, 10-30 cm, 30-60 cm and 60-100 cm (4 scans for each depth) for Pinkawillinie, Karkoo, Warramboo, Rudall and Ungarra. Clay RMSE+/-=5.19, sand RMSE=+/-7.19, silt RMSE=+/-2.84.***

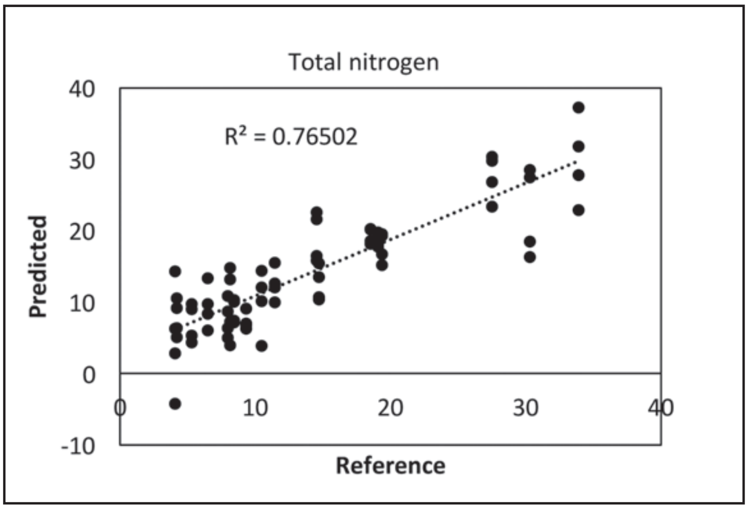


***Figure 10. Relationship between laboratory (reference) and predicted soil nitrogen (%) using the SR-3500. The results are based on the use of dried and ground soil samples from depths 0-10 cm, 10-30 cm, 30-60 cm and 60-100 cm (4 scans for each depth) for Pinkawillinie, Karkoo, Warramboo, Rudall and Ungarra. RMSE=+/-4.27.***

The models used to predict clay (%), sand (%) and silt (%) all presented a very strong correlation of $R^2$ 0.90 (Figure 9). The SR-3500 is also capable of predicting other soil properties such as total nitrogen ($R^2$ 0.77) (Figure 10).

The SR-3500 is a useful tool for monitoring plant nitrogen and biomass in field conditions as well as using ground and dried plant samples. The spectroradiometer is also a good determinant of soil particle size and total nitrogen using dried and ground samples. This instrument has a high initial cost ($113,000), however there are many cheaper field spectrometers available on the market. This technology can be used in place of sending samples to the laboratory for plant and soil N and soil particle size information and unlimited scans can be taken to capture the variability within a paddock which will save costs in the long run. The information can be used to determine the timing of N applications.

## What does this mean?

- Soil moisture probe
  - o A useful, time efficient and cost-effective tool for monitoring soil moisture throughout the soil profile at paddock scale. The information provided by the moisture probes may aid in crop choice decisions by assessing pre-sowing plant available water, potentially provide increased confidence in sowing time by assessing soil moisture reserves, and possibly assist with informed input decisions with the aim of lowering inputs in dry years and increasing yield potential when favourable seasons occur through timing of inputs.

    - The soil moisture data should be collected over more seasons to determine reliability in different conditions.
- SR-3500
    - The infrared spectroradiometer is a good predictor of various plant and soil information on the EP, including plant N in the lab and field at Z3.1, Z4.3 and Z6.5, biomass by combining Z3.1, Z4.3 and Z6.5 into a model, and soil TN and soil particle size using dried and ground samples to any depth.
    - This information could be used to determine the timing of N applications.
    - Further research will involve using the SR-3500 to predict yield and assess how early in the season it can be reliably predicted.
- Using a combination of the soil moisture probes, an infrared spectroradiometer and APSIM provides an opportunity to improve the accuracy of in crop decision making on the EP.
- The tools used in this study have the capability of being used in other areas with different conditions (e.g. rainfall, soil type and crop type).

## Acknowledgements

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## References

1. Pradhan, S.; Bandyopadhyay, K. K.; Sahoo, R. N.; Sehgal, V. K.; Singh, R.; Gupta, V. K.; Joshi, D. K. Predicting Wheat Grain and Biomass Yield Using Canopy Reflectance of Booting Stage. J. Indian Soc. Remote Sens. 2014, 42, 711–718, doi:10.1007/s12524-014-0372-x.
2. Cossani, C. M.; Slafer, G. A.; Savin, R.; Slafer, G. A. Co-limitation of nitrogen and water, and yield and resource-use efficiencies of wheat and barley. Crop Pasture Sci. 2010, 61, 844–851, doi:10.1071/CP10018.
3. Boyd, D. Soil moisture monitoring for crop management. IOP Conf. Ser. Earth Environ. Sci. 2015, 25, 012014, doi:10.1088/1755-1315/25/1/012014.
4. Chanzy, A.; Chadoeuf, J.; Gaudu, J. C.; Mohrath, D.; Richard, G.; Bruckler, L. Soil moisture monitoring at the field scale using automatic capacitance probes. Eur. J. Soil Sci. 1998, 49, 637–648, doi:10.1046/j.1365-2389.1998.4940637.x.
5. Das, B.; Sahoo, R. N.; Pargal, S.; Krishna, G.; Verma, R.; Chinnusamy, V.; Sehgal, V. K.; Gupta, V. K. Comparison of different uni- and multi-variate techniques for monitoring leaf water status as an indicator of water-deficit stress in wheat through spectroscopy. Biosyst. Eng. 2017, 160, 69–83, doi:10.1016/j.biosystemseng.2017.05.007.
6. Soriano-Disla, J. M.; Janik, L. J.; Allen, D. J.; McLaughlin, M. J. Evaluation of the performance of portable visible-infrared instruments for the prediction of soil properties. Biosyst. Eng. 2017, 161, 24–36, doi:10.1016/j.biosystemseng.2017.06.017.
7. Ferrio, J. P.; Bertran, E.; Nachit, M. M.; Català, J.; Araus, J. L. Estimation of grain yield by near-infrared reflectance spectroscopy in durum wheat. Euphytica 2004, 137, 373–380, doi:10.1023/:EUPH.0000040523.52707.1e.
8. Teixeira, E. I.; Brown, H. E.; Sharp, J.; Meenken, E. D.; Ewert, F. Evaluating methods to simulate crop rotations for climate impact assessments – A case study on the Canterbury plains of New Zealand. Environ. Model. Softw. 2015, 72, 304–313, doi:10.1016/j.envsoft.2015.05.012.
9. Hochman, Z.; Rees, H. van; Carberry, P. S.; Hunt, J. R.; McCown, R. L.; Gartmann, A.; Holzworth, D.; Rees, S. van; Dalgliesh, N. P.; Long, W.; Peake, A. S.; Poulton, P. L.; McClelland, T. Re-inventing model-based decision support with Australian dryland farmers. 4. Yield Prophet® helps farmers monitor and manage crops in a variable climate. Crop Pasture Sci. 2009, 60, 1057–1070, doi:10.1071/CP09020.

# Estimating water and N co-limitation levels of wheat using remote sensing technologies across upper Eyre Peninsula

RESEARCH

**Fabio Arsego[1], Andrew Ware[2], C. Mariano Cossani[3] and Victor O. Sadras[3]**

[1]SARDI, Minnipa Agricultural Centre/Port Lincoln, [2]SARDI Port Lincoln, [3]SARDI Waite

**Looking for answers**

**Location**
Minnipa Agricultural Centre, N10 paddock
**Rainfall**
2017 GSR: 141 mm
**Yield**
Potential: 1.2 t/ha (W)
**Paddock History**
2017: Medic pasture
2016: Wheat/Mace
**Soil Type**
Red sandy clay loam
**Plot Size**
5 m x 1.6 m x 3 reps

**Location**
Lock
**Rainfall**
2017 GSR: 191 mm
**Yield**
Potential: 2.8 t/ha (W)
**Paddock History**
2016: Kaspa peas and clover
2015: Barley
2014: Wheat
**Soil Type**
Grey sandy loam
**Plot Size**
5 m x 1.6 m x 3 reps

## Key messages

- **It was possible to estimate N uptake and water content with remote sensing.**
- **Co-limitation of nitrogen and water was associated with wheat yield increases.**

## Why do the trials?

In-season nitrogen applications are challenging for South Australian growers. Due to the high economic risks of extra nitrogen (N) fertilisation, growers miss opportunities to reach maximum attainable yields due to underestimation of optimum fertiliser requirements. Recent studies have proven the positive relationship between the simultaneous limitation of yield (co-limitation) by water and nitrogen, attainable grain yield and water use efficiency. Therefore, growers can reduce management risks and maximise their profit by matching nitrogen requirements with water availability (co-limitation of water and nitrogen levels) during the season.

Spectroradiometry is a type of remote sensing (RS) technology that allows estimation of the nutritional content and stress condition of the crop in a non-destructive way. This tool can be applied to measure in-season co-limitation nitrogen and water levels, assisting growers to make more informed in-season nitrogen decisions. This approach has the potential to minimise economic risks during poor seasons while maximising profit in favourable ones.

The current study aims to validate the 2017 season co-limitation results, and test the remote sensing prediction of water and nitrogen RS status of the crop in different locations of the Eyre Peninsula.

## How was it done?

Field research trials were established across a range of environments with different water availability on Eyre Peninsula with experimental plots at Minnipa, Cummins and Lock. A complete randomised block design with three replicates was used with four genotypes, two N rates and two water availabilities in all locations. Treatments consisted of 60 kg/ha nitrogen with rainfed conditions, and extra nitrogen (100 kg/ha applied at GS31) and water (50 mm/plot applied at GS31). Genotypes consisted of well adapted wheat varieties that have been used during the last 50 years; Halberd (1969), Spear (1984), Mace (2007) and Scepter (2015). Weeds, pests and diseases were managed following practices used for National Variety Trials (NVT).

Soil samples were obtained to estimate water content and N at anthesis and maturity stages. Samples were obtained to a soil depth of 60 cm due to soil structure. Water use was calculated considering water inputs from soil and rainfall.

Stress and co-limitation indices were calculated following the method of Cossani et al. (2010). Nitrogen and water stress indices (NSI and WSI) were calculated following the formulas: NSI=1-((harvested biomass N (N uptake) (kg/ha))/ ((maximum attainable yield (t/ha) x nitrogen reference requirements (kg N))) and WSI=1 - ((rainfall from sowing to anthesis/maturity(mm)+irrigation(mm)-water content in the soil at anthesis (mm)/maturity(mm))/ (maximum attainable yield (t/ha)/ WUE reference requirements)). NSI and WSI were used to derive total, maximum stress indices and co-limitation. Co-limitation indices tending to 1 meant an equilibrium between stress, while co-limitation indices closer to 0 indicate unbalance between limitations.

Spectral data was collected at the same time as soil sampling using a SR-3500 spectroradiometer from Spectral Evolution with 25° (field of view) bare fiber optic. Spectral data were pretreated with standard normal variate, moving average smoothing and Savitzky-Golay derivation. Partial least square regression (pls) was then used to calculate the relationship between pretreated spectral data and nitrogen and water data.

## Results

***Grain yield***

In Minnipa, low rainfall conditions (122 mm from sowing to maturity) affected the overall crop yield performance to an average yield of 1.2 t/ha. Lock had better rainfall conditions (215 mm from sowing to maturity) resulting in an overall crop yield of 2.8 t/ha. Highly significant ($P<0.001$) variation for grain yield was found across extra water treatments, varieties, environments and growth stages. Significant interactions were observed between varieties and environments ($P<0.001$), and between environments and growth stage (Z65 and Z70). No significant variability and interaction was detected for extra nitrogen application, as previously observed in Minnipa 2016. This result may suggest the varieties performance may depend on a better adaption to nitrogen use and responsiveness to extra water application with a significant impact of environment and growth stages. Scepter and Mace were equally the best performing varieties in both sites (Table 1). At Lock, Scepter and Mace yielded an average of 3.55 t/ha with an extra 50 mm of irrigation reaching a yield advantage of 0.5 t/ha. In Minnipa, both varieties had an average yield of 1.67 t/ha with the extra 50 mm of irrigation at stem elongation and 0.6 t/ha of yield advantage. In Minnipa rainfed conditions, Scepter yielded an average of 1.14 t/ha, while Mace was 1.04 t/ha. The lower yielding varieties were Spear in Lock (average grain yield 1.73 t/ha) and Halberd in Minnipa (0.73 t/ha) in rainfed conditions.

***Table 1. Grain yield averages (t/ha) across varieties, treatments and environments.***

| Environment | Treatment | Variety | Mean grain yield (t/ha)±SE |
|---|---|---|---|
| Lock | Irrigated | Halberd | 2.53 ± 1.19 |
| Lock | Rainfed | Halberd | 1.73 ± 0.69 |
| Lock | Irrigated | Spear | 2.81 ± 2.34 |
| Lock | Rainfed | Spear | 2.38 ± 1.35 |
| Lock | Irrigated | Mace | 3.55 ± 1.73 |
| Lock | Rainfed | Mace | 2.97 ± 1.57 |
| Lock | Irrigated | Scepter | 3.55 ± 1.43 |
| Lock | Rainfed | Scepter | 3.11 ± 1.36 |
| Minnipa | Irrigated | Halberd | 1.1 ± 0.97 |
| Minnipa | Rainfed | Halberd | 0.96 ± 1.20 |
| Minnipa | Irrigated | Spear | 1.18 ± 0.86 |
| Minnipa | Rainfed | Spear | 0.73 ± 0.64 |
| Minnipa | Irrigated | Mace | 1.66 ± 0.21 |
| Minnipa | Rainfed | Mace | 1.05 ± 0.36 |
| Minnipa | Irrigated | Scepter | 1.68 ± 0.95 |
| Minnipa | Rainfed | Scepter | 1.14 ± 1.16 |

***Partial least square regression*** (pls) was used to calculate the relationship between pretreated spectral data and nitrogen and water data Across all remote sensing (spectroradiometry) calibrations for water and nitrogen content at maturity, the $R^2$ was greater than 0.93 (Figure 1a-b). These values suggested the regression was good with no overfitting on the calibration models. Minnipa had similar calibration curves (Figure 1a, maturity) to Lock (Figure 1b, maturity). At both sites, water content data tended to cluster at maturity (Figure 1a-b), maybe due to leaves starting to senesce. The resulting reflectance predictions of water and nitrogen were then added in the WSI and NSI formulas as water content at maturity (mm) and harvested biomass N (kg/ha) at maturity.

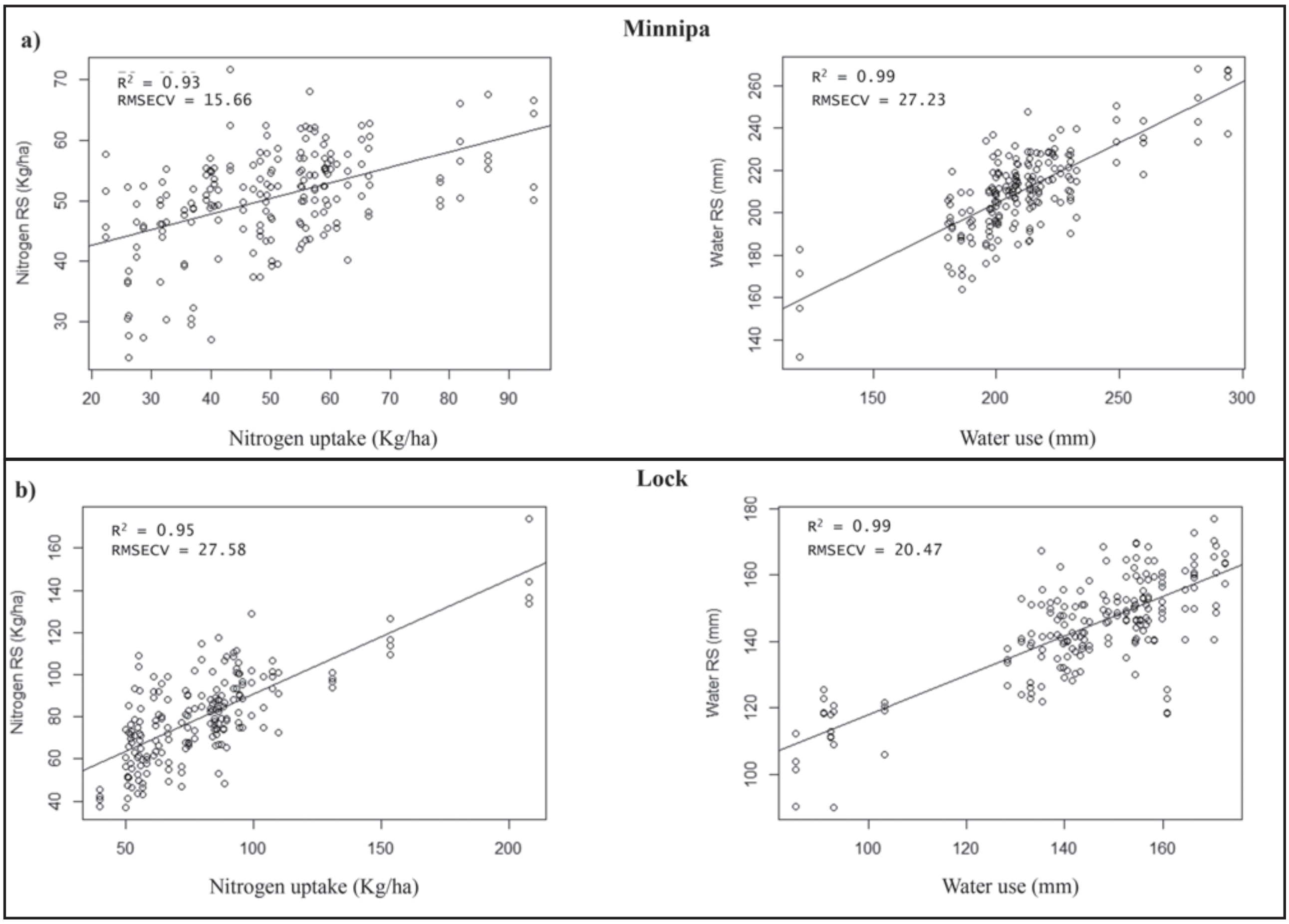


***Figure 1a and b. Calibration lines of water and nitrogen RS predictions vs. actual values at Minnipa (a, maturity) and Lock (b, maturity). The RMSECV (Root mean square error of cross validation) is a measure of deviation between actual and predicted data.***

***Nitrogen and water content RS predictions vs oven dried method***

Water and nitrogen remote sensing predictions were plotted against the actual water and nitrogen values taking into effect the environments and corresponding treatments (Figure 2a-b). As a result, water data seemed to have the best fit ($R^2$=0.97, SE=6.03, Figure 2a) compared to the nitrogen treatment ($R^2$=0.75, SE=10.97, Figure 2b).

An ANOVA test was performed to look at the relationships between variables. In both trials, significant variability ($P<0.001$) was found across water and nitrogen measurements. Lock had also significant ($P<0.01$) variation in nitrogen treatments ($P<0.001$), while Minnipa had significant ($P<0.001$) differences in water treatments. These results suggest that remote sensing can predict water content and nitrogen, however, treatments and variety detection were affected by the environment.

***Co-limitation indices traditional methods vs. RS***

At maturity, co-limitation indices and biomass (kg/ha) were calculated for each cultivar at both trials (Figure 3a-c and Figure 4a-c). In Lock, positive significant relationship ($P<0.001$) have been found between grain yield (kg/ha) and co-limitation indices at both water ($R^2$=0.72, SE=544.5) and nitrogen treatments ($R^2$=0.64, SE=619.3). Interestingly, remote sensing predictions at both trials had a better fit for nitrogen treatment ($R^2$=0.64, SE=613) compared to the actual measurements (Figure 3b). In Minnipa, significant relationships ($P<0.001$, $R^2$=0.29) between co-limitation indices and grain yield were found only under water treatment (Figure 3a).

## What does this mean?

Lock results were in line with the Minnipa 2016 co-limitation experiment and confirmed the positive relationship between co-limitation indices and yield. Nitrogen and water measurements of remote sensing and traditional methods were highly correlated at both stages and environments. However, remote sensing was not capable of detecting differences between varieties and treatments in a consistent way across environments.

Remote sensing technology has a great potential for estimating water and nitrogen content in wheat instead of applying traditional methods, however, further studies need to address environment confounding effects and lack of genotypic variability.

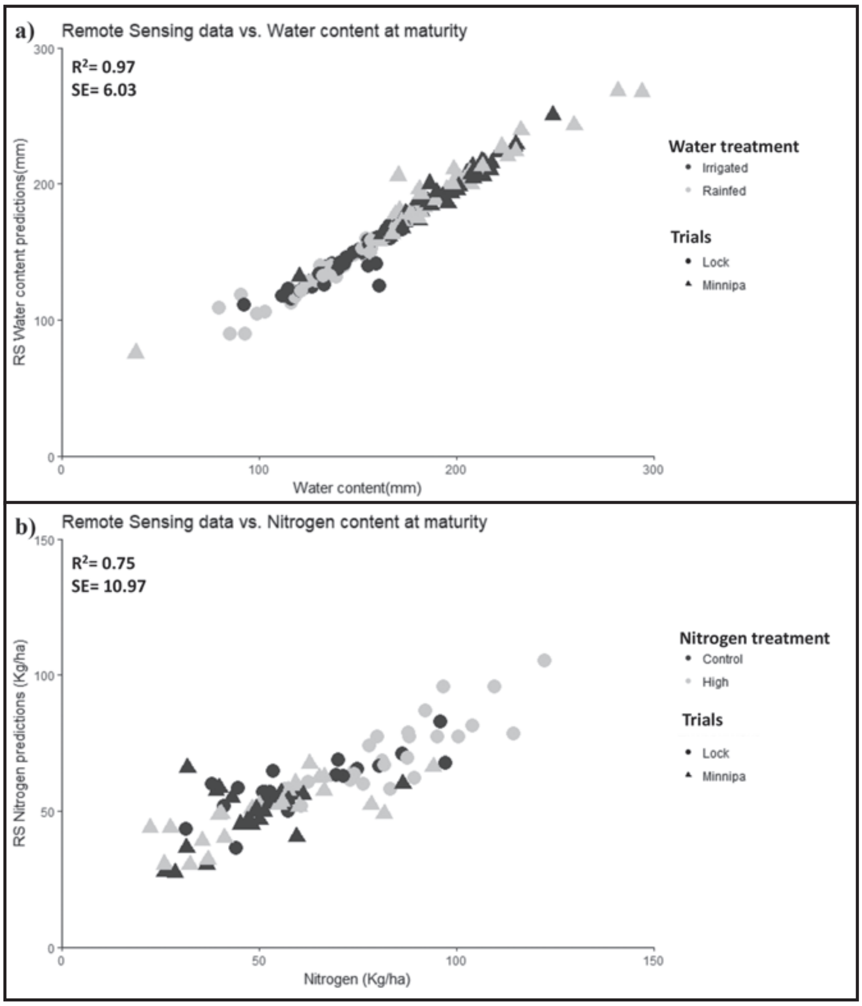


***Figure 2a and b. Relationships between traditional and RS methods for assessing water (a, mm) and nitrogen (b, kg/ha) content.***


## Acknowledgements

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GRAINS RESEARCH & DEVELOPMENT CORPORATION

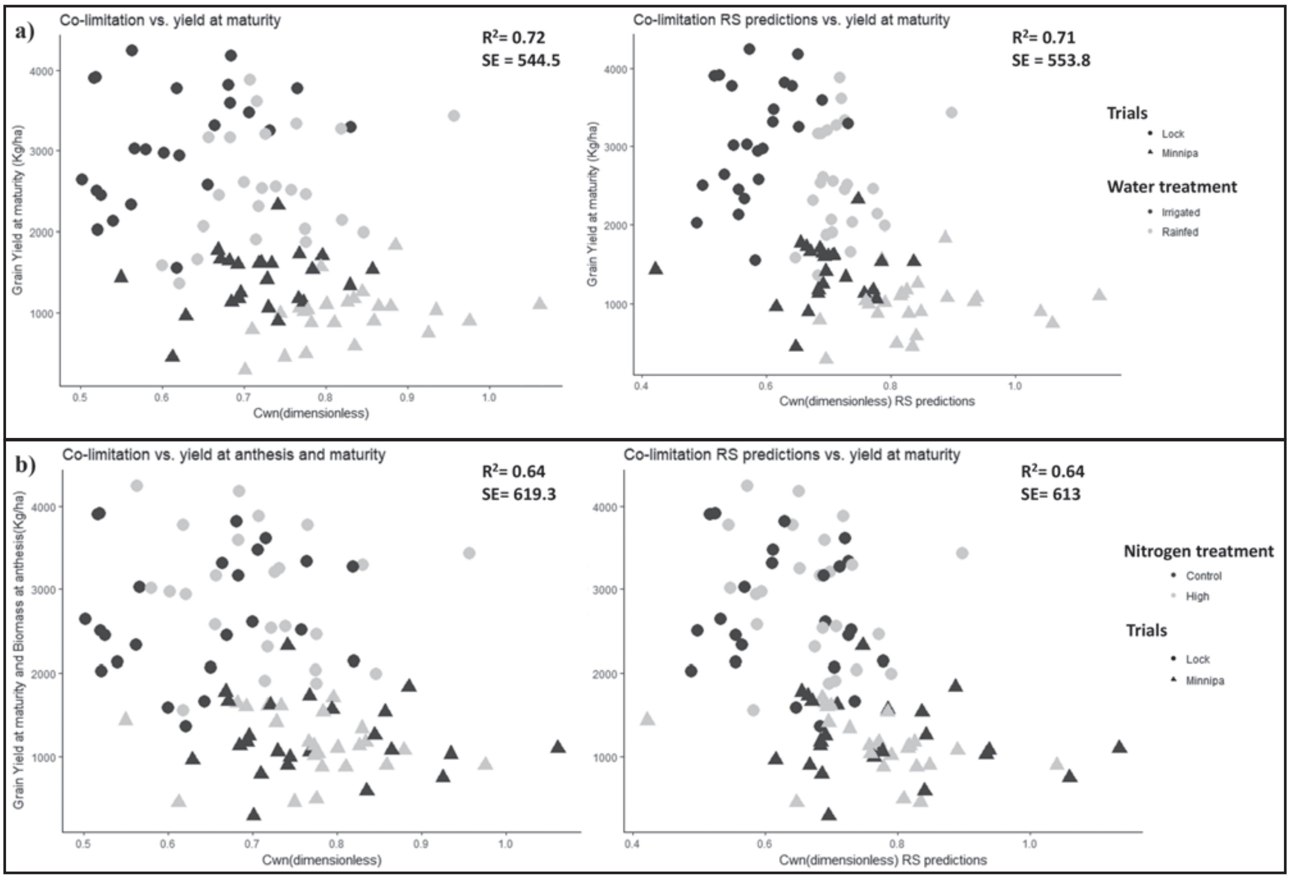


***Figure 3a and b. Comparing traditional and RS methods for assessing co-limitation indices and grain yield relationships at maturity in Lock and Minnipa.***

# The genetics of wheat harvest quality

**William Fairlie[1], James Edwards[2] and Haydn Kuchel[1,2]**

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RESEARCH




## Key messages

- **The digital protocol for rapid black point assessment has been validated.**
- **The digital protocol for threshability assessment has been established.**
- **Validation of pre-harvest sprouting (PHS) markers has occurred which will assist in early generation selection.**

## Why do the trial?

Wheat harvest quality is an important component of gross-return to grain growers. Accumulators will downgrade deliveries which contain sprouted grains, low falling number (minimum of 300 seconds), excessive black pointed grains (5% tolerance), unmillable material above the screen (0.6% tolerance) or a low test weight (minimum 76 kg/hL). Previous studies have relied upon labour-intensive manual assessment methods for black point and threshability when studying the genetic background of these traits in wheat. This limits the amount of germplasm that can be assessed, thus limiting early stage selection in breeding programmes. This is further disrupted by the strong influence of maturity and environmental conditions on the expression of black point, threshability and PHS. The aim of this research is to validate the high-throughput digital protocol for black point, establish a digital protocol for threshability and to validate the effects of recently published PHS resistance DNA markers using Australian Grain Technologies Pty. Ltd. (AGT) breeding data.

## How was it done?

Gladius, Scout and Mace were crossed to produce three breeding populations. These three varieties have a diverse phenotypic response for the three target traits. Scout is susceptible to black point, has poor threshability, and is resistant to sprouting. Mace, on the other hand, is moderately resistant to black point, has good threshability, and a moderate level of sprouting resistance. Gladius is susceptible to sprouting, moderately susceptible to black point and has moderately good threshability.

Three breeding populations consisting of crosses between Gladius/Scout (124 lines), Scout/Mace (171 lines) and Gladius/Mace (234 lines) were sown in single, 2.5 m long rows at Roseworthy (on 3 June 2016) and were also sown in plots of 1.3 x 3.2 m at three sites: Angas Valley (1 June 2016), Roseworthy (15 May 2016) and Winulta (18 May 2016). The plots were harvested at harvest maturity using a Wintersteiger Classic plot harvester.

The plot and row samples were analysed for black point incidence using a pre-existing digital imaging protocol. To validate the digital protocol, a 300-grain sample of a subset of the row experiment samples was manually counted for black point incidence. Grains were considered as being affected by black point when staining affected more than half of the germ.

The grain samples from the row experiment were analysed for pre-harvest sprouting and threshability. Threshability was measured by manually separating unthreshed material from clean grain, and calculating the percentage by weight. A digital imaging protocol was also developed, to enable rapid digital assessment.

For pre-harvest sprouting assessment, three heads from 650 breeding lines in the row experiment were plucked at physiological maturity, which coincides with the grain being at approximately 20% moisture. The grains from these heads were sprouted in a laboratory experiment, where the grains were germinated in the dark at a room temperature of 20°C. Grains were classified as being germinated once the germ had visibly split. Germinated grains were counted and removed every 24 hours for seven days, and sound, ungerminated grains also counted on the seventh day. A germination index (GI) (range of 0 to 1) was then calculated. Additional PHS resistance data was provided by AGT on 1463 lines from advanced breeding trials between 2011-2016. All of the lines from the breeding populations and the 1463 lines provided by AGT were characterised using DNA markers for the presence or absence of three genes known to contribute to improved PHS resistance. The AGT breeding lines were used to validate how useful these DNA markers will be as tools to breed future varieties with improved PHS resistance.

## What happened?

There was a strong ($r^2$=0.83, P<0.001) positive correlation between manual and digital assessment of black point incidence using the AGT imaging protocol (Figure 1). This correlation illustrates that the digital assessment protocol is an accurate and very fast method to measure black point compared to other assessment methods.

Digital image analysis generated a strong correlation ($r^2$=0.63, P<0.001) (Figure 2a) and ($r^2$=0.53, P<0.001) (Figure 2b) between a digital count (TCP) and a manual count of unthreshed material, and digital area (TAP) and a manual area measurement of unthreshed material, respectively. The strong correlation for each of these traits offers an accurate and direct assessment of threshability.

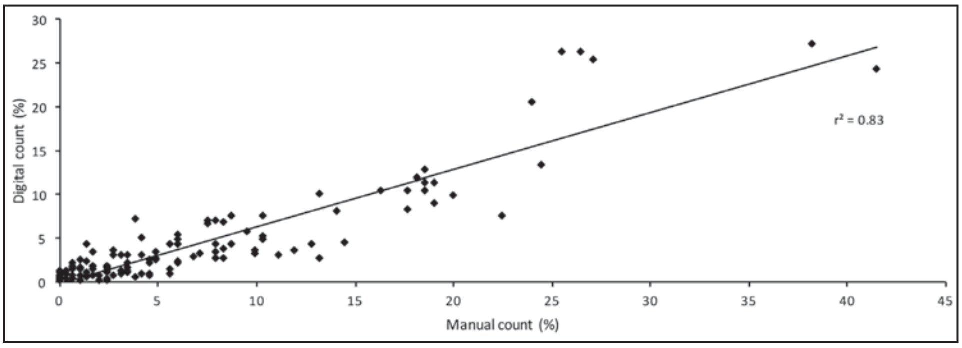


***Figure 1. Comparison of manually counted black point incidence and black point incidence determined by the AGT imaging protocol in clean row experiment samples. Line of best fit shown, (P<0.001).***

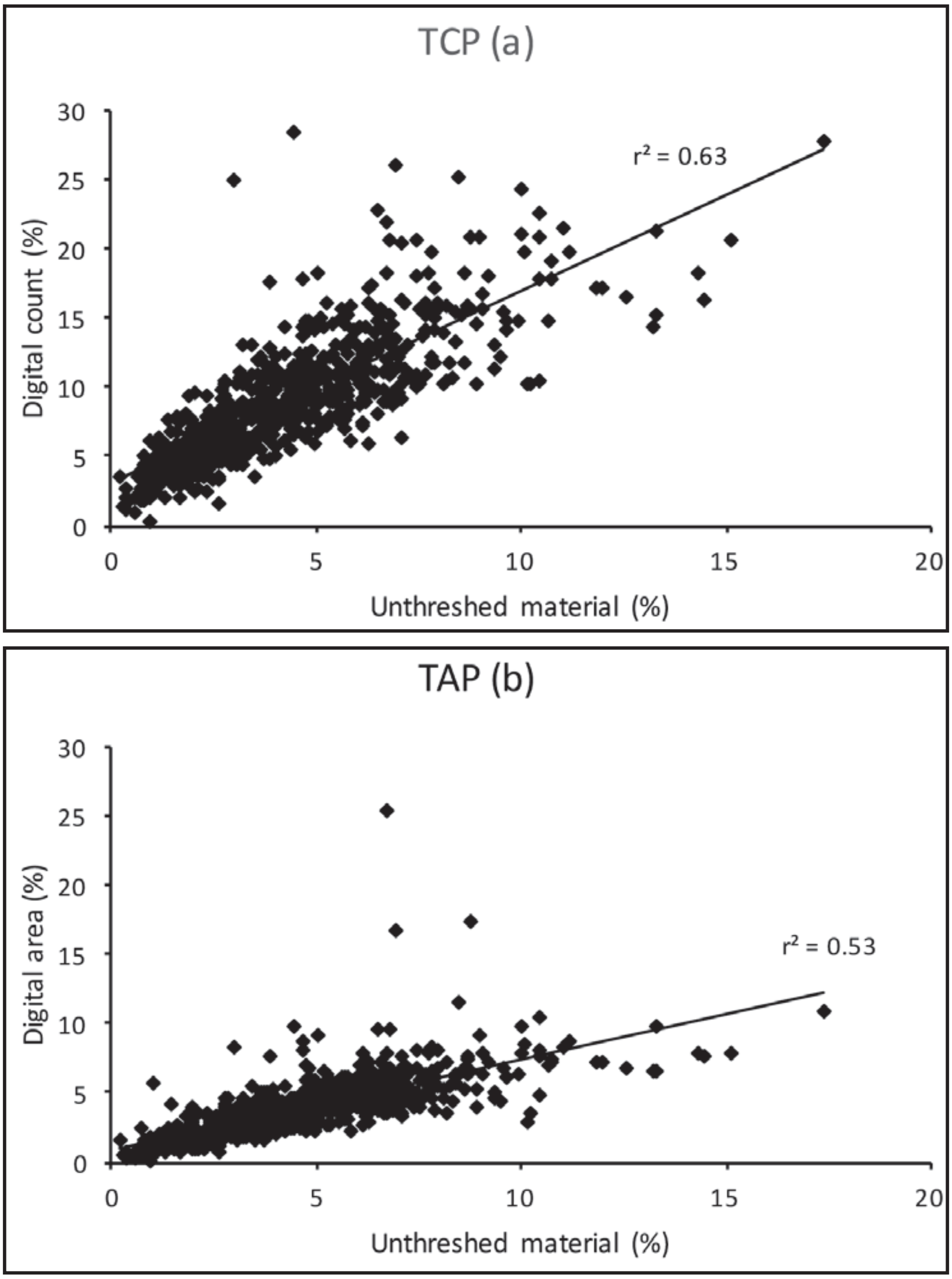


***Figure 2. a) digital count percentage of unthreshed material (TCP) and b) digital area percentage of unthreshed material (TAP), P<0.001, plotted against a manual measurement of unthreshed material in 648 grain samples.***

All four of the DNA markers that were tested improved the PHS resistance of varieties. Three of these four markers appear to be selecting for a significant improvement in sprouting resistance within the AGT germplasm. The presence of each of these three markers generated an improvement of 0.039 to 0.042 on the GI scale. This is a measurable difference in the field which would differentiate between a variety particularly susceptible to sprouting (Gladius) and a moderately susceptible (Mace) variety.

## What does this mean?

The high-throughput imaging protocols developed for black point and threshability assessment have been demonstrated to accurately assess black point and threshability of grain samples. The high-throughput digital protocol will allow much faster phenotyping of germplasm. Previously, assessment was limited to only several hundred breeding lines, as opposed to the tens of thousands that can be assessed using the digital protocol. This will allow phenotypic selection in earlier generations, as opposed to late stage breeding lines.

Pre-harvest sprouting resistance selection based solely on the four DNA PHS markers can occur immediately since these markers have now been validated in a large breeding dataset. These markers can be used in early generations to enhance the level of PHS resistance in breeding germplasm, where pyramiding of at least two markers appears to select for an adequate base level of genetic PHS resistance. This base level of sprouting resistance will mean breeders can quickly and easily eliminate varieties with a genetic background that is susceptible to PHS, such as Gladius.

The more direct, high throughput assessment of black point and threshability, in addition to the validation of developed PHS DNA markers will enable breeders to increase early generation selection, with enhanced performance incorporated into new varieties, benefiting growers. Improved varieties will result in higher returns to growers through less downgrading associated with unmillable material above the sieve, test weight, black point and sprouted grains.

## Acknowledgements

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## **Upper Eyre Peninsula wheat variety yield performance** *2017 and long term (2013-2017) expressed as t/ha and % of site average yield*

| Variety | Upper Eyre Peninsula | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 (as % site average) | | | | | | | Long term yield brackets (2013-2017) | | | | | | |
| | Kimba | Minnipa | Mitchellville | Nunjikompita | Penong | Piednippie | Warramboo | No. Trials | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 |
| Axe | 82 | 97 | 102 | 78 | 92 | trial not sown | 106 | 29 | 110 | 95 | 92 | 91 | 95 | 96 |
| Beckom | 98 | 95 | 105 | 110 | 98 | | 109 | 29 | 106 | 106 | 109 | 110 | 107 | 106 |
| Chief CL Plus | 107 | 87 | 97 | 106 | 111 | | 94 | 16 | 102 | 104 | - | 104 | 104 | 103 |
| Cobalt | 100 | 96 | 108 | 114 | 106 | | 125 | 23 | 113 | 108 | 112 | 109 | 107 | 105 |
| Corack | 91 | 103 | 84 | 94 | 107 | | 99 | 29 | 109 | 103 | 108 | 100 | 105 | 106 |
| Cosmick | 116 | 98 | 107 | 102 | 92 | | 92 | 29 | 104 | 104 | 105 | 107 | 105 | 104 |
| Cutlass | 93 | 85 | 97 | 99 | 97 | | 83 | 20 | 98 | 102 | 101 | 102 | 99 | 99 |
| DS Darwin | - | - | - | - | - | | - | - | - | - | - | - | - | - |
| DS Pascal | - | - | - | - | - | | - | - | - | - | - | - | - | - |
| Emu Rock | 106 | 102 | 105 | 96 | 102 | | 99 | 29 | 113 | 101 | 101 | 102 | 104 | 102 |
| Estoc | 92 | 83 | 85 | 101 | 104 | | 87 | 29 | 98 | 99 | 98 | 98 | 97 | 98 |
| Gladius | 111 | 110 | 101 | 94 | 108 | | 102 | 29 | 102 | 97 | 95 | 96 | 97 | 97 |
| Grenade CL Plus | 89 | 101 | 91 | 90 | 105 | | 94 | 29 | 105 | 97 | 93 | 96 | 96 | 96 |
| Hatchet CL Plus | 85 | 101 | 97 | 90 | 101 | | 112 | 29 | 107 | 96 | 92 | 94 | 97 | 96 |
| Kord CL Plus | 81 | 92 | 85 | 104 | 100 | | 95 | 29 | 105 | 97 | 93 | 93 | 95 | 95 |
| LRPB Arrow | 103 | 104 | 95 | 104 | 103 | | 95 | 20 | 101 | 105 | 109 | 107 | 107 | 106 |
| LRPB Cobra | 100 | 91 | 87 | 92 | 97 | | 70 | 29 | 89 | 100 | 102 | 104 | 104 | 104 |
| LRPB Havoc | 96 | 112 | 94 | 99 | 101 | | 115 | 13 | 106 | 103 | | 103 | 107 | 106 |
| LRPB Scout | 113 | 99 | 86 | 101 | 86 | | 92 | 29 | 97 | 100 | 98 | 102 | 101 | 101 |
| LRPB Trojan | 123 | 104 | 94 | 113 | 105 | | 89 | 29 | 93 | 103 | 106 | 103 | 102 | 104 |
| Mace | 108 | 108 | 95 | 102 | 84 | | 112 | 29 | 108 | 103 | 107 | 102 | 105 | 105 |
| Scepter | 102 | 111 | 116 | 109 | 93 | | 117 | 20 | 116 | 109 | 114 | 108 | 110 | 109 |
| Shield | 95 | 102 | 105 | 102 | 104 | | 105 | 29 | 111 | 102 | 100 | 104 | 102 | 99 |
| Tenfour | 110 | 98 | 108 | 98 | 107 | | 100 | 23 | 106 | 105 | 110 | 108 | 110 | 109 |
| Wyalkatchem | 98 | 106 | 103 | 105 | 97 | | 97 | 29 | 101 | 102 | 105 | 103 | 104 | 103 |
| Yitpi | 95 | 84 | 98 | 103 | 101 | | 79 | 29 | 95 | 97 | 93 | 96 | 93 | 94 |
| **Site av. yield (t/ha)** | **2.07** | **0.98** | **1.19** | **1.10** | **0.59** | | **0.75** | | **0.74** | **1.29** | **1.89** | **2.10** | **2.78** | **3.32** |
| *LSD % (P=0.05)* | *20* | *15* | *5* | *8* | *17* | | *14* | No Trials | 5 | 7 | 3 | 5 | 5 | 4 |
| Date sown | 03 May 17 | 16 Jun 17 | 02 May 17 | 08 May 17 | 08 May 17 | | 19 Jun 17 | | | | | | | |
| Soil type | LSL | LSL | LSL | LSL | LSL | | L | | | | | | | |
| Rainfall (mm) J-M/A-O | 110/161 | 85/155 | 115/110 | 80/135 | 96/170 | | 82/178 | | | | | | | |
| pH (water) | 8.6 | 8.5 | 8.6 | 8.7 | 8.8 | | 8.7 | | | | | | | |
| Previous crop | g/f pasture | g/f pasture | g/f pasture | pasture | pasture | | g/f pasture | | | | | | | |

**Abbreviations**
Soil type: S=sand, L=loam
g/f=grass free

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2013-2017)**

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

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

*2017 and long term (2013-2017) expressed as t/ha and % of site average yield*

| Variety | Mid and Lower Eyre Peninsula | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 (as % site average) | | | Long term yield brackets (2013-2017) | | | | | | | |
| | Cummins | Rudall | Wanilla | No. Trials | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 6 |
| Axe | 94 | 88 | 95 | 15 | 97 | 82 | 93 | 94 | 94 | 86 | 90 |
| Beckom | 110 | 105 | 110 | 15 | 109 | 116 | 109 | 111 | 107 | 109 | 108 |
| Chief CL Plus | 92 | 99 | 100 | 8 | 107 | | 109 | 101 | 102 | - | 98 |
| Cobalt | - | - | - | | - | - | - | - | - | - | - |
| Corack | 104 | 102 | 115 | 15 | 109 | 109 | 112 | 108 | 109 | 105 | 101 |
| Cosmick | 100 | 100 | 107 | 15 | 105 | 109 | 105 | 108 | 105 | 107 | 107 |
| Cutlass | 107 | 103 | 112 | 9 | 101 | - | 98 | 98 | 100 | - | 104 |
| DS Darwin | 94 | 85 | 87 | 14 | 94 | - | 95 | 96 | 98 | 98 | 98 |
| DS Pascal | 81 | 82 | 76 | 5 | 84 | - | 82 | 91 | - | - | 100 |
| Emu Rock | 87 | 96 | 98 | 15 | 104 | 99 | 103 | 107 | 102 | 98 | 99 |
| Estoc | 97 | 99 | 94 | 15 | 98 | 96 | 96 | 96 | 98 | 98 | 100 |
| Gladius | 77 | 99 | 85 | 15 | 97 | 90 | 94 | 96 | 96 | 94 | 97 |
| Grenade CL Plus | 87 | 100 | 76 | 15 | 97 | 87 | 93 | 96 | 95 | 91 | 95 |
| Hatchet CL Plus | 88 | 97 | 88 | 15 | 96 | 84 | 93 | 97 | 94 | 89 | 92 |
| Kord CL Plus | 83 | 100 | 87 | 15 | 97 | 86 | 92 | 92 | 94 | 89 | 93 |
| LRPB Arrow | 102 | 98 | 100 | 9 | 107 | - | 110 | 109 | 107 | - | 106 |
| LRPB Cobra | 102 | 81 | 95 | 15 | 97 | 109 | 104 | 108 | 106 | 111 | 108 |
| LRPB Havoc | 115 | 94 | 112 | 5 | 108 | - | 113 | 110 | - | - | 100 |
| LRPB Scout | 101 | 100 | 96 | 15 | 97 | 99 | 98 | 105 | 102 | 105 | 106 |
| LRPB Trojan | 97 | 95 | 104 | 15 | 101 | 111 | 105 | 105 | 109 | 113 | 111 |
| Mace | 111 | 114 | 96 | 15 | 108 | 109 | 110 | 107 | 106 | 104 | 101 |
| Scepter | 122 | 118 | 110 | 9 | 116 | - | 116 | 114 | 112 | - | 108 |
| Shield | 101 | 104 | 98 | 15 | 104 | 99 | 98 | 102 | 96 | 94 | 97 |
| Tenfour | - | - | - | - | - | - | - | - | - | - | - |
| Wyalkatchem | 97 | 98 | 101 | 15 | 104 | 108 | 106 | 104 | 102 | 103 | 101 |
| Yitpi | 83 | 95 | 95 | 14 | 94 | | 90 | 89 | 92 | 93 | 96 |
| **Site av. yield (t/ha)** | **3.11** | **2.42** | **3.28** | | **2.37** | **2.53** | **3.21** | **3.92** | **4.19** | **5.36** | **5.83** |
| *LSD % (P=0.05)* | *7* | *6* | *6* | No Trials | 2 | 1 | 4 | 2 | 4 | 1 | 1 |
| Date sown | 20 Jun 17 | 19 Jun 17 | 02 Jun 17 | | | | | | | | |
| Soil type | L | LSL | LS | | | | | | | | |
| Rainfall (mm) J-M/A-O | 88/234 | 91/190 | 63/298 | | | | | | | | |
| pH (water) | 8.3 | 8.7 | 5.7 | | | | | | | | |
| Previous crop | Canola | Faba beans | Lupin | | | | | | | | |

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

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2012-2017)**
**Data analysis by GRDC funded National Statistics Group**

**_Upper Eyre Peninsula barley variety yield performance_** *2017 and long term (2013-2017) expressed as t/ha and % of site average yield*

| Variety | UPPER EYRE PENINSULA | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 (as % site average) | | | | Long term yield brackets (2013-2017) | | | | | | | | | |
| | Darke Peak | Elliston | Minnipa | Piednippie | No Trials | 1 | 1.5 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 |
| Alestar | Harvest results not suitable for release | 91 | Harvest results not suitable for release | Trial not sown | 18 | 74 | 86 | 102 | 95 | 99 | 95 | 95 | 98 | 104 |
| Bottler | | - | | | - | - | - | - | - | - | - | - | - | - |
| Commander | | 99 | | | 18 | 92 | 102 | 93 | 105 | 99 | 102 | 98 | 104 | 98 |
| Compass | | 113 | | | 18 | 146 | 149 | 112 | 112 | 119 | 114 | 120 | 106 | 90 |
| Fathom | | 105 | | | 18 | 116 | 123 | 100 | 111 | 100 | 113 | 115 | 111 | 103 |
| Fleet | | 109 | | | 18 | 106 | 112 | 92 | 108 | 98 | 107 | 106 | 108 | 98 |
| Flinders | | - | | | 12 | - | 86 | 100 | 92 | 96 | 92 | 94 | - | - |
| Grange | | - | | | 12 | - | 89 | 101 | 97 | 98 | 96 | 94 | - | - |
| Hindmarsh | | 105 | | | 18 | 146 | 135 | 116 | 105 | 116 | 107 | 112 | 99 | 93 |
| Keel | | 94 | | | 18 | 146 | 125 | 99 | 106 | 103 | 108 | 115 | 102 | 93 |
| La Trobe | | 100 | | | 18 | 137 | 133 | 115 | 107 | 115 | 109 | 111 | 102 | 95 |
| Maltstar | | 82 | | | 18 | 52 | 83 | 98 | 98 | 94 | 99 | 99 | 105 | 109 |
| Oxford | | - | | | 12 | - | 64 | 91 | 95 | 86 | 93 | 86 | - | - |
| RGT Planet | | 100 | | | 6 | 43 | - | - | 107 | - | 112 | - | 114 | 115 |
| Rosalind | | 109 | | | 14 | 107 | 140 | - | 113 | 120 | 116 | 117 | 111 | 104 |
| Scope | | 102 | | | 18 | 118 | 98 | 97 | 98 | 98 | 97 | 99 | 96 | 96 |
| Spartacus CL | | 105 | | | 14 | 145 | 139 | - | 109 | 117 | 110 | 113 | 103 | 94 |
| Topstart | | 85 | | | 14 | 41 | 68 | 91 | 97 | 88 | 95 | 88 | - | - |
| Westminster | | - | | | - | - | - | - | - | - | - | - | - | - |
| **Site av. yield (t/ha)** | | **3.62** | | | | **0.72** | **1.11** | **2.21** | **2.85** | **3.07** | **3.67** | **4.06** | **4.53** | **5.01** |
| *LSD % (P=0.05)* | | *5* | | | No Trials | 1 | 2 | 1 | 5 | 1 | 5 | 1 | 1 | 1 |
| Date sown | 19 Jun 17 | 20 Jun 17 | 16 Jun 17 | | | | | | | | | | | |
| Soil type | LS | SL | LSL | LSL | | | | | | | | | | |
| Rainfall (mm) J-M/A-O | 71/ 184 | 107/ 273 | 85/ 155 | | | | | | | | | | | |
| pH (water) | 7.9 | 8.2 | 8.5 | | | | | | | | | | | |
| Previous crop | g/f pasture | g/f pasture | g/f pasture | | | | | | | | | | | |
| Site stress factors | d | | d | d | | | | | | | | | | |

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

Site stresses: d=droughted

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2013-2017)**
**Data analysis by GRDC funded National Statistics Group**

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

*2017 and long term (2013-2017) expressed as t/ha and % of site average yield*

| Variety | MID AND LOWER EYRE PENINSULA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 (% site average) | | | Long term yield brackets (2013-2017) | | | | | | |
| | Wanilla | Wharminda | Cummins | No. Trials | 1.5 | 3.5 | 4 | 4.5 | 5 | 6.5 |
| Alestar | 96 | 73 | 91 | 12 | 82 | 94 | 97 | 98 | 100 | 106 |
| Bottler | 104 | 88 | 95 | 3 | 81 | - | 100 | - | 102 | - |
| Commander | 80 | 138 | 101 | 14 | 115 | 100 | 100 | 102 | 102 | 95 |
| Compass | 106 | 131 | 106 | 14 | 144 | 119 | 109 | 110 | 105 | 95 |
| Fathom | 107 | 127 | 99 | 14 | 110 | 110 | 109 | 106 | 102 | 99 |
| Fleet | 102 | 125 | 99 | 14 | 119 | 103 | 102 | 103 | 100 | 93 |
| Flinders | 105 | 100 | 97 | 14 | 86 | 94 | 96 | 94 | 96 | 101 |
| Grange | 113 | 69 | 103 | 14 | 87 | 97 | 99 | 98 | 101 | 104 |
| Hindmarsh | 90 | 132 | 109 | 14 | 124 | 116 | 108 | 106 | 104 | 100 |
| Keel | 88 | 106 | 88 | 14 | 123 | 108 | 103 | 102 | 96 | 92 |
| La Trobe | 102 | 134 | 106 | 14 | 122 | 116 | 109 | 107 | 106 | 101 |
| Maltstar | 94 | 64 | 97 | 12 | 75 | 92 | 96 | 100 | 99 | 107 |
| Oxford | 98 | 61 | 103 | 14 | 64 | 87 | 96 | 96 | 100 | 107 |
| RGT Planet | 104 | 84 | 111 | 6 | 75 | - | 110 | 112 | 112 | 122 |
| Rosalind | 116 | 117 | 109 | 12 | 112 | 121 | 116 | 113 | 112 | 111 |
| Scope | 92 | 120 | 88 | 14 | 105 | 98 | 98 | 97 | 97 | 96 |
| Spartacus CL | 101 | 129 | 104 | 12 | 128 | 118 | 111 | 108 | 107 | 100 |
| Topstart | 95 | 67 | 96 | 12 | 69 | 88 | 96 | 97 | 101 | 107 |
| Westminster | 92 | 74 | 90 | 14 | 69 | 83 | 90 | 90 | 95 | 102 |
| **Site av. yield (t/ha)** | **3.87** | **1.25** | **4.73** | | **1.26** | **3.29** | **3.76** | **4.34** | **4.73** | **6.49** |
| *LSD % (P=0.05)* | *15* | *17* | *8* | No Trials | 1 | 2 | 4 | 3 | 3 | 1 |
| Date sown | 02-Jun-17 | 10-Jul-17 | 20-Jun-17 | | | | | | | |
| Soil type | LS | LS | L | | | | | | | |
| Rainfall (mm) J-M/A-O | 63/298 | 60/205 | 88/234 | | | | | | | |
| pH (water) | 5.7 | 6.4 | 8.3 | | | | | | | |
| Previous crop | Lupin | g/f pasture | Canola | | | | | | | |

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

**Data source: NVT & SARDI/GRDC (long term data based on weighted analysis of sites, 2012-2017)**
**Data analysis by GRDC funded National Statistics Group**

Cereals

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# Section 4

# Break Crops

### *Eyre Peninsula field pea variety trial yield performance 2017*
*(as a % of site mean) and long term (2013-2017) average across sites (as % of site mean)*

| | **Lower Eyre Peninsula** | | | | | | | **Upper Eyre Peninsula** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **2017** | | **2013-2017** | | | | | **2013 - 2017** | | | |
| | **Murdinga** | **Yeelanna** | **Trial #** | **Yield Bracket (t/ha)** | | | | **Trial #** | **Yield Bracket (t/ha)** | | |
| | | | | **1.5** | **2** | **2.5** | **3** | | **1** | **2** | **3** |
| Kaspa | 93 | 94 | 10 | 91 | 92 | 86 | 100 | 4 | 111 | 100 | 90 |
| Parafield | 74 | 82 | 8 | 74 | 83 | 88 | 107 | 1 | 79 | - | - |
| PBA Butler | 106 | 102 | 10 | 112 | 104 | 115 | 113 | 3 | 123 | 108 | 103 |
| PBA Gunyah | 102 | 103 | 10 | 96 | 97 | 91 | 111 | 3 | 110 | 104 | 99 |
| PBA Oura | 113 | 98 | 10 | 101 | 103 | 110 | 111 | 4 | 95 | 97 | 94 |
| PBA Pearl | 110 | 99 | 10 | 113 | 109 | 127 | 110 | 4 | 105 | 99 | 96 |
| PBA Percy | 84 | 103 | 10 | 97 | 100 | 107 | 133 | 3 | 111 | 101 | 87 |
| PBA Twilight | - | - | 6 | 88 | 94 | 84 | - | 3 | 100 | 100 | 96 |
| PBA Wharton | 88 | 113 | 10 | 91 | 96 | 96 | 112 | 4 | 83 | 99 | 101 |
| **Site mean yield (t/ha)** | **1.47** | **1.89** | | **1.39** | **1.74** | **2.27** | **2.70** | | **0.85** | **1.65** | **2.88** |
| *LSD (P=0.05) (%)* | *14* | *8* | | | | | | | | | |
| Date sown | 06/07 | 06/07 | | | | | | | | | |
| Soil type | SL | SL | | | | | | | | | |
| Previous crop | Barley | Wheat | | | | | | | | | |
| Rainfall (mm) J-M/A-O | 56/165 | 59/227 | | | | | | | | | |
| pH (water) | 8.7 | 7.7 | | | | | | | | | |
| Site stress factors | de | de | | | | | | | | | |

Soil types: S=sand, L=loam
Site stress factors: de=pre flowering moisture stress
**Data source: SARDI/GRDC, PBA & NVT (long term data based on weighted analysis of sites and courtesy National Statistics Program).**

## *Lower Eyre Peninsula lupin variety trial yield performance 2017*

*and long term average accross sites (2012-2017) expressed as % of site mean*

| Variety | Lower Eyre Peninsula 2017 Ungarra | Trial | 2013-2017 Yield Bracket (t/ha) # | 2 | 2.5 |
|---|---|---|---|---|---|
| Jenabillup | 1.01 | 8 | 102 | 99 | 103 |
| Jindalee | 0.98 | 8 | 87 | 85 | 85 |
| Mandelup | 1.13 | 8 | 103 | 99 | 96 |
| PBA Barlock | 1.01 | 8 | 96 | 102 | 105 |
| PBA Bateman | - | 3 | - | 114 | 115 |
| PBA Gunyidi | 1.10 | 8 | 97 | 107 | 107 |
| PBA Jurien | 1.17 | 7 | 99 | 106 | 107 |
| PBA Leeman | - | 2 | - | 96 | 93 |
| Wonga | 1.04 | 8 | 91 | 92 | 95 |
| **Site mean yield (t/ha)** | **1.11** | | **1.11** | **1.76** | **2.32** |
| *LSD (P=0.05) (%)* | *16* | | | | |
| Date sown | 10/7 | | | | |
| Soil Type | S | | | | |
| Rainfall (mm) J-M/A-O | 65/243 | | | | |
| pH (water) | 5.8 | | | | |
| Previous crop | Wheat | | | | |
| Site stress factors | de | | | | |

Soil types: S = sand
Stress factors: de=pre flowering moisture stress
**Data source: SARDI/GRDC & NVT and PBA Australian Lupin Breeding Program**
**2012 - 2017 MET data analysis by National Statistics Program**

## *Lower Eyre Peninsula lentil variety trial yield performance 2017*

*and long term (2012-2017) average across sites (as a % of site mean)*

| Variety | Lower Eyre Peninsula 2017 Yeelanna | 2013 - 2017 Trial # | Yield Bracket (t/ha) 1.5 | 2.5 |
|---|---|---|---|---|
| Nipper | 95 | 5 | 89 | 97 |
| Nugget | 101 | 5 | 96 | 101 |
| PBA Ace | | 4 | 96 | 100 |
| PBA Blitz | 77 | 5 | 94 | 88 |
| PBA Bolt | 106 | 5 | 101 | 98 |
| PBA Flash | 110 | 5 | 106 | 105 |
| PBA Hurricane XT | 99 | 5 | 98 | 100 |
| PBA Jumbo | | 3 | 95 | 97 |
| PBA Jumbo 2 | 106 | 5 | 104 | 102 |
| **Site mean yield (t/ha)** | **2.15** | | **1.16** | **2.24** |
| *LSD (P=0.05) (%)* | *18* | | | |
| Date sown | 6/7 | | | |
| Soil type | CL | | | |
| Rainfall (mm) J-M/A-O | 59/227 | | | |
| pH (water) | 7.7 | | | |
| Previous crop | Wheat | | | |
| Site stress factors | de | | | |

Soil type: L=loam, C=clay
Site stress factors: de=pre flowering moisture stress

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

Break Crops

# Canola establishment on upper Eyre Peninsula

**Andrew Ware**
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## Key messages

- **Over three years of field experiments time of sowing was found to be the largest driver of canola yields on upper Eyre Peninsula.**
- **Having suitable soil moisture conditions is critical to achieve optimal canola establishment and to maximise yield.**

## Why do the trial?

2017 proved to be a very challenging year to establish canola across Eyre Peninsula. The trials described in this article were part of a South Australian Grains Industry Trust (SAGIT) funded project conducted between 2013-15. It aimed to maximise canola productivity through creating soil specific management strategies that improve canola yields, profitability and establishment in field trials on lower and upper Eyre Peninsula. These experiments may help explain observations from poorly established canola planted in the 2017 growing season and may assist to better manage canola establishment into the future.

## How was it done?

Between 2013-15 a series of 33 field trials were conducted across a range of soil types and environmental conditions on Eyre Peninsula. These experiments focused on examining the effect that time of sowing had on canola establishment and grain yield. Interactions between canola seeding rate and seeding depth were also examined in separate field trials for their effect on establishment and grain yield.

Further to this, pot experiments were conducted using 20 soils collected across Eyre Peninsula. Rainfall events of differing quantity were applied to pots containing the different soils during April. Canola was planted and establishment was calculated. This helped extrapolate the data gathered from the field experiments across more soil types.

## What happened?

### *Time of sowing*

The biggest driver of canola yields in the experiments conducted in 2013-15 at Minnipa was time of sowing, where canola yields declined dramatically with sowing dates after mid-April (Table 1.).

These results highlight the likely poor performance of canola if establishment was delayed until June/July or even August.

***Table 1. Average yields of Minnipa time of sowing (TOS) experiments conducted in 2013, 2014 and 2015.***

| TOS | Dates | Average yield (t/ha) |
|---|---|---|
| TOS 1 | 15-25 April | 1.83 |
| TOS 2 | 26 April-8 May | 1.58 |
| TOS 3 | 9-18 May | 1.26 |
| TOS 4 | 19-29 May | 0.95 |
| *LSD (P=0.05)* | | *0.14* |

### *Seeding rate and depth*

Seeding depth appears to have made a big difference on canola establishment in 2017, where canola that was able to be sown into moisture established far better than where it was sown close to the surface in dry soils. Experiments conducted as part of the SAGIT funded project showed that despite its small seed size, and in the absence of limited soil moisture, canola can establish equally well when sown at 1 cm compared to 4 cm deep (Table 2). This demonstrates that canola can be sown deeper to 'chase' moisture in marginal conditions. These experiments also showed that using higher seeding rates consistently resulted in higher yields.

### *How much rain is needed to establish canola?*

In order to simulate how much rainfall is required to establish canola on a range of soil types across Eyre Peninsula, pot experiments were conducted in autumn growing conditions. Canola establishment was measured at different water inputs, on differing soil types. This showed that heavier, loamy soils (such as those found at Minnipa Agricultural Centre) require at least 15 mm of rainfall to successfully establish canola. Grey calcareous sandy loam soils required similar, whereas sandier soils have a lower rainfall requirement to successfully establish canola (Table 3).

In the period April to July 2017, Minnipa did not receive rainfall totals of 15 mm over three days.

| Minnipa | | Large Seed | | Small Seed | |
|---|---|---|---|---|---|
| | | Yield (t/ha) | Emergence (plants/m²) | Yield (t/ha) | Emergence (plants/m²) |
| Depth | 1 cm | 1.41 | 32 | 1.45 | 47 |
| | 2 cm | 1.42 | 34 | 1.47 | 49 |
| | 4 cm | 1.44 | 29 | 1.50 | 43 |
| *LSD (P=0.05)* | | *ns* | | *ns* | |
| Rate | 1.5 kg/ha | 1.33 | 17 | 1.38 | 28 |
| | 3 kg/ha | 1.44 | 31 | 1.51 | 49 |
| | 4.5 kg/ha | 1.50 | 46 | 1.54 | 62 |
| *LSD (P=0.05)* | | *0.06* | | *0.06* | |

***Table 2. Average yields of Minnipa canola emergence experiments conducted in 2014 and 2015.***

| Site | Texture | Rainfall applied (mm) | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 7.5 | 10 | 15 | 20 |
| Minnipa I | Loam | 0 | 0 | 0 | 65 | 100 |
| Minnipa II | Loam | 0 | 0 | 0 | 95 | 85 |
| Piednippie I | Sandy Loam (calcareous) | 0 | 0 | 5 | 50 | 95 |
| Piednippie II | Sandy Loam (calcareous) | 0 | 0 | 0 | 30 | 65 |
| Lock | Sandy Loam | 0 | 20 | 60 | 70 | 100 |
| Rudall | Sandy Loam | 0 | 43 | 78 | 100 | 100 |
| Warramboo | Sandy Loam | 0 | 23 | 43 | 98 | 100 |
| Darke Peak | Sand | 15 | 68 | 95 | 88 | 100 |
| *LSD (P=0.05)* | *site x texture* | *8%* | | | | |

***Table 3. Average establishment percentage of canola planted on different soil types collected across Eyre Peninsula under differing water regimes in grown in pots in April 2015 and 2016.***

***Table 4. The chance of exceeding rainfall at three locations across South Australia (source CliMate app – Silo).***

| Location | Chance of >15 mm over three days in April | Chance of >15 mm over three days in May | Chance of >15 mm over three days in April and May |
|---|---|---|---|
| Cummins | 40% | 64% | 78% |
| Minnipa | 25% | 48% | 58% |
| Lock | 38% | 55% | 70% |

***How often does this happen?***

In contrast to 2017, in each of the three years the SAGIT Canola Establishment project was conducted there was enough rainfall to get canola established in April. This raises the question, how often does this happen? Using the CliMate app, the chances of getting 15 mm over three days were calculated using historical climate information from Minnipa, Lock and Cummins (Table 4). This showed that the chances of getting enough rainfall to establish canola in April at Minnipa only occurs in 25% of years and in 48% of years in May. This highlights that even with improved seeding technology that may be able to establish canola on lower moisture, there will be a number of years (over a third) where canola is not able to be established in April or May at Minnipa. From the time of sowing experiments, the chances of reaching a successful yield if planted after May are quite low. This highlights the risk of growing canola on upper EP.

## What does this mean?

The three years of data collected by this project show that to maximise canola yields, sowing early is critical. These data and previous research conducted at Minnipa found that canola has the potential to be profitable if sown prior to 15 May. However, using historical rainfall records the frequency of years where enough rainfall is received to successfully establish canola during April only occurs in 25% of years at Minnipa, but improves into May.

This may mean that canola may need to be viewed as an opportunity crop on upper Eyre Peninsula and only planted if rainfall is reliably forecast in the following week, or after rainfall events in April or early May and not sown dry with no rainfall forecast.

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SARDI

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SAGIT

# Managing the risk of canola production in low rainfall environments

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## Key messages

- **Sowing at the earliest opportunity (which requires rainfall) is an important component of reducing the risk of canola production in low rainfall environments.**
- **The amount of N available to the crop is critical to productivity in a canola crop that has established well.**
- **Applying adequate doses of fertiliser N at seeding or early in the crop's development have produced the highest grain yields, but this was less important in a wet spring like 2016.**
- **Legumes can provide N to a subsequent canola crop. In many cases canola growing on legume residue will still respond to fertiliser N inputs.**
- **Analysis of the profit-risk context for optimal N inputs for canola produced in low rainfall environments is underway.**

## Why do the trial?

A co-ordinated series of trials at three low rainfall locations (Mildura, Minnipa and Loxton) were established in 2015 to evaluate options to manage risk in canola crops without yield penalty. The treatments included a range of sowing dates, hybrid (Hyola 450) vs TT (Stingray) comparisons, N fertiliser timings and N fertiliser rates with the aim to improve the reliability of canola establishment, optimise sowing date (while keeping canola at the very beginning of the sowing program), quantify the cost/benefit of hybrid varieties and identify optimal timing for N inputs.

Experiments in 2015 indicated that sowing at the earliest opportunity, in this case a break of season sowing in April, offered the best yield outcome. Yield gains from hybrid canola were small and not economic compared with open pollinated canola. Canola productivity was best with early N application, and in the case of the Mildura site waiting until stem elongation for N application resulted in a 10–20% yield penalty (Ware *et al*. 2017, Moodie *et al*. 2016).

With increased confidence in the key messages around time of sowing and the lack of varietal options, experiments in 2016 focussed on N management. Experiments were established at Ouyen, Minnipa and Karoonda to explore the opportunity and risk associated with N management options in low rainfall canola. The treatments included a range of N fertiliser timing, N fertiliser rate, soil type and sowing date to assess whether:

- differing soil types and N management history require different N management,
- the application of N can be delayed without penalty to yield,
- higher rates of N provide an economic response,
- the optimal management of fertilizer N differs depending on sowing date.

In 2016 the best sowing date was with a break of season rainfall event in May, and establishment issues associated with dry sowing in April caused a yield penalty. At Karoonda there was a response to N fertiliser on all soil types (at 10 kg grain/kg fertiliser N for all soils for the 80 kg N/ha rate) and the highest yielding treatments were those that received most of their N fertiliser later at stem elongation in a season with a dry start and wet spring. However, consistent across all sites and seasons, time of nitrogen application was not as important as the quantity available to the plant (McBeath et al. 2017). Yield gains from increased N application did not impose an oil content penalty.

Given the demonstrated importance of N supply to canola productivity in low rainfall environments and evidence of a N driven yield gap despite relatively high fertiliser N inputs, we established experiments at Minnipa, Mildura and Karoonda in 2017 to explore whether sowing canola into legume stubble can reduce N fertiliser requirement and provide a risk management strategy. The treatments include a range of N fertiliser rates (Karoonda), legume residue types (Mildura and Minnipa) and soil types (Karoonda) to assess whether:

- legume N reduces fertiliser N requirement in canola,
- soil type affects legume and fertiliser N supply and requirement in canola,
- legume type affects N supply in canola.

## How was it done?

The experiments included assessments of pre-sowing soil water and mineral N, crop establishment, NDVI, date of 50% start of flowering and biomass and maturity biomass, grain yield and quality.

***Minnipa***

Canola plots were sown into medic, field pea and wheat residue in May, but conditions were extremely dry and the crop did not establish until August. As a result no fertiliser N was applied.

***Ouyen***

In 2016 plots of barley, field pea, field pea/barley, vetch/barley, vetch/field pea, vetch/field pea/barley and vetch were established. Barley and vetch were spray-topped in the spring in order to brown manure, while field peas were grown to maturity. Stingray canola was sown on 15 May 2017 (resown after failed establishment for April sowing) with 100 kg/ha of single superphosphate. On 13 July 32 kg N/ha was applied as urea to one half of each plot. There was no follow-up rain to incorporate the urea application until 3 August.

***Karoonda***

At Karoonda plots of lupin and wheat were established in 2016. All plots were sown on 3 May with Stingray canola and received 11 kg P/ha, 11 kg S/ha, 27 kg K/ha and foliar Zn, Cu and Mn to ensure other nutrients were non-limiting. Fertiliser was applied as 50 kg/ha MAP + 1% Zn at sowing (5 kg N) and any additional fertiliser was applied after the crop emerged at 2-4 leaves by top dressing with urea (@ 30 or 80 kg N/ha) on 21 June.

## What happened?

***Minnipa***

Given the very late establishment it was surprising that canola yielded 0.3-0.4 t/ha across the residue types, but due to the season there was no significant response to treatments despite a difference in starting N conditions (Table 1).

*Table 1. Pre-sowing soil mineral N in response to 2016 crop type at Minnipa.*

| 2016 crop | Pre-sow soil mineral N (kg N/ha/m) |
|---|---|
| Wheat | 145 |
| Field Pea | 140 |
| Medic | 197 |

*Table 2. Pre-sowing soil mineral N and canola grain yield (t/ha) in response to 2016 crop type and fertiliser N (32 kg N/ha) addition at Ouyen in 2017.*

| 2016 crop | Pre-sow soil mineral N (kg N/ha/m) | Grain yield (t/ha) |
|---|---|---|
| Barley | 39.1 | 0.79 |
| Field Pea | 52.3 | 1.07 |
| Field Pea/Barley | 42.4 | 0.87 |
| Vetch/Barley | 78.5 | 1.35 |
| Vetch/Field Pea | 75.3 | 1.24 |
| Vetch/Field Pea/Barley | 40.3 | 0.89 |
| Vetch | 85.1 | 1.49 |
| *SED (P=0.05)* | | *0.18* |
| **Fertiliser** | 59.0 | |
| Minus | | 1.05 |
| Plus | | 1.22 |
| *LSD (P=0.05)* | | *0.08* |

Break Crops

*Ouyen*

Crop residue had a significant effect on canola grain yield (Table 2). The pre-sowing mineral N derived from the crop residue (Table 2) was found to be a primary driver of the canola yield response with a relationship of 13.3 kg grain/kg pre-sowing mineral N ($R^2$=0.9, Figure 1). Canola grain yield also responded to fertiliser N input but this response was independent of the crop residue type and had a lower efficiency (5.3 kg grain/kg fertiliser N). There was a 2.5 week gap between the urea application and a rainfall event which may have affected the efficacy. Pre-sowing soil water was not found to affect grain yield (data not shown).

*Karoonda*

The 2016 lupin crop provided an additional 19-62 kg pre-sowing mineral N/ha depending on the soil type, with the greatest benefit on the swale. However, there was only a grain yield response to lupin residue compared with wheat on the sandy dune and mid-slope soils with a 40-60% yield benefit, and as a result, soil mineral N and canola grain yield were not directly related at the Karoonda site (Table 3). The grain yield benefit did not directly relate to pre-sowing mineral N or the change in mineral N provided by the legume (e.g. the canola on the swale had the highest mineral N boost from the legume, but there was no yield benefit of legume vs wheat). Residue type did not interact with fertiliser N input for grain yield response. Both of the sands showed significant yield benefit at the 80kg N/ha input level compared with 5 kg N/ha. There was a wide variation in the extra grain produced from this 75 kg N/ha supplied as fertiliser with 4.4-10.6 kg grain/kg fertiliser N. Canola oil content was not affected by treatment and varied from 44.1-47.6%. There was tendency for oil content to be higher in higher yielding plots.

## What does this mean?

For crops that had sufficient surface soil water to establish in 2017, N availability was a key driver of yield on the sandy soil types. Extra pre-sowing mineral N derived from legume residues proved directly beneficial to canola yield. In addition fertiliser N provided yield gains. The lack of interaction between residue and fertiliser N demonstrates the responsiveness of canola on sands to extra N in the system because even with extra N from residue, canola responded to fertiliser N inputs. This is consistent for our findings on wheat crops produced on Mallee sands. Further work to explore the profit-risk trade-offs is needed to arrive at the optimal level of N input for canola in the low rainfall environment. Recent data suggests that there are new varieties that may prove higher yielding than Stingray in low rainfall environments and testing their fit and N requirement together is likely to be beneficial.

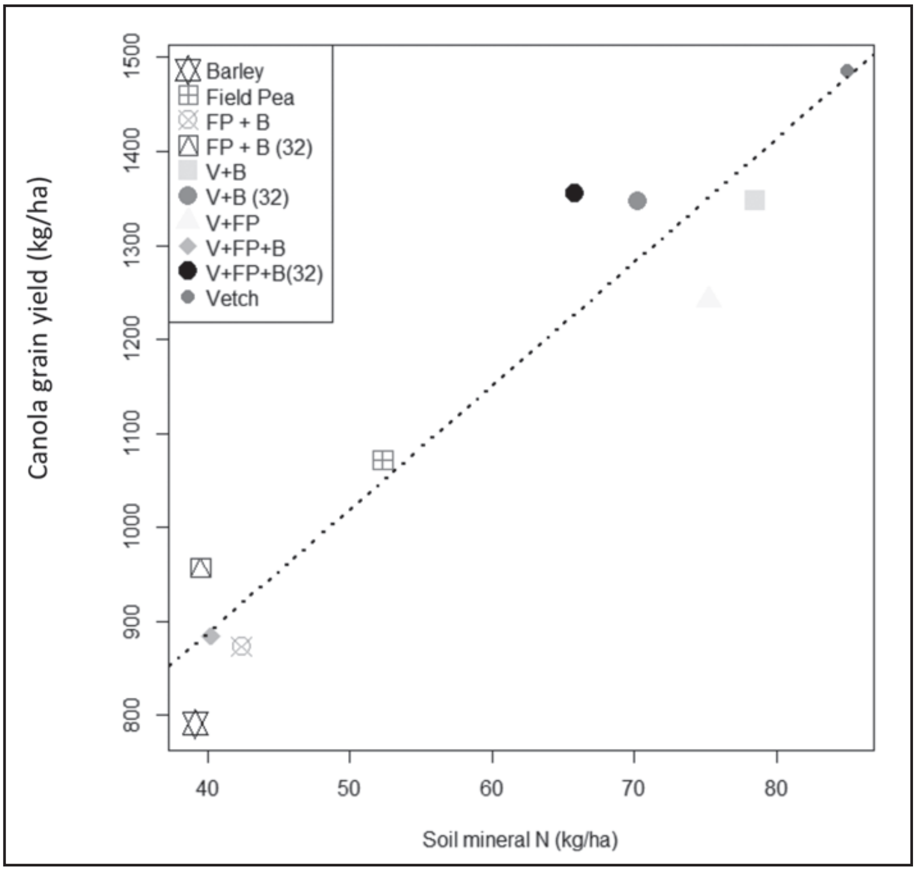


***Figure 1. Relationship between pre-sowing soil mineral N (kg/ha) and grain yield (kg/ha).***

*Table 3. Canola grain yield*(t/ha) on Karoonda dune, mid-slope and swale soils in response to residue type (wheat and lupins) and N fertiliser input (5, 30 and 80 kg N/ha).*

| Soil Type | Dune | Mid-slope | Swale |
|---|---|---|---|
| **Residue Type** | | | |
| Wheat | 0.79 | 0.70 | 0.78 |
| Lupins | 1.29 | 0.98 | 0.86 |
| *LSD (P=0.05)* | *0.11* | *0.09* | *ns* |
| **Fertiliser N rate (kg N/ha)** | | | |
| 5 | 0.70 | 0.74 | 0.79 |
| 30 | 0.92 | 0.71 | 0.79 |
| 80 | 1.50 | 1.07 | 0.88 |
| *LSD (P=0.05)* | *0.24* | *0.11* | *ns* |

**Note that there was a significant hailstorm two days before the plots were hand-harvested. Grain yields have not been adjusted for this damage and while assessments indicated that different treatments did not have different levels of hail damage, canola on sands had approximately 60% pod loss while canola on the swale had approximately 38% pod loss.*

Break Crops


## Acknowledgements

Thanks to MAC and the families for their generous support in hosting the trial, and to Jeff Braun and Lou Flohr for discussions around trial design and management. This work is a component of the 'Optimised Canola Profitability' project (CSP00187), a collaboration between NSW DPI, CSIRO and GRDC, in partnership with SARDI, CSU, MSF and BCG.


## References


McBeath *et al*. 2017. http://www.msfp.org.au/canola-responded-nitrogen-fertiliser-input-across-dune-swale-karoonda-2016

Ware *et al*. 2017 https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/canola-agronomy-and-phenology-to-optimise-yield

Moodie *et al*. 2016 http://www.msfp.org.au/risk-management-strategies-for-growing-canola-in-the-low-rainfall-zone

# Impact of sowing date on phenology and yield of lentil and faba bean – season 2

RESEARCH

**Lachlan Lake, C. Mariano Cossani and Victor O. Sadras**
SARDI Waite

**Searching for answers**

**Location**
Roseworthy
**Rainfall**
Av. Annual: 400 mm
2017 crops were supplementarily irrigated to ensure crop establishment
**Yield**
Actual: 4.0 t/ha (beans) and 2.75 t/ha (lentils)
**Paddock History**
2016: Wheat
2015: Wheat
2014: Chickpea
**Soil Type**
Sandy clay loam
**Plot Size**
1 m x 1 m x 3 reps
**Yield Limiting Factors**
Frost, snails, early finish, late sowing, moisture and heat stress

**Location**
Bool Lagoon
**Rainfall**
Av. Annual: 550 mm
2017 crops were supplementarily irrigated to ensure crop establishment
**Yield**
Actual: 0.0 t/ha
**Soil Type**
Black clay
**Plot Size**
1 m x 1 m x 3 reps
**Yield Limiting Factors**
Waterlogging, frost, snails, early finish, late sowing, moisture and heat stress

## Key messages

- **Lentil and faba bean accelerated their development and flowered earlier when sowing was delayed.**
- **Delayed sowing reduced yield in both pulses.**
- **Results should be considered with regard to the trade-off between early sowing and frost risk.**

## Why do the trial?

Lentil and faba bean are two important pulse crops with growing interest from farmers in low rainfall areas of South Australia. Good prices, together with rotational benefits make these crops valuable options, however frost and combinations of water and heat stress at critical growth stages can compromise 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, water stress and the trade-off between frost and heat risk.

The aim of this work is to analyse the impact of sowing date and variety on the phenology and grain yield of lentil and faba bean across different South Australian cropping environments, including the upper Eyre Peninsula.

## How was it done?

Field trials have been conducted at Minnipa Agricultural Centre (2016 and 2017), Hart (2016), Roseworthy (2017) and Bool Lagoon (2016 and 2017) to test the effect of sowing date on phenology and yield of lentil and faba bean varieties. The trials combined six sowing dates ranging from 20 April to 9 July, with ten varieties of each crop chosen in consultation with breeders and industry experts. Faba bean varieties included 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 HurricaneXT, CIPAL1422, PBA Giant, PBA Jumbo2, Nugget, and Matilda.

For each species at each location, three replications were sown for each genotype and sowing date. Crops were sown by hand in a split-plot design with sowing dates allocated to the main plot and varieties randomized within each subplot. Plot size was 1 m by 1 m and consisted of 3 rows, 0.27 m apart. Prior to sowing, P was supplied by applying 80 kg/ha of MAP.

During the growing season, we measured phenology twice weekly within the central rows of the plots. We recorded the date when 50% of plants within the central row had reached flowering, pod emergence, end of flowering and maturity.

At Minnipa (2016 and 2017) and Roseworthy (2017), yield was measured from a subsample of 0.5 m length from the central rows of all plots. Samples were dried at 70°C until constant weight was achieved and then grains were separated from the pods, cleaned, counted and weighed.

| |
|---|
| **Location** |
| Minnipa Agricultural Centre, paddock N10 |
| **Rainfall** |
| Av. Annual: 325 mm |
| Av. GSR: 241 mm |
| 2016 Total: 281 mm |
| 2016 GSR: 155 mm |
| 2017 crops were supplementarily irrigated to ensure crop establishment - variable for each site and time of sowing |
| **Paddock History** |
| 2016: Wheat |
| 2015: Pasture |
| 2014: Wheat |
| **Soil Type** |
| Clay loam |
| **Plot Size** |
| 1 m x 1 m x 3 reps |
| **Yield Limiting Factors** |
| Frost, snails, early finish, late sowing, moisture and heat stress |

## What happened?

The difference between environments in 2017 was extreme, with drought affecting yields at Minnipa while waterlogging caused crop failure at Bool Lagoon. However, the trends in phenology and yield associated with sowing time have been consistent between environments. Across crops and species, the time to flowering and yield both decreased with delayed sowing (Figure 1). The relationship between sowing date and degree days to flowering was more scattered in lentil than in faba bean, possibly reflecting different roles of photoperiod and temperature as drivers of development.

In terms of yield, faba bean reductions associated with delayed sowing from mid/late April to late June was over 2.5 t/ha (2 fold decrease) at Roseworthy, 0.7 t/ha (~ 6 fold decrease) at Minnipa in 2017 and 1-1.3 t/ha (almost 2 fold decrease) in 2016. For lentil the yield penalty associated with delayed sowing was less severe; at Roseworthy, yield loss was 1.3 t/ha (almost 2 fold decrease), while at Minnipa in 2017 it was 0.4 t/ha (~ 3 fold decrease) and in 2016 was 0.4–0.6 t/ha (1.5 fold decrease). As is common with pulses, yield variation was explained by changes in seed number rather than seed size (Figure 2).

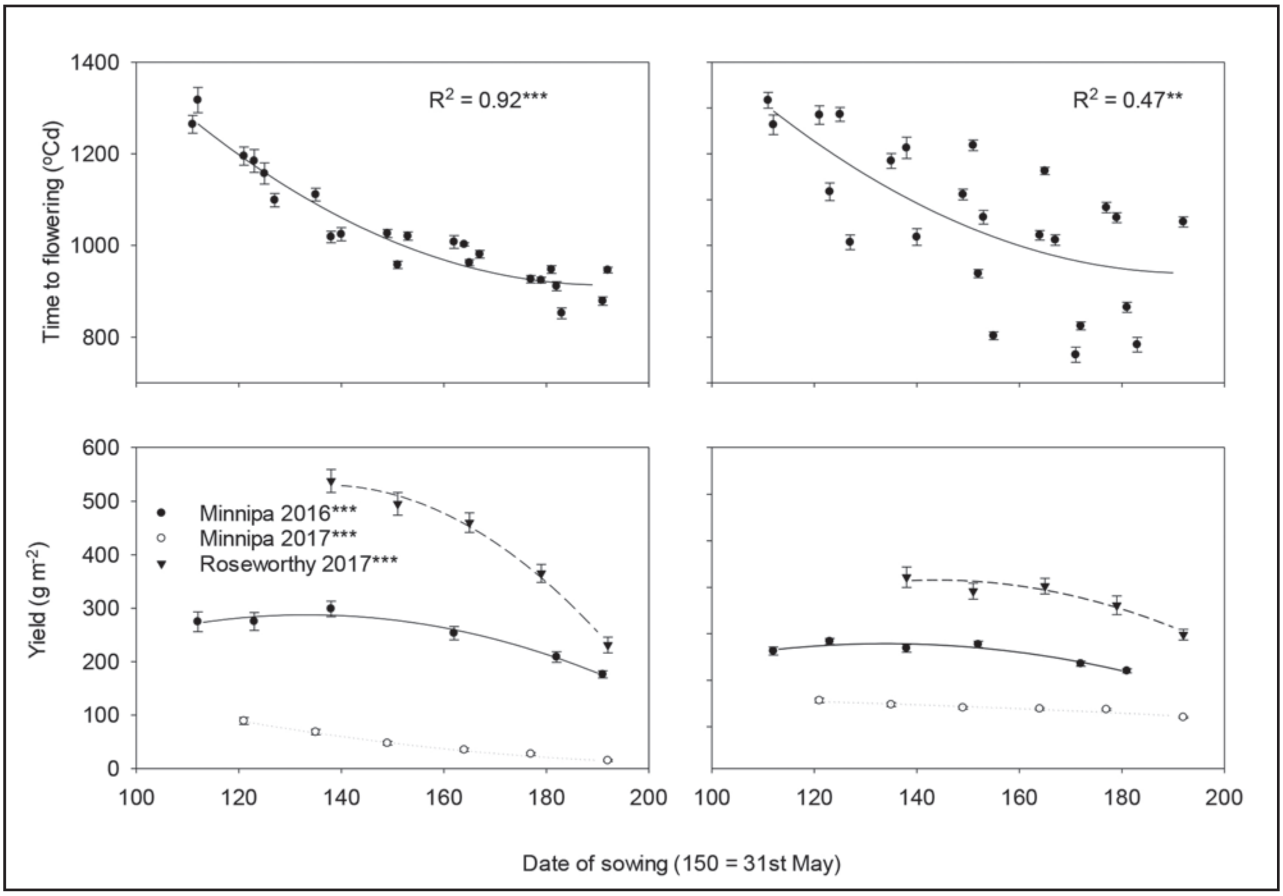


***Figure 1. Phenology (top panels) and grain yield (bottom panels) of faba bean (left panels) and lentil (right panels) as a function of sowing date. Yield has been separated by environment while phenology is pooled across environments.***

Break Crops

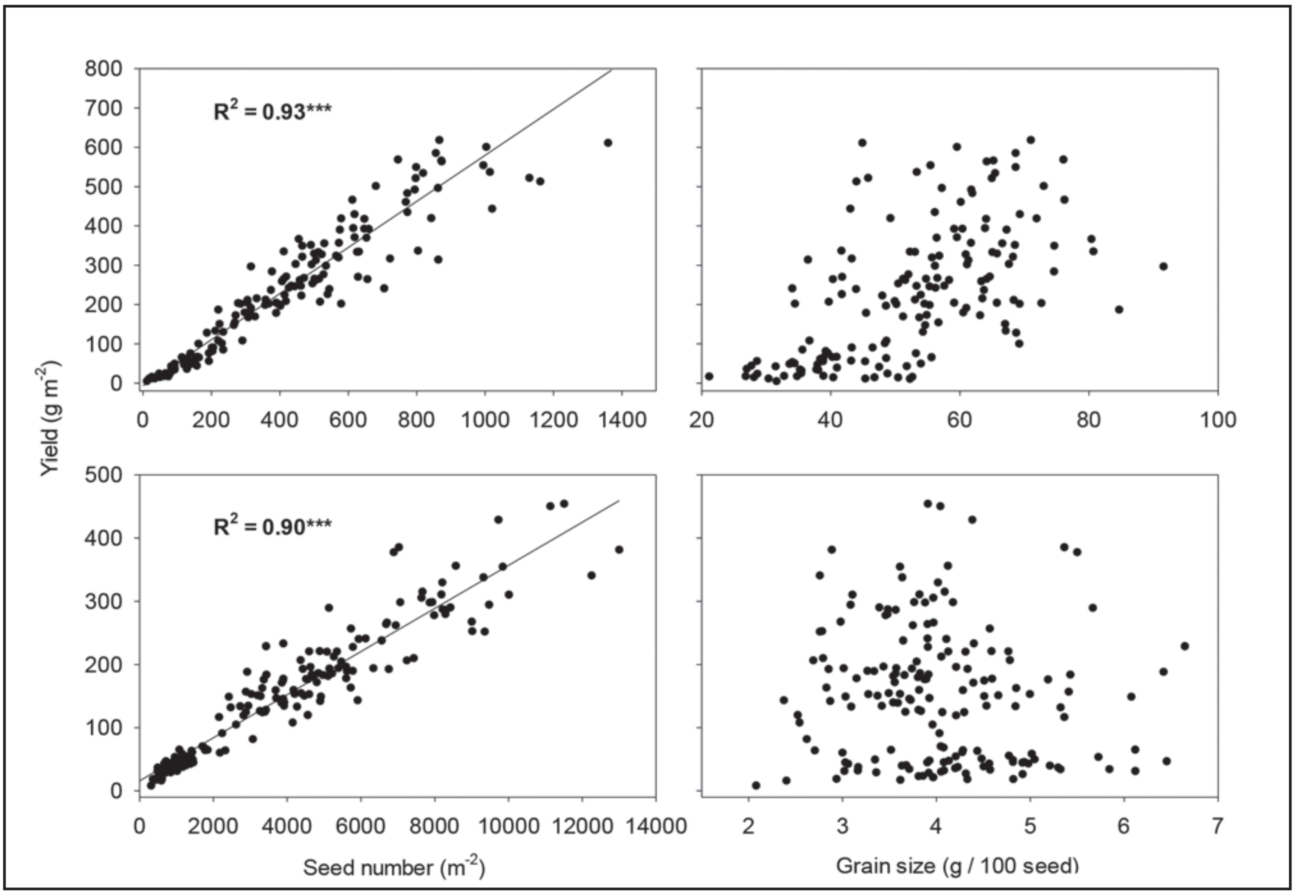


***Figure 2. Yield as a function of seed number (left panels) and grain size (right panels) of faba bean (top panels) and lentil (bottom panels) as a function of sowing date. Lines are linear regression and are only presented where significant.***

***Table 1. Variation in days to flowering of the different lentil and faba bean lines.***

| Beans | Mean | Minimum | Maximum | Lentils | Mean | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| AF03001-1 | 76 | 51 | 117 | PBABlitz | 94 | 71 | 138 |
| Fiord | 79 | 55 | 93 | CIPAL901 | 97 | 71 | 138 |
| AF009169 | 81 | 57 | 99 | PBAGiant | 99 | 72 | 142 |
| Farah | 82 | 57 | 125 | PBAJumbo2 | 100 | 71 | 146 |
| PBAZahra | 86 | 59 | 113 | CIPAL1301 | 101 | 76 | 149 |
| PBARana | 86 | 60 | 110 | CIPAL1422 | 102 | 71 | 150 |
| Nura | 87 | 61 | 115 | PBAHurricaneXT | 103 | 77 | 150 |
| PBASamira | 88 | 60 | 116 | Matilda | 104 | 73 | 149 |
| Aquadulce | 89 | 59 | 122 | Nugget | 107 | 76 | 150 |
| Icarus | 100 | 66 | 133 | Northfield | 111 | 82 | 170 |

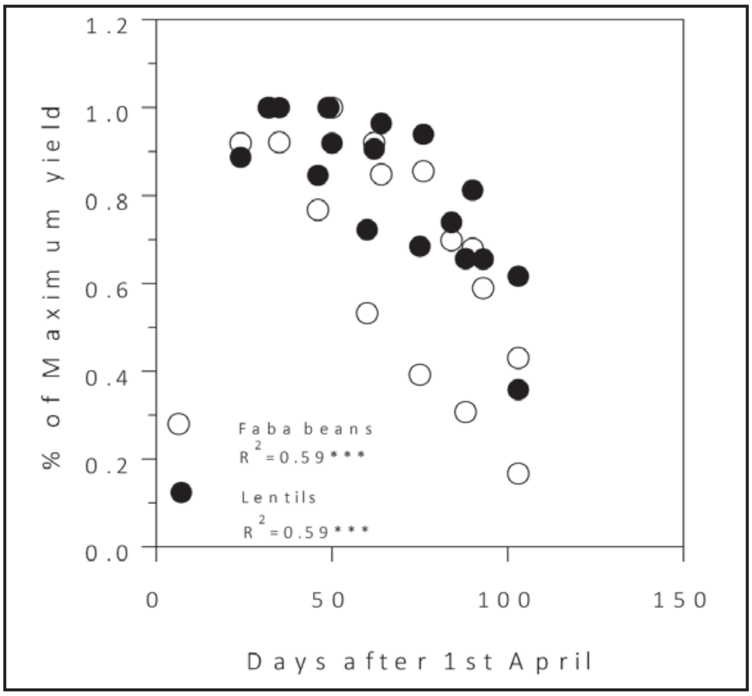


***Figure 3. Yield penalty as a function of sowing delay from 1 April. Yield penalty is presented as a proportion of maximum yield.***

## What does this mean?

The second year of data has reinforced the trends seen in the first year showing a yield penalty associated with delayed sowing (EPFS Summary 2016), this is despite the contrasting environmental conditions, particularly between Minnipa which in 2016 was a good year compared to 2017. These results reinforce that the yield of both lentil and faba bean are reduced when sowing is delayed, particularly after late April. On average, the penalty for both pulse crops is 6.7% of their maximum yield per 10 days that sowing is delayed after 1 April (Figure 3). The yield penalty is a partially a result of a shorter time to flowering, caused by accelerated development; this results in reduced seed set.

We have demonstrated the variability in phenology that is available for growers who wish to target a specific growth window to avoid both frost and heat stress, whilst maximising yield. In the absence of frost, sowing early will be more likely to provide the maximum yield for the environment.

This research will be repeated in the 2018 growing season with the aim of producing high quality quantifications of both phenology and yield in response to variety, environment and sowing time.


## Acknowledgments

Special thanks are given to Leigh Davis, Brenton Spriggs, Sue Budarick and Matthew Cadd for their collaboration with field and lab activities. This project is part of GRDC-SARDI Bilateral.




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# New fungicides offer improved ascochyta blight control and yield benefit in field pea

RESEARCH

**Christine Walela[1], Jenny Davidson[2] and Larn McMurray[3]**
[1]SARDI Clare, [2]SARDI Waite, [3]formerly SARDI Clare

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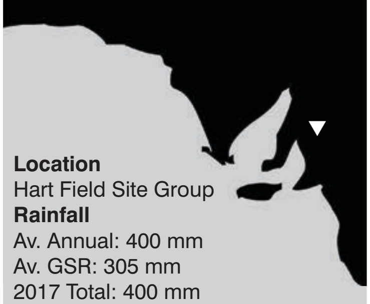


**Location**
Hart Field Site Group
**Rainfall**
Av. Annual: 400 mm
Av. GSR: 305 mm
2017 Total: 400 mm
2017 GSR: 191 mm
**Yield**
Actual: 3.53 t/ha (Peas)
(Chlorothalonil Fungicide treatment)
**Paddock History**
2016: Oaten hay
2015: Canola
2014: Commander barley
**Soil Type**
Clay loam
**Plot Size**
2 m x 10 m x 3 reps

## Key messages

- **Early disease control with new fungicide actives is important for reducing initial AB infection levels in field pea crops with a yield potential above 1.5 t/ha.**
- **A late fungicide spray is important to control AB in spring when rainfall is conducive to disease spread and pod and seed infection.**
- **Early sowing into a high disease risk window with these improved new fungicide actives was demonstrated to have improved yield benefits over later sowing in the 2017 season.**

## Why do the trial?

Fungicides play a key role in managing ascochyta blight (AB) in field pea, as there is no varietal resistance to disease. Recently, new fungicide actives have emerged in the market, offering superior disease control in field crops. However, they have not been tested for ascochyta blight (AB) control in field pea. As part of continuing research, experimental field studies have been undertaken to evaluate the efficacy of new actives in disease control and yield benefits in low (Minnipa, upper Eyre Peninsula) and medium (Hart, mid-north) rainfall zones in South Australia. The trials undertaken by SARDI are part of Southern Pulse Agronomy project (SPA) funded by the GRDC (DAV00150). The performance of two new actives constituting a) Bixafen (75 g/L) in combination with Prothioconazole (150 g/L) trading as Aviator Xpro®, and b) Azoxystrobin (200 g/L) in combination with Cyproconazole (80 g/L) trading as Amistar Xtra® were compared to, Mancozeb (2 kg/ha), seed treatment P Pickle T®, fortnightly Chlorothalonil treatment (complete disease control) and an untreated (Nil) treatment.

## How was it done?

Experimental field trials were conducted from 2015 to 2017. In 2015, trials compared the new actives against the industry standard practice of a seed dressing plus two mancozeb sprays at 9 weeks after sowing (WAS) and early flowering. In 2016, trials included an earlier spray at 4-6 node, when disease was first sighted. In 2017, two times of sowing were included at Hart to produce high and low disease risk with fungicide treatments as per 2016. Minnipa was not sown due to the late break to the season and extended dry conditions.

A number of fungicide treatments were tested over the three years however, only selected treatments have been presented in this report (Table 1). In 2015 and 2016, the trials were designed as Randomized Complete Block Design (RCBD), replicated three times at each site. In the sowing date experiment, treatments were arranged in a split plot design, with sowing date as whole plots and fungicide treatment applied to the split plots, replicated thrice. PBA Coogee was used in 2015 and 2016 and PBA Oura in 2017, with sowing conducted at 55 plants/$m^2$.

To accelerate AB infection field pea stubble infested with AB was uniformly spread adjacent to seedlings at 1 to 2 nodes growth stage, in 2015 and 2016. In the sowing date trial the infested stubble was randomly spread in the trials prior to sowing and the forecasting model 'blackspot manager' was used to predict high and low disease risk sowing windows. Early sowing (27 April) was conducted into a high spore release window and delayed sowing (31 May) into a low risk window.

Disease severity 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 and flowering growth stages. Plots were machine harvested and grain yields recorded for each treatment at physiological maturity.

## What happened?

### *Seasonal conditions*

Low summer rainfall followed by high rainfall during the month of April led to a late release of black spot spores in 2015, with all trials sown into medium or high risk disease situations. The subsequent wet winter favoured plant growth and disease progression, and black spot infection was apparent at all sites.

In 2016, the growing season rainfall (GSR) was above long-term average at Minnipa and Hart. Total GSR of 356 mm and 268 mm was recorded at Hart and Minnipa respectively. The two trials were sown in late autumn into relatively dry seed bed conditions. This was followed by wet conditions in winter and a relatively cool spring that resulted in prolonged maturation of the crop, particularly at Hart.

The 2017 season started with a late break in most parts of the SA. Growing season rainfall (GSR) (191 mm) and annual (330 mm) rainfall was well below the long-term annual average (400 mm) for Hart. Early AB disease infection and progression was low due to an extended dry period during the growing season and non-conducive environmental conditions. However, a high rainfall event occurred in late winter (August, 44 mm)/early spring (September, 24 mm) and may have favoured disease spread in the latter growing stages. Severe frost events occurred in the last week of August, which coincided with the critical development period of pod filling in the early sown crops.

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

Disease onset occurred earlier in the low rainfall zone compared to the medium rainfall zone indicating the drivers of AB onset were different across the two environments, in both 2015 and 2016 (Table 1). Subsequently, results showed AB response to fungicide treatment changed depending on environmental conditions.

Mancozeb applications reduced AB severity compared to the Nil treatment at Hart in 2015 and 2016, while there was no reduction in 2017. In contrast, AB severity was not reduced by this treatment at Minnipa where severity was initially higher. This may be due to the establishment of the disease prior to the first foliar applications 9 weeks after sowing.

Amistar Xtra® reduced disease infection levels at Hart in 2015, but not 2016 nor in either year at Minnipa. In 2017 at Hart, disease severity in Amistar Xtra® was lower than the Nil treatment and similar to Mancozeb and the two Aviator Xpro® treatments.

Aviator Xpro® sprayed at 6-8 WAS plus early flowering reduced disease severity over the Nil at Hart and Minnipa in 2015, and Minnipa in 2015. The strategy of including an early spray of Aviator Xpro® at 4 WAS followed by a second application at 9 WAS and mancozeb at early flowering resulted in lower disease severity at both Hart and Minnipa, compared to the treatments other than fortnightly sprays of Chlorothalonil, in 2016.

There was no fungicide interaction with sowing date in 2017, with the fungicide effect similar across sowing dates. The application of two Aviator Xpro® treatments showed similar disease control to the Amistar Xtra® treatment, compared to Mancozeb and Nil treatments.

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

The mean site grain yield was 1.6 t/ha in 2015 for both Hart and Minnipa, while in 2016 Hart had higher yields (1.74 t/ha) than at Minnipa (1.30 t/ha) (Table 2). In 2017, the first time of sowing (27 April) yielded 3.1 t/ha with the second time of sowing (31 May) 2.3 t/ha (Table 3). Fungicide strategies in field pea are generally economic for yields above 1.5 t/ha.

Grain yields showed a similar fungicide treatment response across the two sites in 2015. In 2016, a fungicide treatment by site interaction was found for grain yield. Across all trials the highest yields were associated with Aviator Xpro®, Amistar Xtra® and fortnightly sprays of Chlorothalonil, while Mancozeb sprays did not significantly increase yield over Nil treatments in any of the trials (Table 2).

In 2017, the three spray application strategy of Aviator Xpro® at early disease sighting plus early flowering and a late spray of Mancozeb at mid-flowering produced yields similar to fortnightly Chlorothalonil (Table 2). In contrast, this response was not found in 2016, where fortnightly Chlorothalonil had higher yields than the three spray strategy. This may be due to the number of Chlorothalonil sprays being applied in seasons with more favourable and wetter finishing conditions. Although 2017 was generally drier, a substantial amount of rain fell in late winter/early spring and the late spray of Mancozeb in the Aviator Xpro® treatment was beneficial in controlling the spread of AB, resulting in yield increases in early sown crops, similar to the fortnightly Chlorothalonil treatment.

Grain yields increased by up to 20% from the use of new actives over the current industry standard in the early sown plots at Hart, in 2017. In the later sowing there was no yield response to fungicides. This result shows that significant yield penalties can occur if field pea crops are sown later or in high disease risk situations, such as early sowing, where fungicides are not applied.

***Table 1. Ascochyta blight disease severity (% plot severity) assessed at between 9 and 13 node growth stage in field pea (PBA Coogee) under different fungicide treatments at Hart (mid-north, SA) and Minnipa (upper Eyre Peninsula, SA), 2015 to 2017.***

| Year | Fungicide Treatment | Application Timing | Disease severity (%) | |
|---|---|---|---|---|
| | | | Hart | Minnipa |
| 2015 | Nil | | 24 | 37 |
| | P Pickle T® | Seed treatment | 28 | 27 |
| | Mancozeb | 8 WAS + Early flowering | 12 | 30 |
| | Amistar Xtra® | 8 WAS + Early flowering | 6 | 30 |
| | Aviator Xpro® | 8 WAS + Early flowering | 4 | 23 |
| | Chlorothalonil | Fortnightly | 9 | 18 |
| | | *LSD (P<0.05) Fungicide x site* | *8* | |
| 2016 | Nil | | 32 | 51 |
| | P Pickle T® | Seed treatment | 36 | 46 |
| | Mancozeb | 6 WAS + Early flowering | 24 | 47 |
| | Amistar Xtra® | 6 WAS + Early flowering | 33 | 49 |
| | Aviator Xpro® | 6 WAS + Early flowering | 24 | 46 |
| | Aviator Xpro® + Mancozeb | 4 WAS, 9 WAS + mancozeb at early flowering | 17 | 42 |
| | Chlorothalonil | Fortnightly | 14 | 25 |
| | | *LSD (P<0.05) Fungicide x site* | *8* | |
| 2017 | Nil | | 55 | |
| | Mancozeb | Early disease + Early flowering | 48 | |
| | Amistar Xtra® | Early disease + Early flowering | 42 | |
| | Aviator Xpro® | Early disease + Early flowering | 39 | |
| | Aviator Xpro® + Mancozeb | Early disease + Early flowering + mancozeb mid-flowering | 37 | |
| | Chlorothalonil | Fortnightly | 2 | |
| | | *LSD (P<0.05) Fungicide* | *8* | |

*NOTE: WAS = weeks after sowing. NB: # All treatments were treated with Apron® (350 g/L Matalaxyl-M) seed dressing to control downy mildew. In 2017, no trial was conducted at Minnipa due to the late break of the season. As some of the fungicide treatments in this research contain unregistered fungicides, application rates have been withheld. The research was carried out for experimental purposes only and the results within this document do not constitute a recommendation for that particular use by the author or author's organisation.*

***Table 2. Mean grain yields (t/ha) of field pea (PBA Coogee) sown with different fungicide treatments at Hart (mid-north, SA) and Minnipa (Eyre Peninsula, SA) in 2015 and 2016.***

| Year | Fungicide Treatment | Application Timing | Grain yield (t/ha) | |
|---|---|---|---|---|
| | | | Hart & Minnipa | |
| 2015 | Nil | | 1.55 | |
| | P Pickle T® | Seed treatment | 1.47 | |
| | Mancozeb | 8 WAS and Early flowering | 1.47 | |
| | Amistar Xtra® | 8 WAS and Early flowering | 1.77 | |
| | Aviator Xpro® | 8 WAS and Early flowering | 1.79 | |
| | Chlorothalonil | Fortnightly | 1.73 | |
| | | *LSD (P<0.05) Fungicide* | *0.16* | |
| | | | Hart | Minnipa |
| 2016 | Nil | | 1.49 | 0.95 |
| | P Pickle T® | Seed treatment | 1.33 | 1.05 |
| | Mancozeb | 6 WAS + Early flowering | 1.54 | 1.19 |
| | Amistar Xtra® | 6 WAS + Early flowering | 1.84 | 1.32 |
| | Aviator Xpro® | 6 WAS + Early flowering | 1.93 | 1.40 |
| | Aviator Xpro® + Mancozeb | 4 WAS, 9 WAS + Early flowering | 1.65 | 1.58 |
| | Chlorothalonil | Fortnightly | 2.67 | 1.67 |
| | | *LSD (P<0.05) Fungicide* | *0.34* | |

*Table 3. Mean grain yields (t/ha) of field pea (PBA Oura) at different sowing dates under varying AB disease risk levels and different fungicide treatments at Hart (mid-north, SA), in 2017.*

| Fungicide Treatment | Grain yield (t/ha) | | Grain weights (g/100 seed) | |
|---|---|---|---|---|
| | 27 April | 31 May | 27 April | 31 May |
| Chlorothalonil | 3.53[a] | 2.29[a] | 22.99[a] | 22.11[a] |
| Aviator Xpro® & Mancozeb | 3.42[a] | 2.19[a] | 22.15[b] | 22.51[a] |
| Aviator Xpro® | 3.22[b] | 2.33[a] | 22.00[b] | 22.46[a] |
| Amistar Xtra® | 3.04[b] | 2.37[a] | 21.21[c] | 22.57[a] |
| Mancozeb | 2.76[c] | 2.31[a] | 20.87[cd] | 22.57[a] |
| Nil | 2.66[c] | 2.28[a] | 20.65[d] | 22.35[a] |
| *LSD ($P<0.05$) Fungicide x Sowing time* | *0.19* | *0.19* | *0.47* | *0.47* |

*NB: Seed dressing of P Pickle T® was used at sowing in all treatments except Nil treatment.*

Frost damage impacted the grain quality of early sown crops, whereby more seeds had a shrunken and discoloured appearance on the seed coat. This suggests that site selection is important when early sowing crops in order to avoid frost event during critical growth and development periods. Growers may need to adjust the sowing window of early sown crops depending on history of frost events in the district.

## What does this mean?

Early disease control with new fungicide actives is important for reducing initial AB infection levels. In addition, a late fungicide spray is important to control AB in spring when rainfall is conducive to disease spread and pod and seed infection. In situations with yield potentials above 1.5 t/ha, the new fungicides showed improved disease control and yield benefit of 15-20% over the current industry standard. Early sowing into a high disease risk window with these improved new fungicide actives was demonstrated to have improved yield benefits over later sowing in the 2017 season. However, the results need to be interpreted with caution as disease pressure was low and progression was reduced by below average rainfall in 2017. The susceptibility of early sown field pea to frost events will also require consideration. Further research is being undertaken to understand the drivers of AB in the different environments.


## Acknowledgement

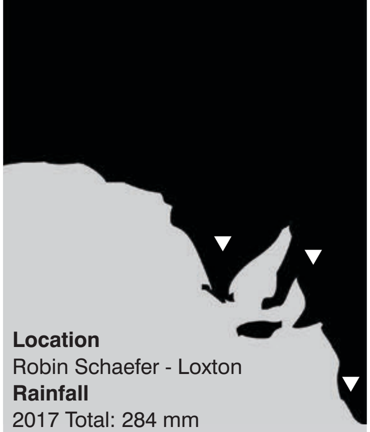
Funding for this work was provided through GRDC project DAV00150 (Southern Pulse Agronomy) and their support is greatly appreciated. We also acknowledge the support of research colleagues from the SARDI teams at Clare and Minnipa. Much gratitude also goes to the land owners/managers of the different farms where the trial sites were located, and to chemical companies for providing us with experimental fungicides to run our trials.

# Identifying the most productive and profitable break crop options for low rainfall farming systems

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

[1]Moodie Agronomy, Mildura; [2]SARDI, Waite Campus; [3]Rho Environmetrics Pty Ltd, Adelaide

**Almost ready**



**Location**
Robin Schaefer - Loxton
**Rainfall**
2017 Total: 284 mm
2017 GSR: 135 mm
2016 Total: 426 mm
2016 GSR: 322 mm
2015 Total 222 mm
2015 GSR: 174 mm
**Paddock History**
Cereal (Wheat/barley) prior to each break phase
**Soil Type**
Loxton Flat: Red loam
Loxton Sand: Deep yellow sand
**Plot Size**
15 m x 2 m x 4 reps
**Yield Limiting Factors**
2016: Frost
2015: Heat

**Location**
Brenton Kroehn - Waikerie
**Rainfall**
2017 Total: 237 mm
2017 GSR: 103 mm
2016 Total: 304 mm
2016 GSR: 208 mm
2015 Total 198 mm
2015 GSR: 133 mm
**Paddock History**
Cereal (Wheat/barley) prior to each break phase
**Soil Type**
Waikerie Flat: Heavy red-grey soil with limestone from 20-30 cm below the surface
Waikerie Sand: Red sandy loam
**Plot Size**
15 m x 2 m x 4 reps
**Yield Limiting Factors**
2016: Frost
2015: Heat

## Key messages

- **The productivity of nine different break crop options across three seasons and four northern SA Mallee soil types was similar. Season and soil type had a greater impact on productivity than crop choice.**
- **Season had the greatest impact on break crop productivity with yields almost four times more in a high rainfall (decile 8-10) year than in a low (decile 2-4) rainfall season.**
- **Break crop yields varied by up to 60 percent between soil types. Production on the deep sand was constantly poor with lentil, chickpea and faba bean yields approximately half of what was achieved on a nearby loam soil.**
- **The potential for high value pulses to be used by Mallee farmers was demonstrated by these trials, with average lentil and chickpea gross margins of more than $600/ha for the three seasons.**
- **The high yield and price variability demonstrated in these trials highlights the need for a diversity of breaks crops to be available for northern SA Mallee farming systems.**

## Why do the trial?

Farmers in the low rainfall zone are looking to increase the proportion and diversity of broadleaved break crops in their paddock rotations, however very little local information is available to support break crop selection and management in these environments. Furthermore, there is often extreme soil type variability within paddocks, which adds additional complexity when selecting an appropriate break crop for these farming systems.

To address these knowledge gaps, Mallee Sustainable Farming Inc, with funding from SAGIT, commenced a three-year project in 2015 to compare broadleaved break crop performance (productivity and profitability) across four major soil types in the northern Mallee of South Australia (SA).

## How was it done?

Nine different broadleaved crop options were compared over three seasons (2015-2017) on four soil types commonly found in the northern Mallee region. Trials were located at Waikerie and Loxton and at each site trials were located on two contrasting soil types. A brief description of each of the four soil types is provided below:

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

Table 1 shows the nine crop type and variety treatments used in each trial. Each trial was sown soon after the break of the season into moist soil to ensure successful inoculation. Trials were sown on the following dates in each season:

- 2015: Loxton, 28 April; Waikerie, 1 May
- 2016: Loxton, 26 May; Waikerie, 30 May
- 2017: Loxton, 5 May; Waikerie, 9 May

Each treatment at each site was managed independently to ensure that it had every opportunity to reach its potential. Agronomic management differences included herbicide choice, fertiliser rates and fungicide and pesticide applications. All trials were machine harvested across multiple dates in each season to ensure grain yield was measured soon after crops matured to minimise losses.

Gross margins were calculated for each treatment using the Rural Solutions Farm Gross Margin and Enterprise Planning Guide. Gross margins used the January grain price from the year following each trial (Table 1).

## What happened?

### *Seasonal conditions*

Figure 1 shows the annual rainfall received at Loxton and Waikerie for each of the three trial years. In 2015 and 2017, rainfall was generally below average with growing season rainfall (GSR) at Loxton decile 5 and 3 and at Waikerie decile 3 and 2 for 2015 and 2017 respectively. Both seasons had good April rainfall allowing for timely sowing in early May. In 2016, both sites received exceptional GSR, especially in spring, with a decile 10 GSR recorded at Loxton and decile 8 GSR at Waikerie.

Frost affected sites in 2015 and 2017. A severe frost (-5°C) at the end of August in 2015 impacted yields on the lower lying 'flat' sites at Loxton and Waikerie and predominately affected the yields of field pea. Impacts on other crops was less obvious. In 2017 minimum temperatures of up to -3.4°C on the 28 and 30 August and then again on the 9 and 10 September visibly impacted field pea and lentil yields at all sites. No frost damage was observed in 2016 due to later sowing of the trials. In 2015, the trials were also subjected to severe heat stress with six days of above 40°C recorded in October.

### *Productivity*

Field pea production, averaged over both soil types and all three seasons, was the best with an average yield of 1.3 t/ha while Albus lupins were consistently the worst yielding crop, producing an average yield of 0.6 t/ha (Table 2). All other break crop options averaged between 0.8-1.1 t/ha over all seasons and soil types.

There was a high level of variation in break crop yields both between seasons and between soil types. For example, the average yield of all break crops in 2016 was nearly four times greater than in 2015 and 2017 (Table 2). The pattern of rainfall and temperatures within years was also important. In 2015, a hot and dry spring favoured crops with early maturity; field peas, vetch and lentils produced the highest average yield. In contrast frosts in August and September and significant rainfall in October favoured later maturity crops with chickpea and lupins producing the highest yields.

Break crops were most productive on the loamy soil of the Loxton flat site with all break crops averaging 1.3 t/ha for the three seasons. However, average break crop yields on the sandy soil at Loxton were only 60% of those achieved on the loam, despite the sites being located just 250 metres apart. Lentils, chickpea and faba bean performed particularly poorly on the sandy soil, producing 50% of the grain yield achieved on the better soil type. At Waikerie the best production was on the sandy loam soil (Waikerie sand) with an average yield of 1 t/ha across all crops and seasons. In comparison, the average yield at the Waikerie flat site was 0.8 t/ha. However, performance at this site was highly variable with seasonal conditions, being almost as productive as the Loxton and Waikerie sand sites in 2016 but extremely poor in 2015 and 2017.

*Table 1. Broadleaved crop and varieties compared in each trial and prices used for gross margin analysis in each season.*

| Crop | Variety | 2015 Price ($/t) | 2016 Price ($/t) | 2017 Price ($/t) |
|---|---|---|---|---|
| Field pea | PBA Wharton | 550 | 350 | 285 |
| Vetch | Rasina | 850 | 300 | 506 |
| Narrow-leaved lupin | PBA Barlock | 380 | 230 | 270 |
| Albus lupin | Luxor | 380 | 230 | 270 |
| Faba bean | PBA Samira | 560 | 270 | 315 |
| Lentil | PBA Hurricane | 1340 | 680 | 420 |
| Desi chickpea | PBA Striker | 950 | 1350 | 800 |
| Kabuli chickpea | Genesis 090 | 1050 | 1450 | 900 |
| Canola | Stingray | 530 | 520 | 500 |

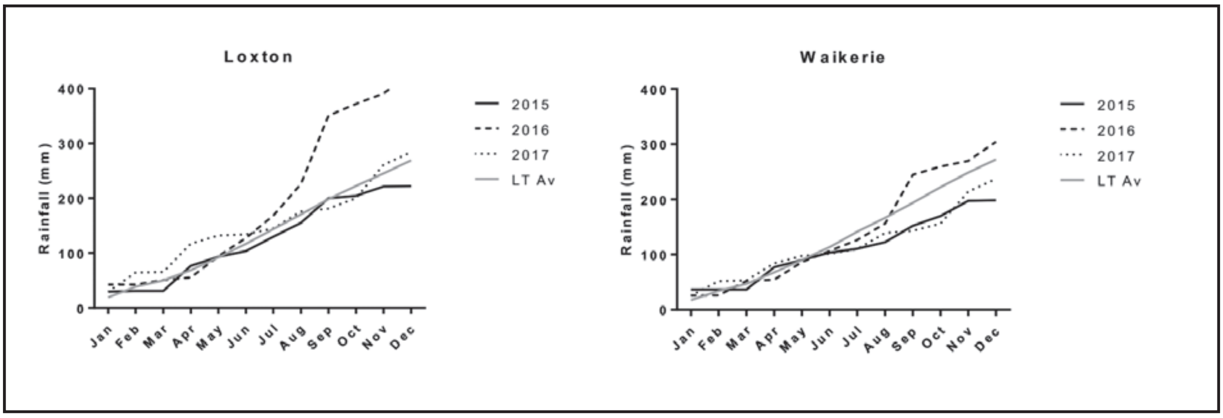



***Figure 1. Cumulative annual rainfall for Loxton and Waikerie locations for the three trial years (2015-2017) and the long-term average (LT Av).***

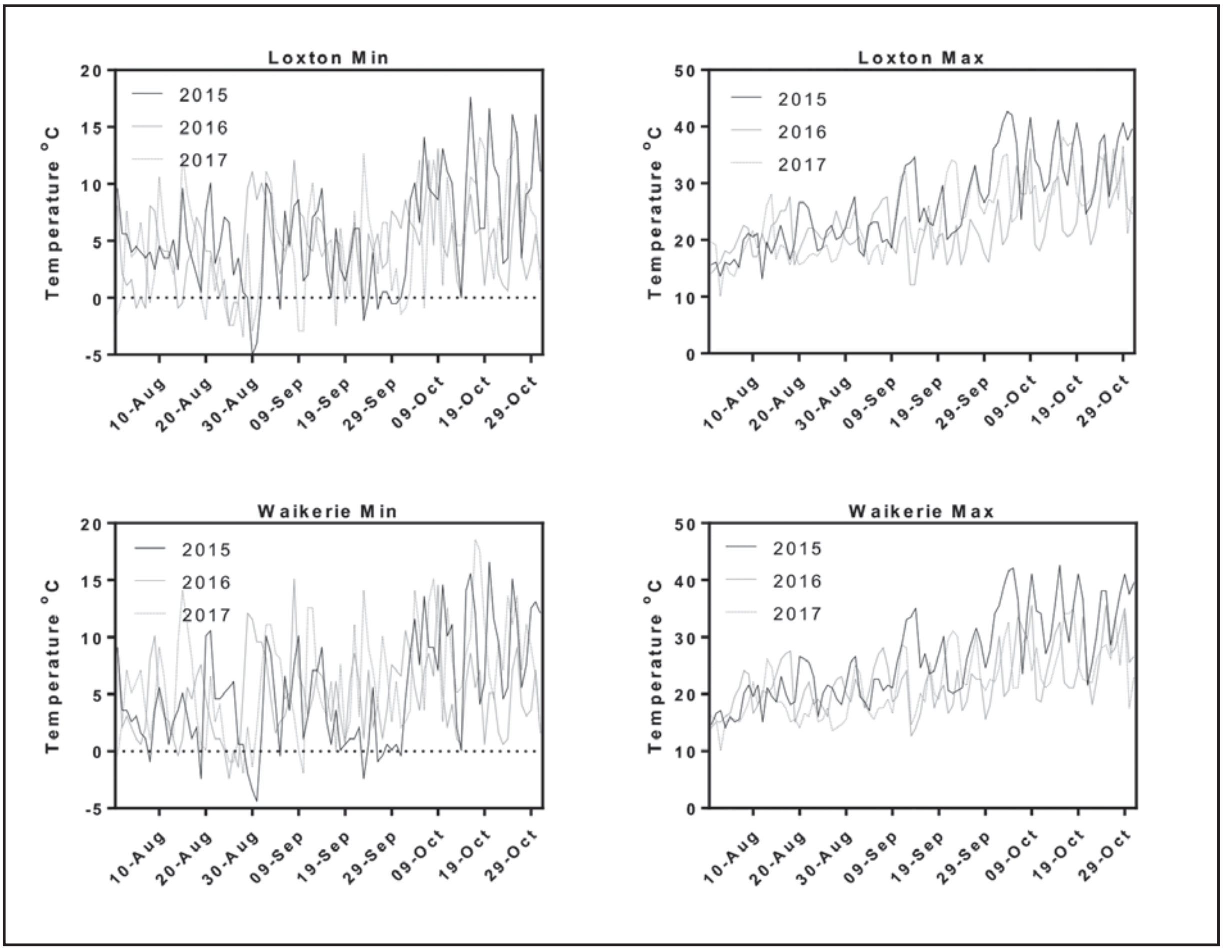



***Figure 2. Daily minimum and maximum temperature measured at canopy height (50 cm) for August – October at the Loxton and Waikerie flat sites.***

***Profitability***

The standout outcome from these trials was the high profitability of chickpea and lentils (Figure 3). Chickpeas (Desi and Kabuli) and lentils averaged more than $600/ha across the three seasons with these options averaging $1000-2000/ha in 2016 when high yield and prices coincided.

Vetch, field pea and canola also produced good gross margins over the three trial years with gross margins of $300, $250 and $200/ha respectively. Field pea had the most variable profitability of all crops, ranging from $700/ha in 2016 to -$50/ha the following season.

The profitability of narrow leaf lupin and faba beans was moderate, averaging approximately $100/ha. Despite producing nearly twice as much grain as lentils and chickpea on the Loxton sand, the overall profitability of lupins was only half of these crops at this site.

The benefit of high value crops was also evident in the lower rainfall seasons. In 2015, lentils produced a gross margin of over $700/ha despite moderate yields (0.7 t/ha across all sites), because their price was $1340/t at the time. However, lentils only just broke even in 2017 when their price had dropped from 2015 levels by nearly $1000/t.

*Table 2. Break crop grain yields (t/ha) on four northern SA Mallee soil types for three seasons (2015-2017).*

| Year | Site | Albus lupin | Kabuli chickpea | Canola | Desi chickpea | Faba bean | Lentils | Narrow lupin | Vetch | Field pea |
|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | Loxton Flat | 0.3 | 0.4 | 0.5 | 0.5 | 0.8 | 1.0 | 0.7 | 0.8 | 0.6 |
| | Loxton Sand | 0.1 | 0.2 | 0.7 | 0.3 | 0.6 | 0.6 | 0.6 | 0.9 | 0.7 |
| | Waikerie Flat | 0.0 | 0.1 | 0.2 | 0.1 | 0.3 | 0.5 | 0.2 | 0.2 | 0.2 |
| | Waikerie Sand | 0.3 | 0.4 | 0.7 | 0.8 | 0.5 | 0.8 | 0.5 | 0.7 | 1.2 |
| | **Average (all sites)** | **0.2** | **0.3** | **0.5** | **0.4** | **0.5** | **0.7** | **0.5** | **0.6** | **0.7** |
| 2016 | Loxton Flat | 2.0 | 1.6 | 1.6 | 2.1 | 2.9 | 3.1 | 2.9 | 2.8 | 3.0 |
| | Loxton Sand | 0.6 | 0.6 | 1.0 | 0.9 | 1.5 | 0.9 | 2.1 | 2.0 | 1.7 |
| | Waikerie Flat | 1.0 | 1.2 | 1.5 | 1.6 | 1.6 | 2.5 | 1.8 | 1.8 | 3.6 |
| | Waikerie Sand | 1.0 | 2.5 | 1.6 | 2.4 | 1.7 | 1.9 | 1.5 | 2.2 | 3.2 |
| | **Average (all sites)** | **1.2** | **1.5** | **1.4** | **1.8** | **1.9** | **2.1** | **2.1** | **2.2** | **2.9** |
| 2017 | Loxton Flat | 0.7 | 1.0 | 0.7 | 1.0 | 0.9 | 0.9 | 1.3 | 0.8 | 0.7 |
| | Loxton Sand | 0.5 | 0.4 | 0.5 | 0.4 | 0.2 | 0.3 | 1.2 | 0.7 | 0.4 |
| | Waikerie Flat | 0.1 | 0.4 | 0.4 | 0.3 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Waikerie Sand | 0.1 | 0.5 | 0.5 | 0.5 | 0.1 | 0.2 | 0.5 | 0.5 | 0.6 |
| | **Average (all sites)** | **0.4** | **0.6** | **0.5** | **0.5** | **0.4** | **0.4** | **0.8** | **0.6** | **0.5** |
| | ***Average (all years)*** | ***0.6*** | ***0.8*** | ***0.8*** | ***0.9*** | ***1.0*** | ***1.1*** | ***1.1*** | ***1.1*** | ***1.3*** |



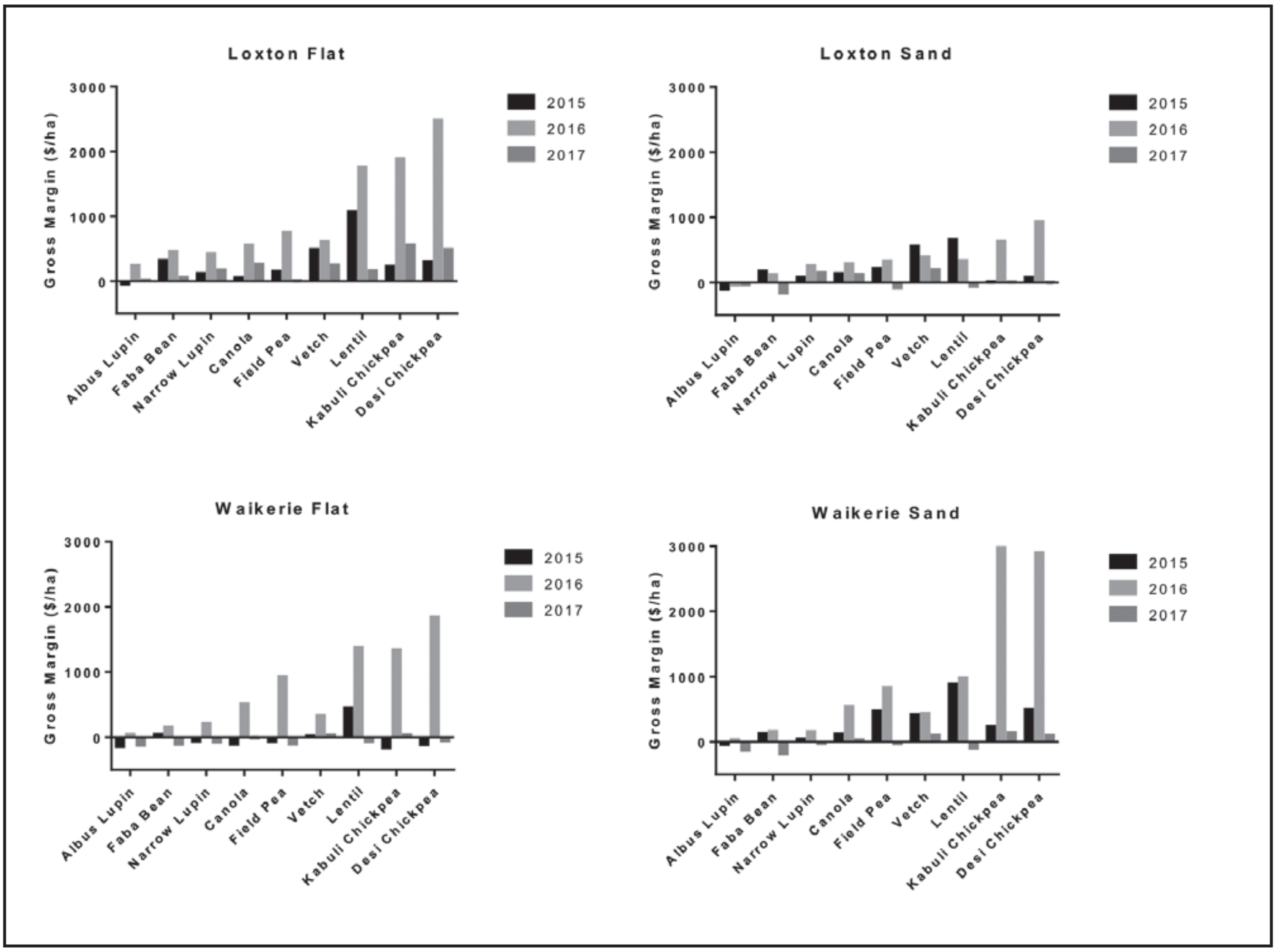



*Figure 3. Break crop gross margins on four northern SA Mallee soil types for three seasons (2015-2017).*

An interesting outcome of the analysis was that there was much greater potential for upside profit than downside risk. For example, all crops with the exception of the poorly adapted Albus lupins at least broke even in 2015 and 2016 at the Loxton flat and sand sites and at the Waikerie sand site. In 2017, negative gross margins were more common, however these losses tended to be relatively small, especially in comparison to the profits achieved by these crops in the previous season. The Waikerie flat site, which has a shallow soil, proved to be the most ‘risky’ site with most crops producing negative gross margins in both of the drier seasons (2015 and 2017), however profitability was similar to other sites with a favourable season (2016).

Profitability varied by more than 50% between soil types. On the Loxton flat, the average gross margin across all crops for the three seasons was $500/ha which was 60% more than the gross margin of crops on the sandy soil. At Waikerie, the average gross margin of all crops on the sandy loam soil was $450/ha, which was 50% greater than the profitability of crops grown on the flat. Break crop profitability was highly variable on the flat with large gross margins produced by canola, field pea, lentil and chickpea in the favourable 2016 season, however only lentils in 2015 produced a gross margin greater than $50/ha in the lower two rainfall years.

## What does this mean?

This project highlights that a high level of diversity is desirable when integrating break crops into Northern SA Mallee farming systems. Overall, most break crops had similar productivity potential, however the yields achieved in any one season were highly influenced by seasonal conditions (e.g. amount and distribution of seasonal rainfall, frost and heat events) and soil type.

In these trials, price had a greater influence on the profitability of the break crops than productivity. High prices received for lentils and chickpeas during the past three years resulted in some exceptionally high gross margins for these crops which demonstrated that high value crops have a fit in the low rainfall Mallee farming systems. However, farmers need to be mindful of the volatility of pulse crop markets, as demonstrated by lentils, whose price fluctuated by nearly $1000/ha over the duration of the trials. This exposure to price risk further confirms the need to grow a number of break crops in low rainfall farming systems.

## Acknowledgements

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

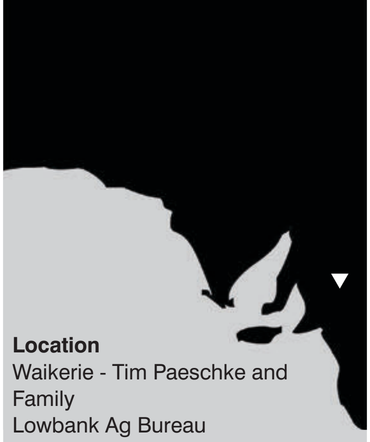
# Optimising the production potential of vetch on poor Mallee sands

**Brian Dzoma[1], Nigel Wilhelm[1] and Peter Telfer[2]**
[1]SARDI Waite, [2]SARDI Turretfield

RESEARCH



**Almost ready**



**Location**
Waikerie - Tim Paeschke and Family
Lowbank Ag Bureau
**Rainfall**
Av. Annual: 288 mm
Av. GSR: 163 mm
2017 Total: 211 mm
2017 GSR: 96 mm
**Paddock History**
2016: Wheat
2015: Wheat
2014: Clearfield barley
**Soil Type**
Alkaline sand (sandhills)
**Plot Size**
25 m x 1.8 m x 4 reps
**Yield Limiting Factors**
Moisture

## Key messages

- **Vetch productivity on poor sandhills can be improved when phosphorus is not limiting.**
- **High soil N levels are detrimental to vetch root and shoot biomass, nodules and grain production.**
- **Placing phosphorus deeper at sowing is beneficial for improved root and shoot biomass and grain yield.**

## Why do the trial?

Legumes have an important role in modern farming systems, greater than their traditional nitrogen fixation and 'disease break' properties. Australian farmers have adopted vetch as a pulse rotation crop in regions where low rainfall is a major environmental stress. The versatility of vetch as a valuable legume is gaining ground in low-medium rainfall mixed farming systems. In 2016, approximately 32,000 ha of vetch was grown in South Australia, with 32% of that area being grown in the SA Mallee (Rural Solutions, 2017).

Traditionally, vetches were sown as mixes for hay, or grown for grazing only. Nowadays vetches are being used for disease and weed break crops in the rotation, grain for stockfeed, hay and silage production, green and brown manure and green and dry grazing. In the SA Mallee, vetch crops on sands, particularly sandhills, struggle to grow and reach their full production potential. The main aim of the trial reported here was to identify if nutrition was a major factor in the poor productivity of vetch on Mallee sands, and if so, which specific nutrients are responsible.

## How was it done?

Nine different broadleaved crop options were compared over three seasons (2015-2017) on four soil types commonly found in the northern Mallee region. Trials were located at Waikerie and Loxton and at each site trials were located on two contrasting soil types. A brief description of each of the four soil types is provided below:

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

## How was it done?

A replicated trial was established at Waikerie on a sandhill with poor-marginal soil fertility (Table 1) on 10 May 2017. Both N and P were low in the top 10 cm and at depth.

Rasina vetch seed was sown in 25 m x 1.8 m plots at 35 kg/ha with varying nutrient packages (Table 2). The trial had two components, with the main trial being set up as a nutrient omission trial starting with a treatment that had a comprehensive nutrient package (N, P, K, S, Zn, Mn, Cu and B), and eliminating one nutrient at a time. The control had no nutrients added to it. The second component of the trial had three treatments which investigated the effect of nutrient placement (shallow vs deep) on vetch establishment, dry matter and seed production.

*Table 1. Background soil fertility.*

| | mg/kg | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $NO_3$ + $NH_4$ N | Colwell P | Colwell K | KCl Sulphur | Boron | DTPA | | |
| | N | P | K | S | B | Zn | Mn | Cu |
| 0-10 cm | 2 | 21 | 175 | 4.1 | 0.3 | 0.8 | 0.9 | 0.1 |
| 10-60 cm | 2.3 | 5 | 132 | 4.1 | 0.5 | 0.2 | 0.6 | 0.2 |

*Table 2. Treatments applied at Waikerie in 2017.*

| | | kg nutrient per hectare | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | | **N** | **P** | **K** | **S** | **Zn** | **Mn** | **Cu** | **B** |
| **Component 1** (Omission trial) | Complete | 50 | 20 | 45 | 20 | 2 | 3 | 1 | 1 |
| | Minus B | 50 | 20 | 45 | 20 | 2 | 3 | 1 | * |
| | Minus Cu | 50 | 20 | 45 | 20 | 2 | 3 | * | 1 |
| | Minus Mn | 50 | 20 | 45 | 20 | 2 | * | 1 | 1 |
| | Minus Zn | 50 | 20 | 45 | 20 | * | 3 | 1 | 1 |
| | Minus S | 50 | 20 | 45 | * | 2 | 3 | 1 | 1 |
| | Minus K | 50 | 20 | * | 20 | 2 | 3 | 1 | 1 |
| | Minus P | 50 | * | 45 | 20 | 2 | 3 | 1 | 1 |
| | Minus N | * | 20 | 45 | 20 | 2 | 3 | 1 | 1 |
| | Control | * | * | * | * | * | * | * | * |
| **Component 2** (P placement) | Deep P + Zn | * | 10 | * | 20 | 2 | * | * | * |
| | Shallow P + Zn | * | 10 | * | 20 | 2 | * | * | * |
| | Shallow P | * | 10 | * | 20 | * | * | * | * |

*(Nitrogen - N, phosphorous - P, potassium - K, sulphur - S, zinc - Zn, manganese - Mn, copper - Cu, boron - B). Zn, Mn and Cu were applied as sulphates and boron as boric acid.*

Crop establishment was estimated on 31 May; sampling for nodulation and root diseases on 4 August, and late dry matter (DM) cuts at mid flowering-early podding on 19 September. On 24 August, Verdict was applied @ 75 ml/ha plus uptake oil for grass control and Lemat @ 200 ml/ha for aphid control at a water rate of 100 L/ha. The trial was harvested on 20 November 2017 to determine vetch grain yield.

## What happened?

During the early stages of crop emergence, any treatment that had N did not look as good as the treatments without N. However, all treatments had similar plant numbers to the control for the nutrient omission trial. The site mean was 57 plants/$m^2$. Shallow P however resulted in a 22 and 27% reduction in plant numbers for the 'shallow P + Zn' and 'shallow P' treatments respectively.

Prior to flowering, some of the vetch plots were showing signs of stunted growth so all plots were sampled (4 samples/plot) for root diseases, root dry matter and nodulation scoring. After scoring, roots from plants without any N added had the best score for root health and any treatment that had N had the worst root health score (Table 3). The site mean root health score was 2.7, which indicates a heavy disease burden on the scale of 1-5 (0 = good and 5 = bad). The site mean for *Pratylenchus neglectus* nematodes was 7760 nematodes/g soil, which is classified as high risk for crops during the growing season (Garrard, 2018). Shallow P (14310) and Minus N (14230) were the only treatments that had significantly higher ($P<0.001$) nematodes per gram of soil, and all the treatments that received N had significantly ($P<0.001$) less nematodes than the control. *Rhizoctonia solani* AG8 was also detected at the site (mean 110 pgDNA/g sample), but in low - moderate levels for an in-crop assessment. The levels ranged from 0 to 470 pgDNA/g sample which suggests there was some impact on the plants but highly unlikely to be the primary cause of root damage.

For vetch on light soils, 20 nodules per plant at 8 weeks post sowing is considered satisfactory (GRDC, 2014). Treatments without any N (minus N, Deep P + zinc, shallow P + zinc) had good nodule numbers over 20, however any treatment that had N at sowing had very poor nodule numbers; less than 10 nodules per plant. For root dry weight, shallow P + Zn, minus N, shallow P and deep P + Zn, produced higher root dry weight than the control, although no treatment performed worse than the control. In terms of final grain yield, no treatment performed better than the control sown with no added nutrition, however, minus S, minus Cu, minus P and minus Zn, had significantly lower grain yield than the control.

## What does this mean?

The production of vetch in low-medium rainfall mixed farming systems is becoming more common because of its versatility. Depending on end use, vetch can return 50-60 kg/ha of nitrogen to the soil after production of grain, and 65-100 kg/ha after cutting for hay (Matic *et al*. 2006); confirming its importance in improving soil N fertility. Results from this trial have demonstrated that high soil N levels are detrimental to vetch root and shoot biomass, nodules and grain production. Removing the N from the 'complete' treatment resulted in a 47% increase in shoot dry matter (t/ha) and a 117% increase in grain yield (kg/ha). Sowing vetch with N is not a common practice, but these results suggest that vetch sown in a paddock with high residual N may be at risk to a biomass and yield penalty.

*Table 3. Crop establishment, root diseases, nodule counts, root dry weight, late DM and grain yield of vetch sown on an alkaline Mallee sand in 2017.*

| Treatment | Crop establishment (plants/$m^2$) | Root health score (0=good 5 =bad) | *Pratylenchus neglectus* nematodes /g soil | *R. solani* AG8 pgDNA/g Sample | Nodules/ plant | Root dry wt (mg/ plant) | Dry matter (t/ha) | Grain yield (kg/ ha) |
|---|---|---|---|---|---|---|---|---|
| Minus N | 64 | 1.7 | 14230 | 0 | 21.9 | 131 | 2.2 | 274 |
| Minus P | 61 | 3.2 | 5560 | 160 | 3.5 | 73 | 1.1 | 155 |
| Deep P + Zn | 61 | 2.0 | 10340 | 80 | 23.2 | 119 | 2.2 | 323 |
| Complete | 60 | 2.8 | 6080 | 120 | 4.5 | 61 | 1.5 | 126 |
| Minus S | 59 | 3.4 | 5560 | 120 | 5.9 | 56 | 1.6 | 159 |
| Control | 59 | 2.5 | 9370 | 120 | 13.9 | 94 | 1.5 | 245 |
| Minus Zn | 59 | 3.1 | 4000 | 0 | 5.1 | 40 | 1.5 | 123 |
| Minus Mn | 58 | 3.4 | 4920 | 0 | 5.2 | 49 | 1.5 | 169 |
| Minus Boron | 58 | 3.1 | 4100 | 330 | 5.0 | 41 | 1.7 | 171 |
| Minus Cu | 57 | 3.1 | 5230 | 0 | 6.9 | 52 | 1.8 | 159 |
| Minus K | 53 | 2.5 | 4470 | 50 | 6.4 | 45 | 1.6 | 166 |
| Shallow P + Zn | 46 | 2.1 | 12700 | 0 | 21.0 | 127 | 2.1 | 287 |
| Shallow P | 43 | 2.4 | 14310 | 470 | 18.6 | 143 | 1.4 | 210 |
| **Grand mean** | **57** | **2.7** | **7760** | **110** | **10.8** | **96** | **1.7** | **198** |
| *LSD (P=0.05)* | *9* | *0.4* | *3500* | *450* | *3.8* | *26* | *0.4* | *84* |

Break Crops

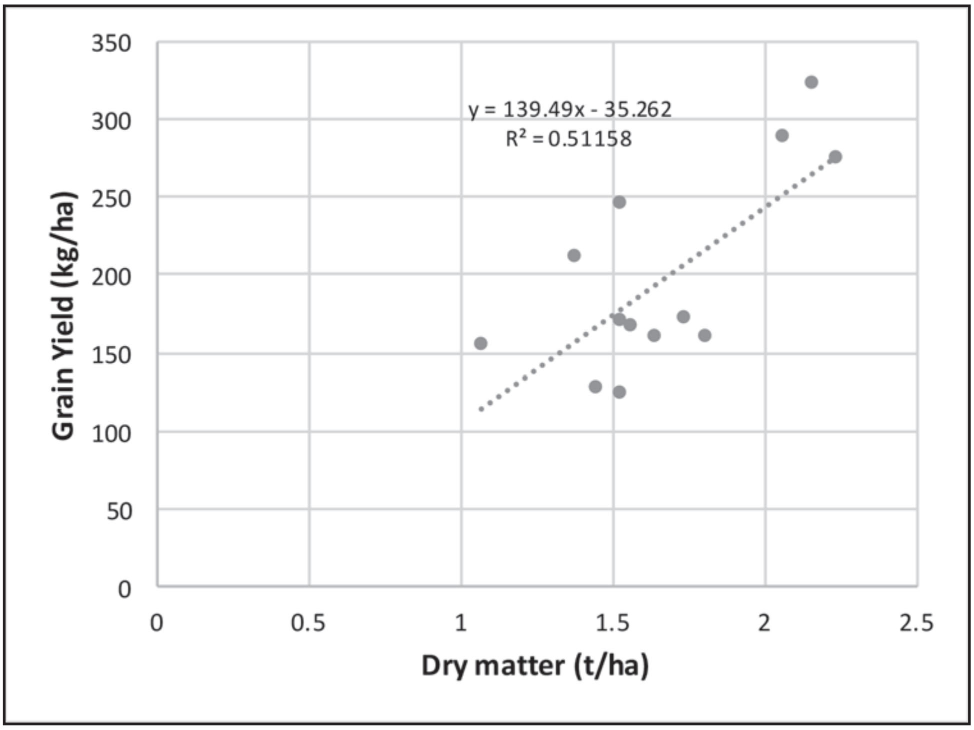



***Figure 1. Relationship between final grain yield (kg/ha) and late dry matter (t/ha).***

This trial has also shown that phosphorus is a critical macronutrient in vetch production, and that the gains in productivity are higher when P is placed deeper away from the seed at sowing. There was a 27% penalty in dry matter when the vetch was sown with no P, and a 47% increase in dry matter by adding P at sowing, 8 cm below the seed. P was marginal in the top 0-10 cm but was limiting in the 10-60 cm subsoil, hence the positive response in root dry weight, late dry matter and grain yield. Potassium, sulphur, zinc, manganese, copper and boron did not significantly change late dry matter and grain yield of the vetch on the sandhill.

Average dry matter yield for Rasina vetch grown in 2006 at a trial site in Kingsford was 4.8 t/ha and 2.5 t/ha in Lameroo (Matic *et al*. 2006), and average grain yield for 2009, 2010 and 2011 was 2.2 t/ha from 4 sites in SA (Nagel *et al*. 2011). Trial site means of 1.7 tDM/ha for late biomass and 198 kg/ha for grain yield reflects the impact of a below average season for the SA northern Mallee. Based on the dry matter produced, higher grain yield was expected, however this was not achieved due to the fact that the crop ran out of moisture during a critical period of grain-filling. Final grain yield was positively correlated to dry matter (Figure 1) i.e. grain yield increased with an increase in dry matter produced. However, the conversion efficiency of the vetch biomass to grain was low, every 1 tonne of dry matter per hectare resulted in only 104 kg grain per hectare.

For the omission trial, the contribution of P, K, S, Zn, Mn, Cu and B was not clear due to the effects of high nitrogen (100 kgN/ha) at sowing. The relative importance of these macro and micro nutrients on vetch still need to be further investigated in replicated field trials where N levels are low or non-toxic. The presence of root diseases should not be disregarded as they also could have affected the response of the crop to the nutirents imposed.

## References

Garrard T (2018). Senior Research Officer, Soil Biology and Diagnostics. Pers. comm., 23/01/2018.

GRDC (2014). Inoculating legumes. The back pocket guide. Grains Research and Development Corporation.

Nagel S, Matic R and Kirby G (2011). Vetch in Australian farming systems. Eyre Peninsula Farming Systems 2011 Summary.

Matic R, Nagel S, Kirby G and Smith K. (2006). Vetch breeding and vetch use in Australia. Proceedings on 8th International Symposium of Forage Crops. Forage Crops Institute Novi Sad, Serbia.

Rural solutions (2017). Crop and Pasture Report South Australia. 2016 – 2017 crop performance summary and final crop estimates. Primary Industries and Regions, SA. Government of South Australia.

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**Section Editor:**
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# Nutrition



## Nutrition packages for lighter soils

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RESEARCH

**Searching for answers**

**Location**
Karoonda - Loller Partners
**Rainfall**
Av. Annual: 337 mm
Av. GSR: 237 mm
2017 Total: 399 mm
2017 GSR: 236 mm
**Paddock History**
2016: Wheat
2015: Wheat
2014: Wheat
**Soil Type**
Dune sand
**Plot Size**
2 m x 20 m x 4 reps

**Location**
Loxton - Bulla Burra
**Rainfall**
Av. Annual: 262 mm
Av. GSR: 172 mm
2017 Total: 290 mm
2017 GSR: 147 mm
**Paddock History**
2016: Wheat
2015: Wheat
2014: Wheat
**Soil Type**
Dune sand
**Plot Size**
2 m x 20 m x 4 reps

### Key messages

- **Good early nitrogen nutrition remains a key driver of yield in Mallee soils and penalties can occur with delays in applications to first node.**
- **Previously observed benefits of improved N use efficiency where Zn is supplied with N were not captured in the 2017 season.**
- **Wheat fertilised with DAP placed with seed yielded 0.5 t/ha (20%) less than wheat with DAP placed below seed in 2017 at Loxton, but had no effect at Karoonda.**
- **Using 50 kg DAP/ha with the seed and 35 kg urea/ha deep was better than 50 kg DAP/ha and 35 kg urea/ha all below the seed on sand at Loxton.**

### Why do the trials?

Supplying nitrogen (N) to wheat crops at 20 kg N/ha utilising products that contained zinc (Zn) produced yields equivalent to 40 kg N/ha supplied as straight urea in two consecutive seasons (2015 and 2016) at Loxton (McBeath *et al*. 2017a). The 2017 cropping season was the third year of testing the potential benefits of nutrition packages containing various combinations of N and Zn for Mallee sands at Loxton and the first year for Karoonda and Ouyen. The aims of the nutrition package work were to address the following question:

- Are there Zn containing N fertiliser products that have a consistent production or N use efficiency advantage over urea?

Following six years of measurements at Karoonda consistently demonstrating production and profit advantages of increased N inputs on sands all applied at sowing (40 kg N/ha relative to district practice of 10 kg N/ha at experiment commencement, McBeath *et al*. 2015), the soil-specific response to the timing and dose of N inputs were tested across a Loxton based dune-swale system and a dune and mid-slope soil at Ouyen in 2017 to address the following questions:

- Are there soil-specific differences in the amount and timing of N that will maximize productivity on new Mallee sites?
- Do high (relative to district practice) rates of N boost productivity on any of the key soil types at other Mallee sites?

**Location**
Ouyen - Hastings
**Rainfall**
Av. Annual: 334 mm
Av. GSR: 230 mm
2017 Total: 355 mm
2017 GSR: 202 mm
**Paddock History**
2016: Wheat
2015: Canola
2014: Wheat
**Soil Type**
Dune sand
**Plot Size**
2 m x 20 m x 4 reps

- Does all N upfront remain the best strategy for productivity and risk at other Mallee sites?

In 2015 we noticed that wheat plant establishment was significantly better on non-wetting sand (crest and dune) plots that received no fertiliser with the seed, compared with those that received 50 kg DAP/ha. Similar effects were measured in trials established by Jack Desbiolles at Moorlands in 2015 (McBeath *et al*. 2016). These effects were explored in more detail for their effects on crop productivity in 2016 demonstrating a 0.5 t/ha (20%) yield penalty for placing 50 kg DAP/ha with the seed. A further interesting lead was that the toxicity effect on yield could be overcome when 50 kg/ha DAP was placed with the seed with an extra 35 kg/ha of urea placed below the seed in 2016 (McBeath *et al*. 2017b).

The aims of fertiliser placement work at Karoonda and Loxton were to establish if;

- Supplying 50 kg DAP/ha with seed had a consistent yield penalty.
- If wheat yield could be improved by altering the placement of sowing fertiliser.

## How was it done?

All experiments at a site were sown on the same day (24 May at Ouyen, 25 May at Loxton and 29 May at Karoonda) into wheat stubble with Scepter wheat on 28 cm row spacing and 1.5 L/ha of trifluralin pre-sowing. The trials were established using knife points and a dual shoot system. Fertiliser placed below the seed was approximately 5 cm below seeding depth (3 cm). Pre-sowing soil water and nutrition was measured. In-season plant assessments of establishment, biomass (first node, GS31 and anthesis, GS65) along with grain yield and quality were assessed.

***Nutrition package***

On the back of the key responses to nutrition packages in 2015-2016 at Loxton a range of N source treatments were implemented at Loxton, Karoonda and Ouyen in 2017 (Table 1). Inputs of P, K and S were balanced across all treatments (10 kg P/ha, 9 kg S/ha, 18 kg K/ha) at sowing and Cu and Mn were applied as a foliar application in-crop.

***Soil-specific inputs and timing of nitrogen***

A range of N rate and timing treatments were set up at Loxton on plots covering the dune swale system over 100 m length. All N was applied as urea and sowing N treatments were applied below the seed while in-season treatments were surface applied.

At Ouyen plots were sown on dune sand and mid-slope soil types. All N was applied as urea and sowing N treatments were applied below the seed while in-season treatments were surface applied.

For both sites, all plots received a pre-sowing application equivalent to 33 kg/ha of potassium sulphate to eliminate K and S as confounding issues and 10 kg P/ha as triple superphosphate at sowing. All plots received an in-crop foliar application of Cu and Mn.

***Fertiliser placement***

To further explore the potential for fertiliser toxicity effects and the possible benefits associated with altered fertiliser depth, a small experiment of four treatments (Table 4) was established at Loxton and Karoonda. All plots received a pre-sowing application of 33 kg/ha of potassium sulphate to eliminate K and S as confounding issues with an in-crop foliar application of Zn, Cu and Mn.

***Table 1. Nutrition package treatments for experiments at Loxton, Karoonda and Ouyen.***

| N and Zn Product | N applied (kg/ha) | Zn applied (kg/ha) |
|---|---|---|
| Nil | 0 | 0 |
| Urea | 20 | 0 |
| Urea | 40 | 0 |
| MAP | 20 | 0 |
| ZnMAP | 20 | 0.4 |
| Zn-coated urea | 20 | 0.4 |
| Zn-S coated urea | 20 | 0.4 |
| Urea plus foliar Zn | 20 | 0.4 |

*Note: The Zn-coated urea treatment was discarded at Loxton due to a calibration issue.*

***Table 2. Nitrogen rate (kg N/ha) and timing (GS22 is early tillering and GS31 is first node) treatments for the dune-swale at Loxton.***

| Treatment | N applied (kg/ha) |
|---|---|
| Nil N | 0 |
| 10 N at sow + 10 N GS22 | 20 |
| 10 N at sow + 10 N GS31 | 20 |
| 40 N at sow | 40 |
| 20 N at sow + 20 N GS22 | 40 |
| 20 N at sow + 20 N GS31 | 40 |

*Table 3. Nitrogen rate (kg N/ha) and timing (GS22 is early tillering and GS31 is first node) treatments for the dune and mid-slope soils at Ouyen.*

| Treatment | N applied (kg/ha) |
|---|---|
| Nil N | 0 |
| 20 N at sow | 20 |
| 10 N at sow + 10 N GS22 | 20 |
| 40 N at sow | 40 |
| 10 N at sow + 30 N GS22 | 40 |
| 40 N at sow + 20 N GS22 | 60 |
| 10 N at sow + 50 N GS22 | 60 |
| 40 N at sow + 40 N GS22 | 80 |
| 10 N at sow + 70 N GS22 | 80 |
| 40 N at sow + 60 N GS22 | 100 |
| 10 N at sow + 90 N GS22 | 100 |

## What happened?

***Nutrition package***

Contrary to previous seasons, there was no clear response to adding 40 kg N/ha compared to 20 kg N/ha as urea across all sites except the Mid-Slope soil at Ouyen (Table 5). Where there was differentiation between 20 and 40 kg N/ha as straight urea, with the exception of ZnMAP, all other treatments containing 20 kg N/ha produced yields similar to 40 kg N/ha as straight urea (Table 5). The 2017 growing season featured some extremely dry periods at critical growth stages (May-July and September for Loxton and Ouyen and June and September for Karoonda) and these conditions often diminish responses to fertiliser inputs.

***Soil-specific inputs and timing of nitrogen***

The highest yields at Loxton in the Dune Sand were produced from 40 kg N/ha and 20 kg N/ha, except when half was applied at first node (Table 6). For the Loamy Sand and Mid-Slope, yields were reduced if 40 kg N/ha was split with half delayed and applied at first node or if only 20 kg N/ha was applied.

At Ouyen, the highest yields were produced at 60 kg N/ha, but they were not significantly more than yields at 40 kg N/ha, nor 20 kg N/ha if all was supplied at sowing (Table 7). While production potential differed between soils, there was no clear difference in N requirement.

***Fertiliser placement***

Establishment was not affected by fertiliser placement with all plant numbers close to or in excess of 90 plants/m$^2$ at both sites. Placement of 50 kg DAP/ha with the seed caused a 0.2 t/ha or 30% yield penalty compared with below the seed at Loxton but not Karoonda. Despite the possibility of a toxicity effect of DAP with the seed, the best performing treatment was 50 kg DAP/ha with the seed plus 35 kg urea/ha deep. Similarly, 50 kg DAP and 35 kg urea/ha applied below the seed was high yielding, with only a small decrease in yield observed at Loxton (0.14 t/ha) compared with a split placement.

*Table 4. Fertiliser treatments applied.*

| Fertiliser with seed | Fertiliser below seed |
|---|---|
| Nil | 50 kg DAP/ha |
| 50 kg DAP/ha | Nil |
| 50 kg DAP/ha | 35 kg urea/ha |
| Nil | 50 kg DAP/ha+35 kg urea/ha |

## What does this mean?

While we have measured increased productivity per unit N input when Zn is supplied with N in the fertiliser in past seasons, this was not clearly measured in 2017. We will continue to explore the dynamics of this interaction in order to better predict the soil types and seasons it will be of most benefit.

Sands continue to show responses to increased inputs of N across a range of environments and seasons, but responsiveness is dependent on yield potential. Nitrogen inputs at first node appear less effective than at early tillering and sowing, indicating good early N nutrition on sands remains a consistent requirement for cereal productivity.

We have measured toxicity effects of supplying 50 kg DAP/ha with seed. This effect does not tend to outweigh the benefits that come from having some fertiliser with and some below the seed compared with all deep. There are several combinations of fertiliser placement that remain to be tested to ensure that we have identified the optimal configuration.

***Table 5. Grain yield (t/ha) in response to nutrition package treatments for experiments at Loxton, Karoonda and Ouyen. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment. Treatments containing Zn supplied 0.4 kg Zn/ha.***

| N and Zn Product | Loxton | Karoonda | Ouyen-sand dune | Ouyen-mid slope |
|---|---|---|---|---|
| 0 N Nil | 0.43b | 2.60c | 0.31d | 1.71c |
| 20 N urea | 0.83a | 3.58a | 0.88abc | 2.23b |
| 40 N urea | 0.83a | **3.75a** | **1.09a** | **2.58a** |
| 20 N MAP | **0.88a** | 3.25ab | 0.80bc | 2.56a |
| 20 N ZnMAP | 0.85a | 3.44ab | 0.80bc | 2.20b |
| 20 N Zn-coated urea | * | 3.36ab | 1.01ab | 2.34ab |
| 20 N Zn-S coated urea | 0.86a | 3.61a | 1.06a | 2.46ab |
| 20 N urea plus foliar Zn | 0.75a | 2.98bc | 0.74c | 2.29ab |
| *LSD (P=0.05)* | *0.2* | *0.56* | *0.22* | *0.32* |

***Table 6. Grain yield (t/ha) in response to rate and timing of N input across dune-swale soils at Loxton. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment.***

| Treatment | N input (kg/ha) | Dune Sand | Mid-slope | Loamy Sand Swale |
|---|---|---|---|---|
| Nil N | 0 | 0.31d | 0.72d | 1.16d |
| 20 N at sow | 20 | 0.56abc | 1.07bc | 1.29cd |
| 10 N at sow + 10 N GS22 | 20 | 0.56abc | 1.04bc | 1.32cd |
| 10 N at sow + 10 N GS31 | 20 | 0.51c | 0.96c | 1.17d |
| 40 N at sow | 40 | **0.65a** | 1.18ab | **1.62a** |
| 20 N at sow + 20 N GS22 | 40 | 0.63ab | **1.27a** | 1.54ab |
| 20 N at sow + 20 N GS31 | 40 | 0.54bc | 1.08abc | 1.42bc |
| *LSD (P=0.05)* | | *0.09* | *0.19* | *0.20* |

***Table 7. Grain yield (t/ha) in response to rate and timing of N input in dune sand and mid-slope soils at Ouyen. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment.***

| Treatment | N input (kg/ha) | Dune Sand | Mid-slope |
|---|---|---|---|
| Nil N | 0 | 0.34d | 1.93d |
| 20 N at sow | 20 | 1.04abc | 2.43abcd |
| 10 N at sow + 10 N GS22 | 20 | 0.80c | 2.43abcd |
| 40 N at sow | 40 | 1.13abc | 2.90ab |
| 10 N at sow + 30 N GS22 | 40 | 1.11abc | 2.80ab |
| 40 N at sow + 20 N GS22 | 60 | **1.29a** | **3.00a** |
| 10 N at sow + 50 N GS22 | 60 | 0.85bc | 2.10cd |
| 40 N at sow + 40 N GS22 | 80 | 1.08abc | 2.64abc |
| 10 N at sow + 70 N GS22 | 80 | 1.00abc | 2.38bcd |
| 40 N at sow + 60 N GS22 | 100 | 1.23ab | 2.36bcd |
| 10 N at sow + 90 N GS22 | 100 | 1.00abc | 2.00d |
| *LSD (P=0.05)* | | *0.41* | *0.57* |

*Table 8. Establishment and grain yield and protein response to fertiliser placement. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment.*

| Fertiliser with seed | Fertiliser deep | Establishment (plants/m$^2$) | Grain yield (t/ha) | Protein (%) |
|---|---|---|---|---|
| Loxton | | | | |
| Nil | 50 kg DAP/ha | 97 | 0.84c | 10.70ab |
| 50 kg DAP/ha | Nil | 95 | 0.64d | 10.88a |
| 50 kg DAP/ha | 35 kg urea/ha | 94 | **1.18a** | 10.90a |
| Nil | 50 kg DAP/ha+35 kg urea/ha | 94 | 1.04b | 10.43b |
| *LSD (P=0.05)* | | *ns* | *0.12* | *0.35* |
| Karoonda | | | | |
| Nil | 50 kg DAP/ha | 94 | 2.33c | 8.30 |
| 50 kg DAP/ha | Nil | 89 | 2.36c | 8.28 |
| 50 kg DAP/ha | 35 kg urea/ha | 91 | **3.02a** | 8.68 |
| Nil | 50 kg DAP/ha+35 kg urea/ha | 89 | 2.81ab | 8.55 |
| *LSD (P=0.05)* | | *ns* | *0.44* | *ns* |


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## References


McBeath *et al*. (2015) http://agronomyaustraliaproceedings.org/images/sampledata/2015_Conference/pdf/agronomy2015final00260.pdf

McBeath *et al.* (2016) Sowing strategies to improve the productivity of crops in low rainfall sandy soils. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Sowing-strategies-to-improve-the-productivity-of-crops-in-low-rainfall-sandy-soils

McBeath *et al.* (2017a) http://www.msfp.org.au/effect-fertiliser-sown-wheat-seed-mallee-soils

McBeath *et al.* (2017b) http://www.msfp.org.au/managing-nutrition-sandy-soils-yield-gains-zn-n


Nutrition

# Disease

## Cereal variety disease guide 2018

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EXTENSION

### Summary of 2017 season and implications for 2018

2017 was a relatively quiet year for foliar diseases in the cereals. In some areas this was due in part to dry conditions and late sowing, in others the cold winter helped to suppress some of the pathogens. The good spring conditions however favoured late development of diseases particularly in the longer season areas.

**Septoria tritici blotch** and to a lesser extent **eyespot** were observed at higher levels across the medium and high rainfall areas. Both diseases were favoured by a significant build-up of inoculum in the previous two years. Most varieties are susceptible to varying degrees to both these diseases and fungicide sprays were likely to have been beneficial in many situations. There is some indication that the septoria population is adapting to different regions through increased virulence to local varieties. Confirmation of these changes will require further testing.

**Net form net blotch and spot form net blotch** were at lower levels in 2017 than previous years and this will have resulted in lower inoculum levels leading into 2018. However, the high yields of RGT Planet will possibly lead to large areas sown to this variety in coming years and this could lead to significant future issues with NFNB as this variety is very susceptible (SVS) to this disease.

### Leaf rusts in wheat and barley

Leaf rust in wheat was observed early in 2017 but was kept in check by cold temperatures through winter and through effective fungicide management of crops, in most cases as a precaution against stripe rust and/or septoria. Barley leaf rust was also present at much lower levels than previous years.

Stripe rust arrived very late and caused little or no problem owing to its late arrival and effective use of fungicides.

### Stem rust

Stem rust was not observed in wheat in 2017. It is a concern however that quite a few new wheat varieties are quite susceptible to stem rust. This is particularly the case with some long season wheats not included in this table, some of them bred overseas where stem rust is not such a concern. Whilst stem rust has not been a problem in recent years this has perhaps led to some complacency that growers should be aware of as an epidemic could be hard to control and very damaging.

### Eyespot

Eyespot resistance ratings have been included in the table for the first time, although many varieties are yet to be tested and rated. Whilst there is not a lot of variation amongst the varieties, those that are rated MS or MSS should provide a useful level of resistance over varieties rated S. Note however that taller varieties or varieties with weaker straw will be more prone to lodging due to eyespot than varieties with similar resistance ratings but which have stronger stems. Mace for example is more prone to eyespot lodging than Wyalkatchem, although both are equally susceptible to infection and yield loss other than through lodging. Saintly is also more prone to eyespot lodging compared to other durums.

### Powdery mildew

It has become apparent that variation in this pathogen has not been adequately reflected in the data obtained from nurseries on the Waite Campus. Specifically, Trojan has been found quite susceptible in the South-East but has shown more resistance in the nursery. For this reason data in the table should be treated with some caution.

Powdery mildew has become 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 Corack, and with stripe rust under better control it is possible this will lead to an increase in powdery mildew in future.

Barley powdery mildew is also variable and so the ratings provided here may not reflect all situations. Some barleys from Europe carry the *mlo* resistance gene which has proven durable over a long period of time. Where known this will be indicated in the table so that growers are notified that mildew control is not required in seed treatments for these varieties. All other varieties should be treated for mildew control to avoid loss of disease resistance and later fungicide efficacy in other varieties.

**Black point** is not a disease but a genetic response to particular environmental conditions, mainly damp weather post flowering. It is however included in this sheet for historical reasons. The damp conditions prior to harvest in 2016 meant higher levels of black point were observed in grain from several NVT trials as well as our special nursery near Millicent. This has resulted in a significant improvement in data for this guide in 2018.

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 is currently only used for some barley and oat diseases where the pathogens are particularly variable and unpredictable.

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 as 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 | Eyespot | Powdery mildew | Root lesion nematodes | | Crown rot | Common root rot | Flag smut | Black point ‡ | Quality in SA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stem | Stripe | Leaf | | | | | | *P. neglectus* | *P. thornei* | | | | | |
| Arrow | S | S | SVS | S | MS | MRMS | - | RMR | MRMS | MRMS | S | MS | MS | MRMS | AH |
| Axe | MS | RMR | SVS | SVS | S | S | S | MS | S | MS | S | MSS | S | S | AH |
| Beckom | MRMS | MRMS | MSS | SVS | R | MSS | S | MS | S | MSS | S | MSS | MR | MRMS | AH |
| Chief CLPlus | RMR | S | R | S | MS | MRMS | - | RMR | MS | MS | S | MS | SVS | MS | APW |
| Cobra | RMR | MSS | MR | MS | MS | MRMS | S | MSS | MSS | MSS | S | MSS | S | MSS | AH |
| Corack | MR | MS | SVS | S | RMR | MR | S | SVS | MSS | MSS | S | MS | S | S | APW |
| Cosmick | MS | MSS | SVS | SVS | S | MRMS | S | MSS | MSS | MSS | S | MSS | SVS | MRMS | AH |
| Cutlass | R | MS | R | MSS | MR | MSS | S | S | MSS | MSS | S | MS | MS | MS | APW |
| Darwin | MRMS | MR | S | SVS | MS | S | MSS | MRMS | S | S | S | MSS | MR | MS | AH |
| Emu Rock | MS | MRMS | S | SVS | S | MRMS | MSS | MSS | MSS | S | MS | MSS | MS | MS | AH |
| Forrest | RMR | RMR | MSS | SVS | S | MRMS | MS | MS | VS | SVS | SVS | MS | MR | MR | APW |
| Grenade CL Plus | MR | MRMS | S | S | MR | S | S | MS | MSS | S | S | MRMS | MR | MSS | AH |
| Harper | MRMS | MS | S | MSS | MRMS | S | S | S | S | MSS | S | MRMS | RMR | MRMS | APW |
| Hatchet CL Plus | MS | MRMS | SVS | VS | MR | S | S | MRMS | MSS | MSS | S | MS | RMR | S | AH |
| Havoc | S | MR | S | MSS | S | MRMS | - | - | S | MSS | S | MS | MS | MS | AH |
| Impala | MR | MR | SVS | VS | MSS | MSS | - | R | SVS | S | S | MSS | S | MS | 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 | MSS | S | MRMS | MR | MRMS | AH |
| Longsword | MR | RMR | MSS | MSS | MRMS | MRMS | - | - | MRMS | MRMS | S | MRMS | MRMS | MRMS | Feed |
| Mace | MR | SVS | MSS | S | MRMS | MRMS | S | MSS | MS | MS | S | MS | S | MRMS | AH |
| Manning | MR | RMR | MS | MR | S | MRMS | MS | MS | MSS | S | VS | SVS | R | SVS | Feed |
| Orion | MR | MSS | R | MS | MS | MSS | S | SVS | MS | S | S | MSS | S | S | Soft / Hay |
| Pascal | MSS | RMR | MS | MS | S | MRMS | MSS | - | S | S | S | MS | S | MS | APW |
| Revenue | RMR | R | VS | S | S | MS | - | R | S | MSS | S | SVS | S | MS | Feed |
| Scepter | MR | MSS | MSS | S | MRMS | MRMS | S | SVS | S | MSS | S | MS | MSS | MS | AH |
| Scout | MR | MS | MS | S | R | SVS | S | MRMS | S | MS | MSS | S | MR | S | AH |
| Shield | RMR | MR | R | S | MRMS | MSS | S | MR | MSS | MSS | S | MRMS | S | MSS | AH |
| Tenfour | S | SVS | S | SVS | MS | MRMS | S | MS | S | S | S | MS | RMR | MS | Feed |
| Trojan | MRMS | MR | MR | MS | MS | MSS | MS | S | MSS | MSS | MS | MS | SVS | MRMS | APW |
| Wyalkatchem | MS | S | S | SVS | S | MR | S | SVS | MRMS | MS | S | MSS | SVS | MS | APW |
| Yitpi | S | MRMS | S | MSS | MR | SVS | MSS | 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

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

| Triticale | Rust | | | *Septoria tritici* blotch | CCN Resistance | Yellow leaf spot | Eyespot | Powdery mildew | Root lesion nematodes | | Crown rot | Common root rot | Flag smut | Black point ‡ | Quality in SA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stem | Stripe | Leaf | | | | | | *P. neglectus* | *P. thornei* | | | | | |
| Astute | RMR | RMR | RMR | R | R | MRMS | – | R | R | MS | MSS | MS | R | – | Triticale |
| Bison | RMR | R | RMR | R | R | MR | – | R | R | RMR | MSS | MRMS | R | MRMS | Triticale |
| Fusion | R | RMR | RMR | R | R | MRMS | MS | R | RMR | MSS | MS | S | R | MSS | Triticale |
| Goanna | R | MR^ | RMR | R | R | MR | – | R | MRMS | SVS | – | – | R | – | Triticale |
| KM10 | R | RMR | MRMS | R | S | MR | – | – | RMR | MRMS | – | MRMS | R | MRMS | 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

‡ Black point is not a disease but a response to certain humid conditions.

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Disease

| Barley | Leaf rust* | Net form net blotch* | Spot form net blotch* | Scald* | CCN Resistance | Powdery mildew | Eyespot* | Barley grass stripe rust | Covered smut | Common root rot | Root lesion nematodes | | Black point |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | ***P. neglectus*** | ***P. thornei*** | |
| Alestar | R-MS | MR-S | MSS | MS-SVS | R | – | – | – | R | MSS | MR | MR | MRMS |
| Charger | MR-S | VS | S | S-VS | R | R | – | RMR | MSS | MS | MR | MRMS | MRMS |
| Commander | MS-S | MSS-SVS | MSS | S-SVS | R | MRMS | – | R | RMR | MSS | MRMS | MRMS | MSS |
| Compass | R-SVS | MR-MS | MR-MSS | MS-SVS | R | MRMS | MS | R | R | MS | MRMS | MR | MSS |
| Explorer | R-MRMS | R-S | MRMS-S | SVS | R | R | – | – | MRMS | MS | MRMS | MRMS | MS |
| Fathom | MR-MSS | MS-VS | RMR | R-MS | R | MRMS | MRMS | R | MR | MSS | MRMS | MR | MSS |
| Fleet | MRMS-S | S-VS | MR | MR-SVS | R | MRMS | – | RMR | MR | S | MRMS | MRMS | MS |
| Grange | R-MS | R-MS | S | MS-SVS | R | R *mlo* | – | R | RMR | S | MRMS | MRMS | MRMS |
| Hindmarsh | MRMS-S | MR-MS | S | R-VS | R | MR-S | MRMS-S | MR | MS | S | MRMS | MRMS | MSS |
| La Trobe | MRMS-S | MR-MS | MSS | R-VS | R | MR-S | MRMS-S | RMR | MS | S | MRMS | MRMS | MSS |
| Maritime | MRMS-S | R-VS | MRMS | MS-SVS | R | SVS | – | S | MS | MSS | MR | – | MS |
| Oxford | R-MR | MR-SVS | S | MR-SVS | S | R | MRMS | R | MRMS | MSS | MR | MRMS | MRMS |
| RGT Planet | MR-MS | MRMS-SVS | S | R-S | R | R | – | – | R | MSS | MRMS | RMR | MRMS |
| Rosalind | MR | MR | MS-S | MR-SVS | R | MR-S | MS | – | MRMS | S | MRMS | MR | MSS |
| 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 | MS | RMR | MS | MS | MRMS | MRMS | MS |
| Shinestar | MRMS | R-MS | MRMS | MS-S | R | MS-SVS | – | – | MRMS | MS | MRMS | MRMS | MS |
| Spartacus CL | MR-S | MR-MSS | S | R-VS | R | MR-S | MS | RMR | MS | MS | MRMS | MRMS | MSS |
| Westminster | R-MRMS | R-S | S | R-S | – | R *mlo* | – | 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
*mlo* - These varieties carry durable resistance

| Oats | Rust | | CCN | | Stem nematode | | Bacterial blight | Red leather leaf | BYDV | *Septoria avenae* | *P. neglectus* Nematodes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stem* | Leaf* | Resistance | Tolerance | Resistance | Tolerance | | | | | |
| Bannister | MR-S | R | VS | I | – | MI | MR-S | MS | MS | S | – |
| Brusher | MS-S | MS-S | R | MI | MS | I | MR-MS | MS | MS | MS | MR-MS |
| 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 | – |
| Kowari | MR-S | R | VS | – | – | I | MR | MS | S | S | – |
| 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, MT - mildly tolerant, I - intolerant, MI - moderately intolerant, ,  - = uncertain
[1]BYDV = Barley Yellow Dwarf Virus

Disease

# Sclerotinia in canola on lower Eyre Peninsula

**Blake Gontar**
SARDI, Port Lincoln

**Searching for answers**

**Location**
Mount Hope (field trial)
**Rainfall**
Av. Annual: 400 mm
Av. GSR: 325 mm
2017 Total: 390 mm
2017 GSR: 274 mm
**Yield**
Potential: 1.70 t/ha (B)
Actual: 1.68 t/ha
**Paddock History**
2017: Canola
2016: Lupin
2015: Wheat
**Soil Type**
Red chromosol
**Plot Size**
2 m x 10 m x 3 reps

## Key messages

- **Despite a below-average rainfall season, sclerotinia was widespread, being present in all 20 surveyed paddocks across the lower Eyre Peninsula. However, inoculum loads varied between paddocks.**
- **The major driver of infection appeared to be favourable humid conditions in the crop canopy, at least partly driven by the size of the early canola canopy.**
- **The incidence of sclerotinia ranged from 0 to 16.8% of surveyed plants infected.**
- **Severity, measured as the difference in yield between individual plants that were sclerotinia-infected and non-infected, ranged from 0 to 21%.**
- **The overall impact of sclerotinia (incidence x severity) on crop yields was therefore quite minor, ranging from 0 to 1.7% yield loss.**
- **In a fungicide trial conducted at Mt Hope in 2017, below average rainfall conditions resulted in no sclerotinia and hence no response to fungicides. Cv. Diamond averaged 1.68 t/ha.**
- **While the paddock survey indicates the potential for serious crop loss from sclerotinia should the right conditions occur on LEP, the plot trial shows that applying fungicides may provide no benefit under certain conditions.**

## Why do the trial?

Sclerotinia stem rot affects canola and most pulses. It is known to affect canola crops in Australia, with significant yield loss recorded in parts of NSW and northern Victoria (Hind et al. 2003; Kirkegaard et al. 2006). Whilst it is commonly seen in South Australia, in particular, in the lower Eyre Peninsula (LEP), it has rarely been reported as causing a significant yield loss in this region. However, reports from growers and advisors suggest Sclerotinia may be becoming more common and more severe with some growers and advisors taking precautionary action in the form of fungicide applications.

The aim of this research, involving paddock surveys and field plot trials, was to generate baseline incidence and severity data to quantify the extent of the sclerotinia issue. Furthermore, it is hoped that the paddock surveys will indicate the contributing factors of sclerotinia epidemics, to answer the question of why sclerotinia incidence and severity may have increased, and also allow better prediction of outbreaks which would facilitate improved spray application decision-making. Finally, it is hoped that the field trials will quantify any economic benefits of fungicide applications.

## How was it done?

### *Paddock monitoring and survey*

Initially, six paddocks around the LEP were chosen to locate a monitoring point for detailed crop, weather and disease monitoring. Given the unusual lateness of opening rain for most of the LEP, the six sites were chosen based mostly on their early establishment following localised storms in April/ May. The details of monitoring points are shown in Table 1.

For each monitoring point, plant density and crop biomass at flowering onset, was initially recorded. A temperature and relative humidity sensor was installed between crop rows at 50 cm above ground level. Crop height, growth stage/bloom stage and the presence of fungal mycelia (‘white fluffy growth’), apothecia (‘mushrooms’) and lesions were recorded at each weekly visit. At each visit, 20 randomly selected flowers were sampled from within 10 m of the monitoring point and were plated on a PDA growth medium to score the presence of viable sclerotinia spores on petals.

The incidence of sclerotinia was calculated by counting 500 plants within 10 m of the monitoring point, and recording the number of plants with any type of sclerotinia lesion. The severity of this infection was determined by comparing yield from a sample of healthy plants to that of infected plants.

*Table 1. Details of monitoring locations on lower Eyre Peninsula.*

| Location | Paddock History* | Cultivar | Germinating rainfall date (mm) | Sowing density (kg/ha) | Est. density (plants/m²) | GSR (mm) | Paddock yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Coulta | WLWCWCL | 45Y91 | 27 April (13) | 2.0 | 20 | 306 | 2.86 |
| Edillilie | BLWWCLW | 44Y90 | 28 May (27) | 2.0 | 47 | 333 | 2.00 |
| Kapinnie | BWLWCWP | Diamond | 16 May (8) | 2.0 | 27 | 277 | 2.28 |
| Mt Drummond | WWCWCWW | 44Y90 | 27 May (12) | 3.0 | 36 | 293 | 2.50 |
| Mt Hope | WLWCWCW | 44Y89 | 3 July (25) | 2.2 | 22 | 274 | 1.45 |
| Wangary | WLWWC | 45Y91 | 24 May (10) | 2.5 | 23 | 310 | 2.40 |

**Paddock history from most recent year (2016) to least recent record.*

For each of the six paddocks where a monitoring point was located and the incidence and severity of sclerotinia was calculated, a second incidence and severity calculation was then conducted in a randomly selected location within the same paddock (>100m away). Furthermore, 14 additional paddocks were surveyed and the incidence of sclerotinia calculated using the same method described above. Severity of infection was only calculated for the additional paddocks at Wanilla and Wangary, as none of the other additional paddocks had significant infection (>1% incidence).

Weather data was reviewed by considering average relative humidity (RH) throughout flowering and peak flowering for each site. It has previously been reported that >95% RH for a period of at least 48 hours is optimal for sclerotinia disease development. Thus, the total number of hours within each period which exceeded the 48 hours where average RH >95% and did not go below 80% RH, are reported, as well as the number of these periods within each season.

***Plot trial***

A plot trial was established at Mt Hope following opening rains. The trial comprised two varieties (Diamond and Hyola575CL) and five spray treatments (Unsprayed, Early Flowering, Mid Flowering, Late Flowering and Full Control) with a registered fungicide (Prosaro®). The full control treatment received three spray applications, at each of the other three spray timings (early, mid, late). Seed of both varieties was treated with fluquinconazole (Jockey®) and sown using a standard narrow point/press wheel seeder. A plant density of 45 plants/m² was targeted for both.

The trial was sown on 22 June and was located in a paddock with a history of sclerotinia, near the Mt Hope monitoring point discussed above. The site was managed for weeds, pests and nutrition as per district practice. A fungicide (Prosaro) application was made at the 3-5 leaf growth stage to assist in controlling blackleg in the vulnerable young crop, but is not expected to have influenced the later development of sclerotinia during reproductive stages.

## What happened?

***Paddock monitoring and survey***

***Crop growth and weather***

Table 2 shows the details of crop growth and development. The crops were all generally germinated within the acceptable window for canola on the LEP, except for Mt Hope, where the combination of low early rainfall and water-repellent soil type resulted in staggered germination and generally delayed the growth of the crop as a whole.

Rainfall was below average at all sites during the growing season. However, there were a number of distinctly prolonged moist periods at most sites during flowering, resulting in high humidity at various times. Average RH within the crop canopy throughout the flowering ranged from 80.8-96.1% across all sites.

Figure 1 shows the minimum, mean and maximum daily RH for each monitoring site, with the peak flowering period for each site and 'infective periods' indicated on each graph.

It is clear from the weather data that the crop canopy at Edillilie remained moist for long periods throughout flowering and particularly through 'peak' flowering (>30% bloom). To a lesser degree, Coulta and Kapinnie also remained quite humid. Wangary appeared to experience two clear periods of very high RH.

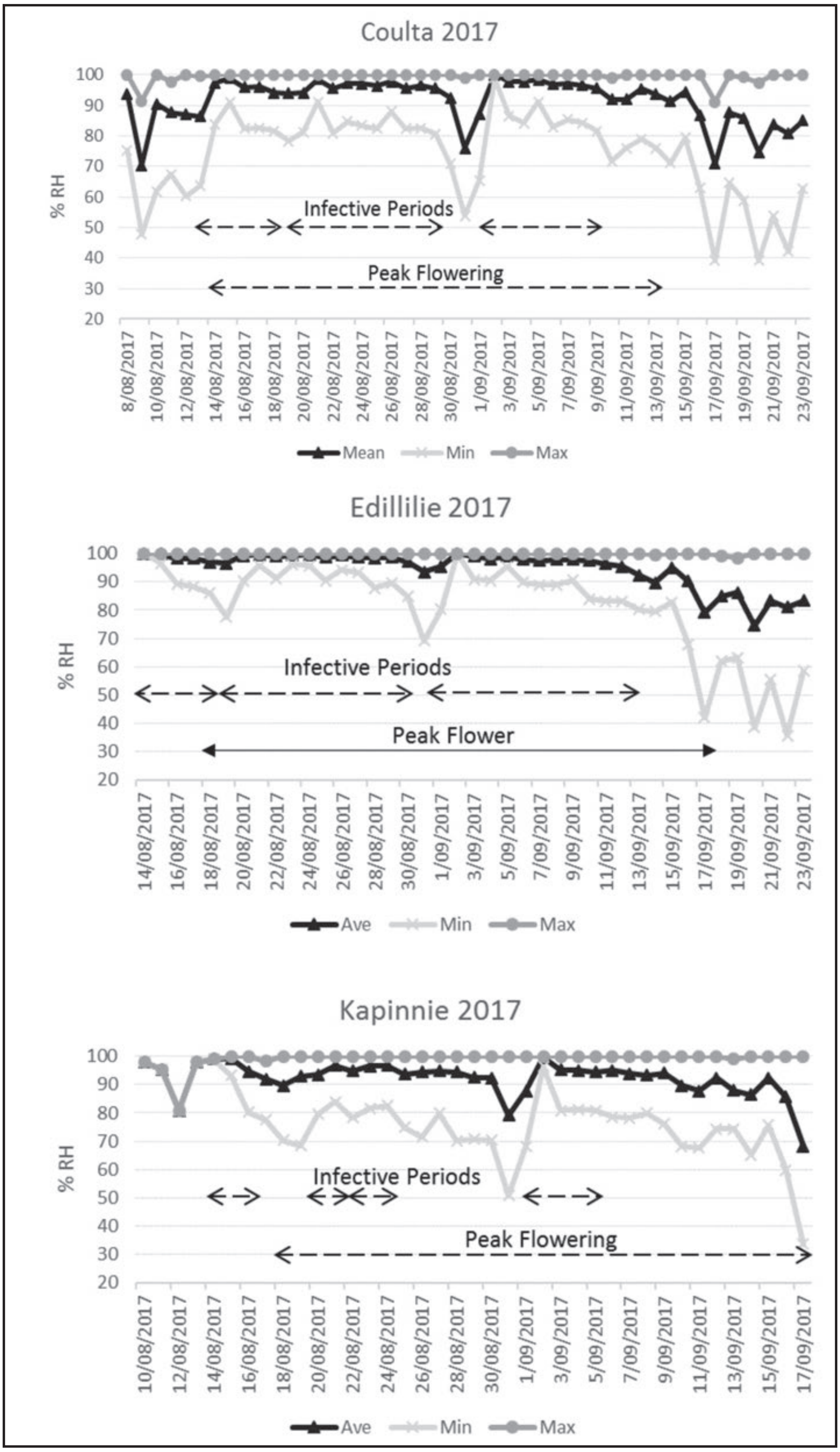
When the weather data is reviewed in terms of 'infective' periods as defined above, Kapinnie (4) experienced the greatest number of infective periods, followed by Coulta and Edillilie (3) and Wangary (2). Mt Drummond and Mt Hope did not appear to experience any periods optimal for disease development throughout flowering.

The total number of 'infective' hours experienced at each site varied considerably and did not necessarily reflect the number of periods. Edillilie experienced the greatest combined 'infective' period with a total of 753 hours, followed by Coulta (613), Kapinnie (310) and Wangary (138).

*Table 2. Crop growth and development at monitoring sites on the lower Eyre Peninsula.*

| Site | Germination | Flowering initiation | 30% bloom | 50 % bloom | End flowering | Maturity* |
|---|---|---|---|---|---|---|
| Coulta | 27 April | 08 Aug | 14 Aug | 21 Aug | 24 Sep | 27 Oct |
| Edillilie | 28 May | 14 Aug | 24 Aug | 03 Sep | 24 Sep | 24 Oct |
| Kapinnie | 16 May | 10 Aug | 18 Aug | 21 Aug | 18 Sep | 29 Oct |
| Mt Drummond | 27 May | 21 Aug | 28 Aug | 03 Sep | 03 Oct | 3 Nov |
| Mt Hope | 3 July | 28 Aug | 03 Sep | 18 Sep | 10 Oct | 14 Nov |
| Wangary | 24 May | 18 Aug | 24 Aug | 03 Sep | 03 Oct | 5 Nov |

*Maturity defined as physiological maturity i.e. 'windrowing stage', although not all crops were windrowed.



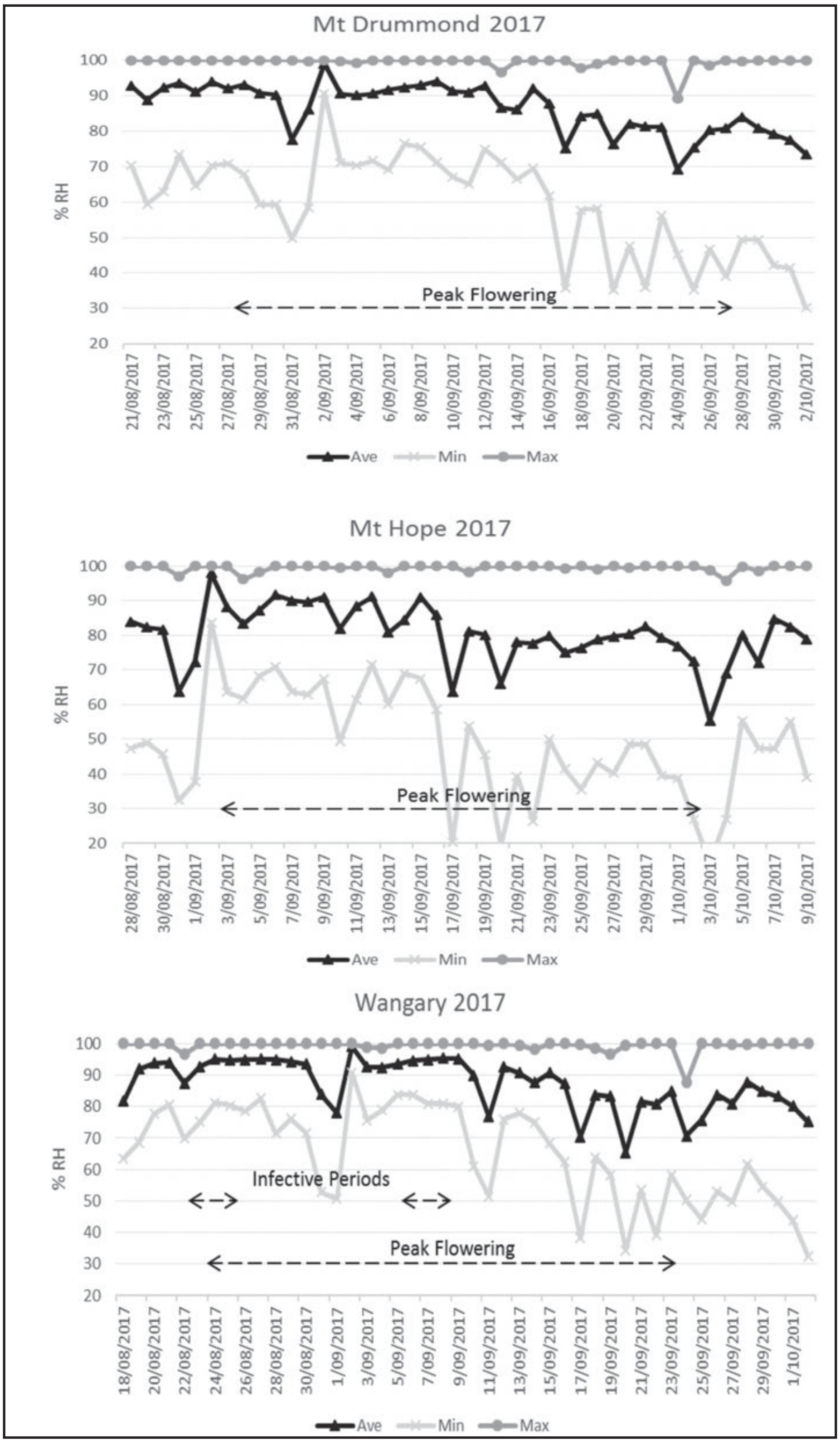



***Figure 1. Relative humidity through canola flowering periods at detailed monitoring sites on the LEP in 2017.***

***Table 3. Petals with sclerotinia spores present as a percentage of total.***

| Site | Sampling Date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 Jul | 7 Aug | 14 Aug | 21 Aug | 28 Aug | 3 Sep | 11 Sep | 18 Sep | 24 Sep | Ave* |
| Coulta | 20 | 75 | 90 | 90 | 35 | 30 | 95 | 55 | 0 | 70 |
| Edillilie | NA | 70 | 40 | 25 | 55 | 40 | 45 | 20 | 0 | 30 |
| Kapinnie | 0 | 10 | 0 | 35 | 45 | 0 | 45 | 5 | 0 | 25 |
| Mt Drummond | NA | NA | 0 | 45 | 5 | 0 | 10 | 5 | 0 | 5 |
| Mt Hope | NA | NA | 45 | 55 | 25 | 5 | 70 | 10 | 0 | 20 |
| Wangary | NA | 70 | 70 | 80 | 95 | 90 | 100 | 90 | 5 | 75 |

**Average spore release throughout the ‘peak’ flowering period (30% bloom onward for 5 weeks).*

***Inoculum***

Sclerotinia was present at each of the six main monitoring sites, with at least one lesion present in each crop, and petal samples confirming the presence of spores in each crop. The rotational histories of these paddocks support the likelihood of inoculum build-up, with a susceptible broadleaf crop being grown roughly 2/5 years at each site, for at least the last 20 years (data not shown). Combined with a reduction in tillage and stubble burning reported by all growers (data not shown), the build-up of viable inoculum within 2-3 cm of the soil surface is expected. However, the degree to which petals were infested with spores varied between sites and throughout the season.

Table 3 shows the proportion of petals infected at each sampling date for each of the six sites.

Mt Drummond appeared to have consistently lower levels of spores released throughout the season, with only one sampling date (28 August) showing moderate levels of spores. Despite low rainfall conditions throughout the season and a significant delay in starting rainfall, there were moderate levels of petal infestation throughout the season at Mt Hope. Heavy spore release occurred relatively early at Coulta, Edillilie and Wangary, whereas Kapinnie appeared slower to start and remained quite variable throughout the season.

Spore release appeared to almost completely halt by the end of September.

***Disease***

Disease incidence in the six survey paddocks ranged from 0.2% at Mt Hope to 16.8% at Kapinnie. Severity ranged from 5.2% at Coulta to 20.8% at Edillilie. Combined, these estimates of incidence and severity gave a total predicted yield loss estimate of between 0.23% at Wangary to 1.72% at Kapinnie. At the second site surveyed from within each of these paddocks, yield loss was very similar, 0.16% at Edillilie to 1.36% at Kapinnie. Sclerotinia incidence was low in all other additional survey paddocks, except one at Wanilla, where incidence was 3.6% and severity 11.1%, giving an estimated yield loss of 0.4%. The incidence and severity, as well as an estimated total yield loss for the survey site is given in Table 4.

***Table 4. Incidence and severity of sclerotinia in canola crops surveyed on the LEP in 2017.***

| Site | Variety | Sclerotinia incidence (%) | Severity (yield difference) (%) | Total estimated yield loss (%) |
|---|---|---|---|---|
| Coulta (Main) | 45Y91 | 10.2 | 11.3 | 1.16 |
| Coulta (2nd) | 45Y91 | 12.2 | 5.2 | 0.63 |
| Edillilie (Main) | 44Y90 | 3.2 | 20.8 | 0.67 |
| Edillilie (2nd) | 44Y90 | 0.8 | 19.7 | 0.16 |
| Kapinnie (Main) | Diamond | 16.8 | 10.2 | 1.72 |
| Kapinnie (2nd) | Diamond | 13.0 | 10.4 | 1.36 |
| Mt Drummond (Main) | 44Y90 | 0.4 | NC | <0.5 |
| Mt Drummond (2nd) | 44Y90 | 0.0 | NC | 0 |
| Mt Hope (Main) | 44Y89 | 0.2 | NC | <0.5 |
| Mt Hope (2nd) | 44Y89 | 1.0 | NC | <0.5 |
| Wangary (Main) | 45Y91 | 4.6 | 4.9 | 0.23 |
| Wangary (2nd) | 45Y91 | 6.6 | 6.2 | 0.41 |
| Mt Drummond | 44Y90 | 0.8 | NC | <0.5 |
| Kapinnie | Bonito | 0.0 | NC | 0 |
| Mt Hope | Diamond | 0.8 | NC | <0.5 |
| Wangary | 45Y91 | 1.8 | -1.6 | <0.5 |
| Edillilie | 45Y91 | 0.0 | NC | 0 |
| Wanilla | 45Y91 | 0.4 | NC | <0.5 |
| Wanilla | Banker | 0.0 | NC | 0 |
| Wanilla | 44Y89 | 3.6 | 11.1 | 0.4 |
| Wanilla | 44Y89 | 0.4 | NC | <0.5 |
| Yeelanna | NA | 0.0 | NC | 0 |
| Karkoo | NA | 0.0 | NC | 0 |
| Yeelanna | 45Y91 | 0.0 | NC | 0 |
| Yallunda Flat | NA | 0.4 | NC | <0.5 |
| Cummins | Quartz | 0.0 | NC | 0 |

*NC = not calculated (due to low incidence of sclerotinia)*

***Plot trial***

No sclerotinia lesions were observed in any treatment, including fungicide timings or variety, of the plot trial. There were no yield differences between fungicide treatments and, whilst there was a substantial yield difference between varieties, this difference clearly does not relate to the interactions between flowering timing and sclerotinia development, but rather to yield potential differences and probably specifically to the varying phenology of the two varieties in response to the short season. Table 5 below shows the evenness of yields within each variety, for all spray timings.

## What does this mean?

***Paddock monitoring and survey***

Sclerotinia is a widespread disease on LEP, with virtually every paddock monitored showing some signs of sclerotinia inoculum. Furthermore, there is real potential for damage given the incidence of infected plants within certain paddocks, under relatively dry, unfavourable conditions. However, despite the unexpectedly high incidence in some paddocks, yield loss was highly variable, and, at worst, only 1.7% in a reasonably high yielding crop. Application of a registered fungicide at label rate would not prove economical under this sclerotinia disease burden.

Explaining incidence and severity appears complex based on the data presented above. At Mt Drummond, the significantly lower inoculum levels, combined with no favourable periods conducive to infection quite adequately explained the lack of sclerotinia disease. Similarly, the lack of adequate conditions, despite the higher inoculum levels, appeared to limit disease at Mt Hope. Whilst all other sites had overlap of spore release, flowering and humid conditions, they varied greatly in their response. Edillilie experienced extremely wet conditions during flowering, with significant levels of inoculum, however disease expression did not occur to the extent that it did at Kapinnie, which experienced fewer favourable humid hours, similar spore release and yet far greater disease incidence and severity. Similarly, Coulta and Wangary appeared to be less suitable for sclerotinia than at Edillilie, yet both experienced equal or greater disease burden. From the data collected to date, incidence appears to be somewhat explained by inoculum load (petal testing). The exception to this was at Kapinnie, where a lower inoculum load still resulted in high infection rate and relatively high disease severity, however this may have been due to other factors, such as cultivar. Severity appears to be somewhat related to the total number of infective hours i.e. once an infection occurs, greater periods of high humidity may control the degree to which the infection progresses and, hence, how much yield is lost in that plant.

This work will continue in 2018 and it is expected that further data points from a range of seasons/ inoculum levels/crops will give a clearer picture of the nature of sclerotinia on LEP and hopefully lead to greater predictability and more certain decision-making around fungicide application.

***Table 5. Yields and oil content of fungicide x variety treatments at Mt Hope in 2017.***

| Variety | Spray timing | Yield (t/ha) | Oil (%) |
|---|---|---|---|
| Diamond | Unsprayed | 1.62 | 44.5 |
| | Full (all timings) | 1.69 | 45.3 |
| | Early (10% bloom) | 1.67 | 44.0 |
| | Mid (30% bloom) | 1.66 | 44.8 |
| | Late (50% bloom) | 1.76 | 44.8 |
| Hyola 575 CL | Unsprayed | 1.01 | 43.9 |
| | Full (all timings) | 1.01 | 43.2 |
| | Early (10% bloom) | 0.94 | 43.6 |
| | Mid (30% bloom) | 0.98 | 43.8 |
| | Late (50% bloom) | 0.98 | 43.8 |

***Plot trial***

The plot trial clearly illustrates two key points. Firstly, for sclerotinia to develop, there must be coincidence between spore release, prolonged wet conditions and the presence of senescing (dying/falling) flowers. The petals collected from the grower's crop surrounding the plot trial as part of the paddock survey showed that sclerotinia spores were present in this paddock and a small number of infected plants were found in the grower's crop. However, this crop was dry sown and germinated earlier than the plot trial and, thus, there were flowers senescing earlier in the season. It is likely that some of these petals contained spores and were able to lodge against the canola stems during a period humid enough earlier in the season for minor sclerotinia lesions to develop. However, in the plot trial, where spore release likely occurred when plots were still at vegetative or bolting stages, it is likely that any spores released did not contact suitable senescing material to begin the infection process. It is also possible that spore release did occur as late as flowering stages in the plot trial but that the dry conditions at this time did not allow for further infection of stems.

Secondly, the complete lack of response to fungicide is notable. Although it should be expected that no fungicide application would have an effect on sclerotinia given the conditions were not suitable for it to develop, it might have been expected that there would be some associated benefit from the control of other diseases, including upper canopy infection (UCI) blackleg, given this certainly was present in the trial and blackleg appears to be less dependent on extended wet conditions. However, in this trial, despite the presence of UCI blackleg disease and sclerotinia inoculum, there was absolutely no gain from spraying a fungicide. 2017 was an atypical season and more data needs to be collected before management conclusions can be made from this research.

## Acknowledgments

Thank you to Dr Jenny Davidson (SARDI) and her team for confirming presence of sclerotinia on petal samples, Ashley and Sam Ness for hosting the plot trial and providing a monitoring site; Jarrod Doudle, Tom Phelps, Scott Mickan, Dustin Parker and Simon Giddings for providing a monitoring site; David Holmes (SARDI) for assistance with paddock sampling.

## References

Hind, TL, Ash, GJ & Murray, GM (2003) Prevalence of sclerotinia stem rot of canola in New South Wales, *Australian Journal of Experimental Agriculture,* Vol. 43, pp. 163–168.

Kirkegaard, JA, Robertsonj, MJ, Hamblin, P & Sprague, SJ (2006) Effect of blackleg and sclerotinia stem rot on canola yield in the high rainfall zone of southern New South Wales, Australia, *Australian Journal of Agricultural Research,* Vol. 57, pp. 201–212.

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# Improving eyespot disease prediction and refining management strategies based on risk

**Blake Gontar**
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**Searching for answers**

**Location**
Yeelanna
**Rainfall**
Av. Annual: 425 mm
Av. GSR: 325 mm
2017 Total: 360 mm
2017 GSR: 204 mm
**Yield**
Potential: 3.0 t/ha (B)
Actual: 2.94 t/ha
**Paddock History**
2017: Wheat
2016: Canola
2015: Wheat
**Soil Type**
Red chromosol
**Plot Size**
2 m x 10 m x 4 reps

## Key messages

- **In a late break, low rainfall season at Yeelanna, under low-moderate disease levels, there was no yield response to fungicide application at any timing.**
- **Whilst variety choice did influence yield, this appeared to be unrelated to eyespot or any other disease, but rather related to phenology and season.**
- **Whilst some eyespot infection was recorded, there did not appear to be any effect of cultivar or fungicide application on disease incidence or severity.**
- **It is likely that total inoculum in the soil/stubble was reduced in all plots, due to the weather conditions alone and not influenced by either variety or fungicide treatments.**

## Why do the trial?

Eyespot disease can have devastating effects on the yield of wheat under the right conditions. Growers on the lower Eyre Peninsula (LEP) are likely to have seen these effects in recent years, or at least heard about them. Yield losses in the order of 20-30% are common, resulting from both direct grain fill reduction as well as losses associated with harvesting difficulty.

Eyespot can be difficult to manage. Symptoms only appear long after infection has occurred and, by that point, fungicides are no longer effective. Thus, management decision-making is pre-emptive and based on risk. Management options include sowing cereals less often, choosing a more resistant cereal cultivar, sowing of eyespot-affected paddocks last in the normal sowing program, and application of a fungicide during early growth stages.

This research program is aimed at evaluating the benefit of various management strategies within cereal phases under varying eyespot inoculum levels and seasonal conditions, particularly in wheat-on-wheat situations, so that eyespot management remains flexible and fungicide use is limited to situations where a return is likely.

## How was it done?

A trial was established at Yeelanna. The site was chosen based on a previous eyespot problem and the likelihood that the grower would plant consecutive cereal crops in 2017 and 2018, allowing a 2-year wheat-on-wheat trial to be established. The initial Predicta B soil test showed a low level of eyespot inoculum. Further testing of soil disease inoculum levels (eyespot only) was undertaken for every plot to identity variation across the trial site.

The trial was sown using a standard knife point/press wheel plot seeder, with two cultivars of varying susceptibility, Mace (S) and Trojan (MS) on 27 June, ahead of a forecast rain event on 3 July (30 mm). All seed was coated with a fungicide to assist in control of rusts. Herbicides and fertilisers used throughout the trial reflected district practice.

Plots received a fungicide treatment at either GS25 (25 August), GS31 (11 September) or GS 39 (3 October). There were also control plots for each variety, where no fungicide was applied. As yet, no fungicides are registered for the control of eyespot in wheat, however a fungicide registered for control of other diseases in wheat was used at maximum label rate.

Disease incidence and severity was calculated by visually inspecting plants from samples taken from 10 cm of row in eight locations across each plot on 16 November, with a 0-4 scoring scale for each plant used to calculate a disease index for that plot. The trial was harvested on 11 December and plot weights were recorded and grain samples retained for analysis.

| Range | Row 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.62 | 1.80 | 0 | 0 | 0 | 0 | 0.42 | 0 | 0 | 0 | 0 | 1.04 | 0 | 0 | 0.47 | 0 |
| 3 | 0 | 0.64 | 0 | 0 | 0.61 | 0.90 | 0 | 1.42 | 0 | 1.36 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 2.60 | 2.05 | 0 | 2.03 | 1.24 | 0 | 0 | 1.01 | 0 | 0 | 0 | 0 | 1.22 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1.46 | 0.4 | 0 | 0 | 0 | 0 | 2.23 | 0 | 0 | 0.53 | 1.09 | 0 | 0.46 |

***Figure 1. Starting inoculum at Yeelanna in 2017 (log10kDNA copies/g soil), where 0.3-1.5 is considered low risk, 1.5-3.1 moderate and >3.1 high.***

## What happened?

Starting disease inoculum at the trial site varied greatly between plots, ranging from 0 to 2.6 log10kDNA copies/g soil. Figure 1 shows the trial site layout and inoculum level.

Growing season rainfall was below average with just 204 mm from April to October. However, with the late break, the growing season at the trial site, measured from seeding to harvest, was just 161 days (23 weeks) compared to a common LEP growing season of 28 weeks.

All plots had at least some eyespot present, but incidence was generally low, ranging from 1–13% stem infection. Severity was extremely low, ranging across all plots from 0.01 to 0.18 (out of a possible 4). However, disease incidence and severity were not affected by either fungicide or variety, nor the starting inoculum present in the plot.

Yield was not affected by fungicide timing and no fungicide treatment was any higher yielding than the untreated control for either Mace or Trojan. Cultivar did significantly affect yield ($P=0.0004$), with Mace yielding 2.94 t/ha and Trojan 2.82 t/ha across all fungicide treatments. There was no relationship between starting inoculum and disease incidence or yield.

## What does this mean?

For eyespot, risk is related to two factors; the inoculum level present in the paddock, since eyespot is predominantly rain-splashed from stubble already present in the paddock and, the weather conditions in any given season. Higher levels of inoculum in a paddock make infection more likely – this can now be tested as part of the Predicta B disease DNA soil test, but is also likely to be indicated by a recent eyespot problem in that paddock. Because of the disease's need for rain-splash to spread spores, as well as its slow growing nature, early sown crops which experience substantial or multiple rainfall events from early tillering to early stem elongation are likely to incur yield penalties if untreated where inoculum is present. Late-sown crops or crops which do not experience heavy and prolonged rainfall through this period, may not see yield effects, even though some infection may still occur (which would influence risk for the following year).

The starting inoculum levels, shown in Figure 1, highlight an important point. Eyespot inoculum was highly variable between plots at a trial scale. At a paddock scale this variability is also normally visible. The implications of this variability is that a PredictaB test conducted in part of a paddock may not represent the problem over the whole paddock. Likewise, a quick perimeter check of a paddock may not identify an eyespot problem throughout the paddock. Identifying the extent of inoculum presence is critical to making management decisions in following years and there is clearly the need to thoroughly assess the whole paddock based on the spatially-variable nature of this disease.

It is quite clear from this trial that the combination of low-moderate levels of starting inoculum and a late break/below average rainfall year is not conducive to eyespot disease development and does not justify fungicide application or the selection of a wheat cultivar of lower disease susceptibility. Whilst the low rainfall is likely to have directly reduced infection (fewer rain-splash events), it is also likely that the late break and low rainfall, which resulted in low crop biomass and thus low canopy humidity throughout peak spore release, reduced eyespot infection. Eyespot generally requires extended wet/humid conditions in early growth stages to successfully infect the host. Where there was infection, the severity scores of these infections were low. This is likely due to the short growing season, as eyespot is considered to be a slow-growing disease which generally needs a long growing season to have substantial yield impacts.

This trial highlights the cost-benefit of knowing the eyespot risk for each paddock, in each season, before making management decisions. Under the low-inoculum, late break conditions of 2017, choosing a variety of higher resistance status, Trojan, resulted in a yield reduction of 0.12 t/ha, compared with the less eyespot-resistant Mace. This equates to a loss of $30/ha (@ $250/t). Furthermore, application of a prophylactic fungicide would cost between $16.50 and $31/ha (depending on product and including contract spraying costs of $10/ha). Overall, management for eyespot in a low risk scenario could reduce profit by $46.50/ha.

Furthermore, the treatments did not appear to affect disease incidence and severity and, thus, may not have had any residual benefit on inoculum levels for the following year. This will be further tested ahead of the second cereal phase in this trial, however it appears that there would be little benefit of extensive management to successive wheat crops in a paddock where starting inoculum is low and seasonal conditions are unconducive to eyespot.

This trial will continue in 2018, with wheat plots sown directly over 2017 plots (i.e. wheat on wheat). Further assessment of disease inoculum will be undertaken in the established plots to determine whether 2017 treatments had any effects on inoculum build-up (or decline). In 2018, we plan to evaluate the effects of 2017 management decisions on both Trojan and Mace (possibly replaced with Scepter). A second trial site will also be established to restart the 2-year trial under different conditions.

## Acknowledgments

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Disease

**Section Editor:**
**Naomi Scholz**
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Section
7

# Soils

## Can soil organic matter be increased in a continuous cropping system in the low to medium rainfall zone?

RESEARCH

**Harm van Rees[1], Anne Jackman[1], Amanda Cook[2] and Jeff Baldock[3]**
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### Key messages

- **Eight trial sites were established across SE Australia to investigate whether soil carbon levels can be increased in no-till farming practices, inclusive of adding nutrients to aid the biological breakdown of stubble into soil organic matter. After 3 and 5 years of treatments no increase in soil carbon could be demonstrated.**
- **We demonstrated that soil carbon is unlikely to increase with current cropping practices over a period of 5 years. But we do know that no-till and stubble retention protects the soil from wind and water erosion and over a longer time-frame the soil carbon levels may increase.**

### Why do the trial?

Soil organic matter has physical, chemical and biological functions in soil. Increasing soil organic matter levels may improve the capacity of these functions in the soil, thereby improving the soils' resilience to degradation and possibly improving the soil productivity. Increasing soil organic matter also sequesters atmospheric carbon dioxide which can mitigate greenhouse gas emissions.

Increasing soil organic matter on broad-acre farms in the Australian wheat-sheep zone has been difficult to achieve. Soil organic matter content is typically measured by determining the content of organic carbon in a soil. Long term trials have showed little or no increase in soil carbon regardless of management practices imposed. Recent research undertaken by CSIRO at a medium to high rainfall site in NSW, demonstrated that increasing soil organic carbon was possible if residues were pulverised and incorporated with a rotary cultivator together with an application of sufficient fertiliser nutrients (nitrogen N, phosphorus P and sulphur S) to enhance soil biological activity to break down the crop residues into soil organic matter (Kirkby *et al*. 2016). This innovation was adapted to broadacre farming methods and tested over a three and five-year cropping rotation with grower groups at eight sites across the southern grain belt. The sites were located at Minnipa - EPARF, Hart, Birchip - BCG and Temora - Farmlink for five years, and Winchelsea - SFS, Cressy - SFS, Condobolin - CWFS and Ouyen - MSF for three years[#].

Three fractions of soil organic carbon are recognised – Particulate (POC), Humus (HOC) and Resistant (ROC). The three fractions have different physical, chemical and biological functions in sandy loam soils. The proportions of the three fractions as components of the soil organic matter were measured and are reported in these results.

***POC:***

- Reducing soil crusting and improving infiltration,
- Improving soil friability,
- Lowering the soil bulk density,
- Increasing Plant Available Water (note – POC has a small effect on the Drained Upper Limit of the soil but because sandy loam soils in dry environments such as the upper Eyre Peninsula are rarely at Drained Upper Limit, this benefit is only minor),
- Storage and cycling of nutrients,
- Food source for soil micro-organisms.

*[#] EPARF = Eyre Peninsula Agricultural Research Foundation; BCG = Birchip Cropping Group; SFS = Southern Farming Systems; CWFS = Central West Farming Systems; MSF = Mallee Sustainable Farming*

***HOC:***

- Improving soil friability,
- Storage and cycling of nutrients,
- Soil pH buffer (reducing acidification),
- Improving the Cation Exchange Capacity (CEC),
- Food source for soil micro-organisms,
- Mineralisation of ammonium and nitrate (plant available N).

***ROC:***

- Binding detrimental ions (such as aluminium),
- Some effect on the CEC.

It is clear that if soil organic carbon levels can be increased, the benefits for improving the soil physical, chemical and biological condition would be significant.

## How was it done?

Eight sites were established in SE Australia to test whether soil organic carbon levels could be increased by retaining stubble and applying additional nutrients to enhance soil biological activity to breakdown the stubble into soil organic matter. Four of these sites were maintained for three years, the other four sites for five years. The site at Minnipa was maintained for five years.

The trial compared stubble retention versus stubble removal, with the application of additional fertiliser nutrients to aid the breakdown of stubbles into soil organic matter over a cropping rotation. Each season the stubble load of the previous crop was determined, and additional nutrients were applied to match the stubble load as a treatment to enhance the breakdown of stubble into soil organic matter.

Soil microbes use stubble as a food source and convert stubble into humus. Stubble is carbon rich relative to the other essential nutrients required by microbes and additional nutrients are required by the soil microbes to convert stubble into humus. The amount of NPS required by the microbial population to break down stubble into humus is worked out from:

- 1 tonne of carbon as humus contains 80 kg N, 20 kg P and 14 kg S
- 1 tonne of wheat stubble contains 450 kg carbon, of which 70% is lost to the atmosphere (hence 135 kg carbon is retained for every tonne of stubble)
- For the soil microbes to convert this amount of stubble carbon into humus requires 10.8 kg N, 2.7 kg P and 1.9 kg S
- 1 tonne of wheat stubble already contains 5 kg N, 0.5 kg P and 1 kg S
- Hence for every tonne of wheat stubble an additional 5.8 kg N, 2.2 kg P and 0.9 kg S is required to enable the soil microbes to break down stubble into humus.

The trial was established on behalf of EPARF at the Minnipa Agricultural Centre in 2012. Treatments were replicated 4 times and consisted of:

**Stubble:** (i) retained and left standing; (ii) cultivated and incorporated prior to sowing; (iii) removed prior to sowing.

**Nutrients:** (i) normal application of NPS to optimise production; (ii) additional nutrients applied at sowing to enhance microbial activity to breakdown stubble into soil organic matter. (Note – the Yield Prophet model was used to optimise N requirements in-crop).

The trial ran for five cropping seasons (2012 to 2016). At the end of the trial, in March 2017, all treatment plots were soil sampled to 30 cm depth with three replicate cores taken in each plot. Each core was divided into 0-10 and 10-30 cm sections. Each sample was air dried and analysed for bulk density, total soil carbon (Leco) and the fractions of soil organic matter – Particulate (POC), Humus (HOC) and Resistant (ROC) using mid infrared (MIR) spectroscopic techniques.

Treatment crop yields were recorded.

*Table 1. Crop rotation and yield over five years of treatments (2012 to 2016) at Minnipa.*

| Stubble treatment | Nutrition treatment | Yield (t/ha) | | | | |
|---|---|---|---|---|---|---|
| | | 2012 | 2013 | 2014 | 2015 | 2016 |
| GSR (April to October rainfall mm) | | 185 | 237 | 290 | 249 | 261 |
| Crop type | | Wheat | Wheat | Wheat | Wheat | Canola |
| Variety | | Scout | Mace | Grenade | Mace | TT |
| Stubble removed | Normal practice | 1.3 | 2.6 | 3.8 | 2.6 | 1.0 |
| Stubble removed | “ plus NPS | 1.4 | 2.5 | 3.9 | 2.9 | 1.0 |
| Stubble standing | Normal practice | 1.3 | 2.6 | 3.6 | 2.7 | 1.0 |
| Stubble standing | “ plus NPS | 1.2 | 2.5 | 3.6 | 2.8 | 1.1 |
| Stubble incorporated | Normal practice | 1.3 | 2.6 | 3.8 | 2.9 | 0.9 |
| Stubble incorporated | “ plus NPS | 1.2 | 2.5 | 4.0 | 3.0 | 1.2 |
| | *LSD (P=0.05)* | *ns* | *ns* | *ns* | *ns* | *ns* |

Soils

*Table 2. Soil organic carbon stock (t/ha, 0-30 cm) after five years of treatments (2012 to 2016) at four trial sites.*

| Stubble treatment | Nutrition treatment | Soil C (Leco) 0-30 cm (t/ha) | | | |
|---|---|---|---|---|---|
| | | Minnipa | Hart | Birchip | Temora |
| Stubble removed | Normal practice | 38.1 | 50.5 | 31.8 | 42.9 |
| Stubble removed | “ plus NPS | 38.3 | 53.0 | 29.8 | 44.0 |
| Stubble standing | Normal practice | 37.0 | 49.7 | 32.0 | 42.5 |
| Stubble standing | “ plus NPS | 35.7 | 49.7 | 31.9 | 44.5 |
| Stubble incorporated | Normal practice | 37.9 | 51.9 | 30.9 | 39.8 |
| Stubble incorporated | “ plus NPS | 39.0 | 53.0 | 31.4 | 41.5 |
| Double stubble | Plus NPS | | 52.6* | | |
| | LSD (P=0.05) | ns | ns | ns | ns |

*Annual application of double the stubble load plus additional NPS at Hart only

## What happened?

### *Trial rotation and crop yield*

Over the five-year trial there were no differences in yield between treatments (Table 1). This result implies that the additional nutrients applied as a treatment were not used by the crop for yield but were available to the soil microbes for potential stubble breakdown into humus.

At the other three sites with a five year rotation (Hart, Birchip and Temora) there were no differences in crop yield between treatments.

### *Change in soil organic carbon after five years of treatments*

The average soil organic carbon content of the topsoil (0-10 cm) at Minnipa was 1.2% and 0.8% in the subsoil (10-30 cm). After five years of trial work there was no difference in total soil organic carbon (t/ha, 0-30 cm) at Minnipa (Table 2) nor at the other three trial sites. (Note: in this study soil organic carbon was measured with the Leco technique, these values are generally 20% higher than the more traditionally used analysis for soil organic carbon with the Walkley Black technique).

At the Hart site an extra treatment was included – each year the stubble load was doubled and the required additional nutrients were applied. This treatment did not result in higher soil carbon levels (Table 2) after five years of experimentation.

### *Soil carbon fractions*

At Minnipa and the other three trial sites the treatments did not result in changes in the soil organic matter fractions. After five years of treatment applications the soil carbon fraction proportions were: 15% POC, 55% HOC and 30% ROC.

## What does this mean?

In the SE Australian low to medium rainfall zone it is difficult to increase soil organic carbon levels using current cropping techniques, even if additional nutrients are applied to enhance soil microbial activity for the breakdown of stubble into soil organic matter. The previous research undertaken in southern NSW where significant increases in soil organic carbon were measured (Kirkby *et al*. 2016), included pulverising the residues with a flail mulcher followed by incorporation with a rotary cultivator – this treatment was not applied in our trials because we regarded it unlikely that farmers could be persuaded to pulverise stubbles and cultivate the soil, increasing the risk of soil erosion in low rainfall environments, to see a potential increase in soil organic carbon.

Eight sites in SE Australia undertook the trial work outlined in this paper, four of the sites were maintained for three years, and four sites – including Minnipa – for five years. At all sites the result was the same – an increase in soil organic carbon could not be demonstrated with the treatments outlined in this paper.

The take home message in relation to soil organic carbon is that it is unlikely to increase with current cropping practices through stubble and fertiliser management. We do know that no-till and stubble retention protects the soil from wind and water erosion and over a longer time-frame soil organic carbon levels may increase. However, based on these results it is likely that any potential increases in soil organic carbon will be small.

## References

Kirkby CA, Richardson AE, Wade LJ, Conyers M, Kirkegaard JA (2016). Inorganic nutrients increase humification efficiency and C-sequestration in an annually cropped soil. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0153698

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# Herbicide residues in low rainfall sandy soils

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RESEARCH


## Key messages

- **A study of herbicide residues in sandy soils in the southern low rainfall region found glyphosate and its breakdown product AMPA at all nine sampled sites.**
- **The combined residue load (glyphosate plus AMPA, 0-30 cm) represented between 0.7 and 6.1 typical applications. The majority (~85%) of the herbicide residue was found in the top 10 cm, and was predominantly AMPA (~80%) rather than glyphosate.**
- **Little is known of the toxic effects of AMPA and how it may affect root growth and function across different crop species. Identifying threshold levels of AMPA that negatively impact crop productivity would be valuable.**
- **The study detected trifluralin (8/9 sites) and 2,4D (4/9 sites) at low concentrations unlikely to be damaging to crops. We did not detect prosulfocarb, imidazolinones (imazapic, imazapyr, imazamox), triclopyr, or MCPA. Spray history details are being collated to further understand the glysphosate results and assess whether non-detection of other herbicide residues is due to infrequent use or to breakdown.**

## Why do the trial?

There is a lot of concern amongst farmers and advisers about damage to following crops from herbicide residues in sandy soils. The fate and behaviour of herbicides in soils is complex and is governed by a range of processes. The type of herbicide, the soil characteristics, and the environment all play an important role in where herbicides move in the soil profile, and how long they persist there. Herbicides break down through chemical and biological reactions. The opportunity for biological breakdown in sandy soils may be limited due to a relatively small microbial biomass, limited organic matter to fuel microbial activity, and reduced activity due to limited soil moisture. Where acidic soils exist, the microbial community is likely to be further limited. It is important to understand: a) whether the breakdown of herbicides is slower in sandy soils; b) what factors result in longer residence times; and c) what aspects of management can be changed to avoid reduced crop vigour.

Anecdotal evidence of damage from herbicide residues in following crops has been widespread in sandy soils across the low-medium rainfall region. However, there has been little measurement of how much, and what type, of herbicide residues may persist in sandy soils. The work reported here aimed to assess the presence/absence of a range of herbicides in typical sandy soils of the southern region.

## How was it done?

The GRDC Sandy Soils project (CSP00203) undertook a study in early 2017 to quantify the amount of a broad range of herbicides present in sandy soils. Soils were sampled from nine typical paddocks from south western NSW, the Victorian and South Australian Mallee, the Yorke Peninsula, and the upper Eyre Peninsula. Soil samples were taken at 0-10, 10-20, and 20-30 cm depths to understand where herbicides were in each profile. Samples were analysed for glyphosate and its break-down product AMPA (aminomethylphosphonic acid), trifluralin, prosulfocarb, three imidazolinone herbicides (imazapic, imazapyr, imazamox), and three acidic herbicides (2,4-D, triclopyr, and MCPA). Germination assays (lucerne) were also carried out on these soils and compared to a herbicide-free sand control.

## What happened?

The presence of herbicides and their amounts in the top 30 cm of soil profile are summarised in Table 1. MCPA, triclopyr, and prosulfocarb were not detected at any of the nine sites. 2,4-D was detected at four sites, and trifluralin at eight sites, both at low levels (<0.1 kg/ha) unlikely to be damaging to crops.

*Table 1. Herbicides measured in soils across nine sandy sites in the LRZ of the Southern region. Data include the presence (# sites found out of 9 sampled) and the average, minimum and maximum herbicide load (kg/ha, 0-30 cm) of a range of herbicides. Nine sites were included with 6 sampling points across the sand dune/area.*

| Herbicide load (0-30 cm, kg/ha) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Glyphosate** | **AMPA** | **2,4-D** | **MCPA** | **Triclopyr** | **Trifluralin** | **Prosulfocarb** |
| Average | 0.30 | 1.39 | 0.01 | nd | nd | 0.04 | nd |
| Presence | 9/9 | 9/9 | 4/9 | 0/9 | 0/9 | 8/9 | 0/9 |
| Minimum | 0.10 | 0.27 | nd | nd | nd | nd | nd |
| Maximum | 0.56 | 3.25 | 0.05 | nd | nd | 0.10 | nd |

*nd= not detected.*

Glyphosate and AMPA were found at all sites (Table 1), with AMPA detected at higher levels (average 1.4 kg/ha) compared to the parent compound, glyphosate (average 0.3 kg/ha). Across the nine sites, the glyphosate content varied from 0.1 to 0.56 kg/ha, while AMPA varied from 0.27 to 3.25 kg/ha. These results are in line with previous work that included a few sandy soils from the southern region.

Glyphosate and AMPA were always higher in the top 10 cm (0.28 and 1.14 kg/ha), and declined rapidly with depth (Figure 1a). Typically 85% or more of the combined load was in the top 10 cm. In soils with known texture changes or chemical gradients (e.g. pH) a finer level of depth stratification may be important as these differences may concentrate herbicides in more discrete soil layers. Sampling at smaller intervals of depth would provide a more detailed picture of what the growing plant root is exposed to. There was no evidence that glyphosate or AMPA were moving down the profile and accumulating at the sites sampled in this study.

Herbicide application history should play an important part in understanding these results (still being collated). However, the data clearly indicate several applications worth of glyphosate and AMPA within the top 30 cm of all sites. On average, the cumulative glyphosate load (glyphosate plus AMPA) was 1.6 kg/ha and ranged from 0.4 to 3.7 kg/ha across sites (Figure 1b). A typical glyphosate application rate provides 0.60 kg/ha of active ingredient (not the product). Therefore, the combined amount measured at these sites represented between 0.7 to 6.1 typical applications.

It is notable that AMPA content was always higher compared to glyphosate. On average AMPA was 80% of the cumulative load, and was largely responsible for the higher cumulative load at sites 7-9 (Figure 1b). The higher AMPA content suggests slower breakdown compared to glyphosate, and accumulation over several applications at most sites. Better understanding of the breakdown rates of both glyphosate and AMPA in these sands, along with sampling at different times after application may help to explain the higher levels of AMPA compared with glyphosate.

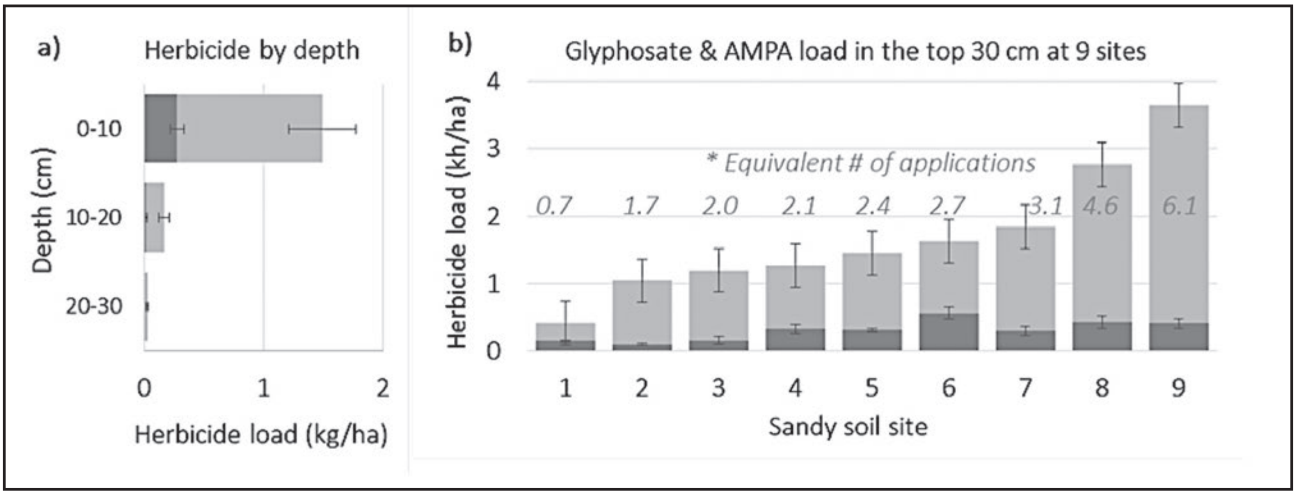


***Figure 1. a) the distribution of glyphosate and AMPA down the profile at 10 cm increments (n=9, ±standard error); b) the amount (kg/ha) of glyphosate (dark) and AMPA (light) in the top 30 cm across 9 sand soil sites (n=6, ±standard error); where the equivalent number of applications are estimated (*) for each site.***

Both glyphosate and AMPA are toxic to sensitive plant species. A lab-based toxicity test on the same soils (0-10 cm) indicated that the concentrations did not have a negative impact on germination of lucerne. However, lucerne may not be the most sensitive species to AMPA. Further bioassays on sensitive species, and over longer growth periods would be valuable. There is limited information available about the toxicity of AMPA and its potential impact on root growth and function across a broad range of crop species.

Improved knowledge of the effects of AMPA on root function and plant vigour is needed to identify threshold levels that may impact productivity of different crops. Wider research has indicated that glyphosate residues interact with phosphorus fertiliser, making them more bioavailable. Therefore, an understanding of how herbicide residues interact with aspects of management, soil condition, and constraints to plant growth (e.g. high penetration resistance, poor nutrient supply, low biological activity) would be valuable.


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Soils

# Increasing water extraction and production on Mallee sands through enhanced nutrient supply in the root zone

**Michael Moodie[1], Lynne Macdonald[2], Mick Brady[1], Todd McDonald[1], Chris Davies[1], Chris Saunders[3] and Therese McBeath[2]**

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## Key messages

- **Deep ripping reduced soil penetration resistance and resulted in a grain yield increase of 0.85 t/ha.**
- **Deeper placement of nutrients had no effect on production above the physical impact of ripping.**
- **Spading nitrogen rich organic matter resulted in a yield increase of 0.6-1.0t/ha.**
- **Grain protein was significantly increased where available nitrogen was increased by either fertilisers or organic matter.**
- **Ground cover was rapidly established following a one pass spade and sow system; however, establishment counts were lower and more variable compared to normal no-till sowing methods.**

## Why do the trial?

There are opportunities to increase production on Mallee sands by developing cost effective techniques to diagnose and overcome the primary constraints to poor crop water-use. Commonly recognised constraints that limit root growth and water extraction on sands include compaction (high penetration resistance), poor nutrient supply and low levels of biological cycling and crop establishment.

Opportunities for increasing crop production exist through a range of management strategies that can be broadly categorized as:

- Mitigation: lower cost, annual strategies that aim to minimise the impact of a particular soil constraint on crop water use.
- Amelioration: higher intervention, higher cost approaches that aim to have greater, longer-lasting impact, through changing the properties of the soil profile.

Two new long-term trials were established at Ouyen in the Victorian Mallee in 2017 as part of the GRDC project: *Increasing production on sandy soils in the low-medium rainfall areas of the southern region*. The trials at Ouyen are a collaboration between Moodie Agronomy and Mallee Sustainable Farming, CSIRO and UniSA. Both trials are aiming to improve productivity through enhanced nutrient supply in the root zone to increase rooting depth and water extraction.

## How was it done?

The trials were located near Ouyen, Victoria on a sand ‘dune’, which is typical of an underperforming sandy soil in the region. The yellow coloured sand layer was approximately one metre thick and was characterised as having high penetration resistance (up to 4000 Megapascals (MPa)), and poor fertility in the subsurface layers (Table 1).

Two separate trial sites were established to investigate both mitigation and amelioration strategies to overcome constraints and improve root growth and water extraction in the sub-surface layers. The mitigation approach was to build up subsoil fertility with deeper placement of fertiliser using pre-drilling or deep-ripping ahead of seeding. The amelioration trial aims to build longer-term subsoil fertility by incorporating organic material with a spader to 30 cm depth. The trial is particularly focused on evaluating farm grown sources of organic material such as vetch and oaten hay. The trial compares these farm-grown residues to a wider range of organic inputs to assess whether the quality/complexity of organic matter is important for multiple years of impact.

***Fertiliser placement trial (mitigation)***

The mitigation trial compared surface banding (7-8 cm deep) of nitrogen (N) and other nutrients to deeper nutrient placement using a pre-drilling (20 cm) or deep ripping (30 cm) operation ahead of seeding (Table 2). Nitrogen was applied as urea alone or urea plus a wider nutrient package (P, K, S, Zn, Cu, Mn). Furthermore, nutrients were applied at an annual (30 kg N/ha) or once in three-year (90 kg N/ha) rate. The trial design will allow us to quantify the impact of physical disruption, deeper placement of nutrients and the combination of these interventions (Table 2).

*Table 1. Key soil properties at the Ouyen sites.*

| Depth (cm) | Total organic carbon (%) | pH ($CaCl_2$) | Clay (%) | Electrical conductivity (μ/cm) | Colwell P (mg/kg) |
|---|---|---|---|---|---|
| 0-10 | 0.3 | 6.3 | 3.8 | 53.7 | 18 |
| 10-20 | 0.2 | 5.1 | 4.2 | 20.5 | 18 |
| 20-40 | 0.1 | 6.0 | 4.3 | 16.1 | 10 |
| 40-60 | 0.2 | 7.0 | 3.8 | 39.9 | - |
| 60-80 | 0.1 | 7.3 | 4.1 | 35.7 | - |
| 80-100 | 0.1 | 7.5 | 4.9 | 35.2 | - |

*Table 2. Key factors in the mitigation trial, incorporating physical disturbance with pre-drilling or deep ripping, 2017 nitrogen rate, depth of N placement (banding) and the addition of a nutrient package (P, K, S, Zn, Cu, and Mn) applied with N fertiliser.*

| Description | Physical disturbance | 2017 nitrogen rate (kg N/ha) | Fertiliser placement | | | Nutrient package (P, K, S, Zn, Cu, Mn) |
|---|---|---|---|---|---|---|
| | | | 7.5 cm | 20 cm | 30 cm | |
| Control | Nil | 30 | ✔ | | | +/- |
| Pre drill control | Pre Drill | 30 | ✔ | | | +/- |
| Pre drill N (annual) | Pre Drill | 30 | | ✔ | | +/- |
| Pre drill N (1 in 3) | Pre Drill | 90 | | ✔ | | +/- |
| Deep rip control | Deep Rip | 30 | ✔ | | | +/- |
| Deep rip N (annual) | Deep Rip | 30 | | | ✔ | +/- |
| Deep rip N (1 in 3) | Deep Rip | 90 | | | ✔ | +/- |

*Table 3. Treatments included in the amelioration trial.*

| Treatment | Application rate (t/ha) | C:N ratio | *N applied (kg/ha) |
|---|---|---|---|
| Spaded Vetch Hay | 6 | 16:1 | 156 |
| Spaded Oaten Hay | 5.9 | 72:1 | 35 |
| Spaded Vetch + Oat Hay | 3.3 + 2.7 | 25:1 | 102 |
| Spaded Chicken Litter Compost | 6.8 | 16:1 | 218 |
| Spaded Compost | 15.8 | 10:1 | 252 |
| Urea | 0.34 | N/A | 156 |
| Spaded control | Nil | N/A | - |
| Non-spaded control | Nil | N/A | - |

**An additional 50 kg N/ha was applied to all treatments through fertiliser.*

***Management 2017***

Both the mitigation and amelioration trials were sown to Spartacus barley on 29 May 2017. The site had a full profile of moisture at sowing due to 100 mm of rainfall falling in the month preceding sowing. The site received 363 mm (decile 6) for the year with 195 mm (decile 3) falling during the growing season (April-October). In-crop rainfall was very patchy with most of this rainfall received during the months of April, May and August.

All treatments in both trials received a total fertiliser N input of 50 kg/ha except for the 1 in 3-year treatments in the fertiliser placement trial where 110 kg N/ha was applied in 2017. In addition to the nitrogen treatments outlined above, both trials received DAP S Z (16:17:0:8; 0.5%Zn) @ 62.5 kg/ha at seeding and 47 kg/ha of ammonium sulphate applied on 25 July during tillering. Urea was also applied to the spaded organic matter trial to supply 10 kg N/ha at seeding and a further 20 kg N/ha during tillering on 25 July. Foliar trace elements (Cu, Zn, Mn) were applied during tillering. Weeds were controlled using 0.6 L/ha of Intervix and 0.5 L/ha of MCPA LVE 570.

## What happened?

***Fertiliser placement trial (Mitigation)***

Deep ripping had a positive impact on penetration resistance, significantly reducing resistance in the 15–40 cm soil layer compared to the control (Figure 1). However, disturbing the soil using the pre-drilling approach had little impact on reducing penetration resistance.

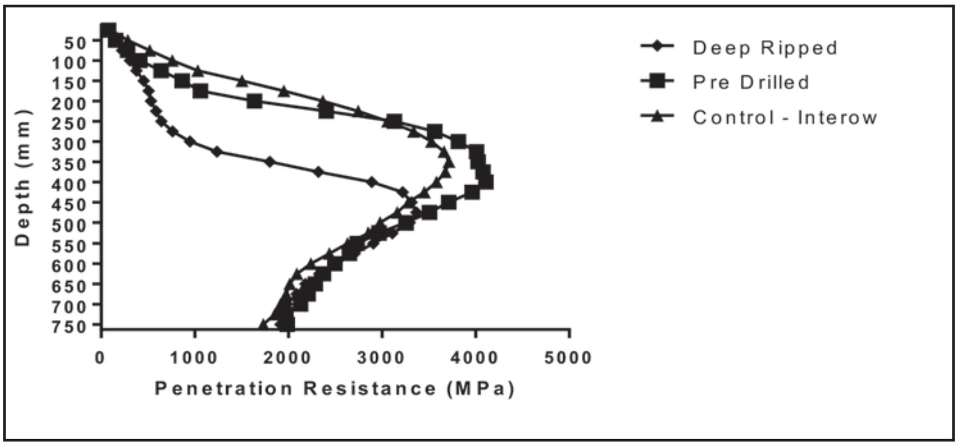


***Figure 1. Impact of pre-sowing soil disturbance using pre-drilling (20 cm) or deep ripping (30 cm) on soil penetration resistance.***

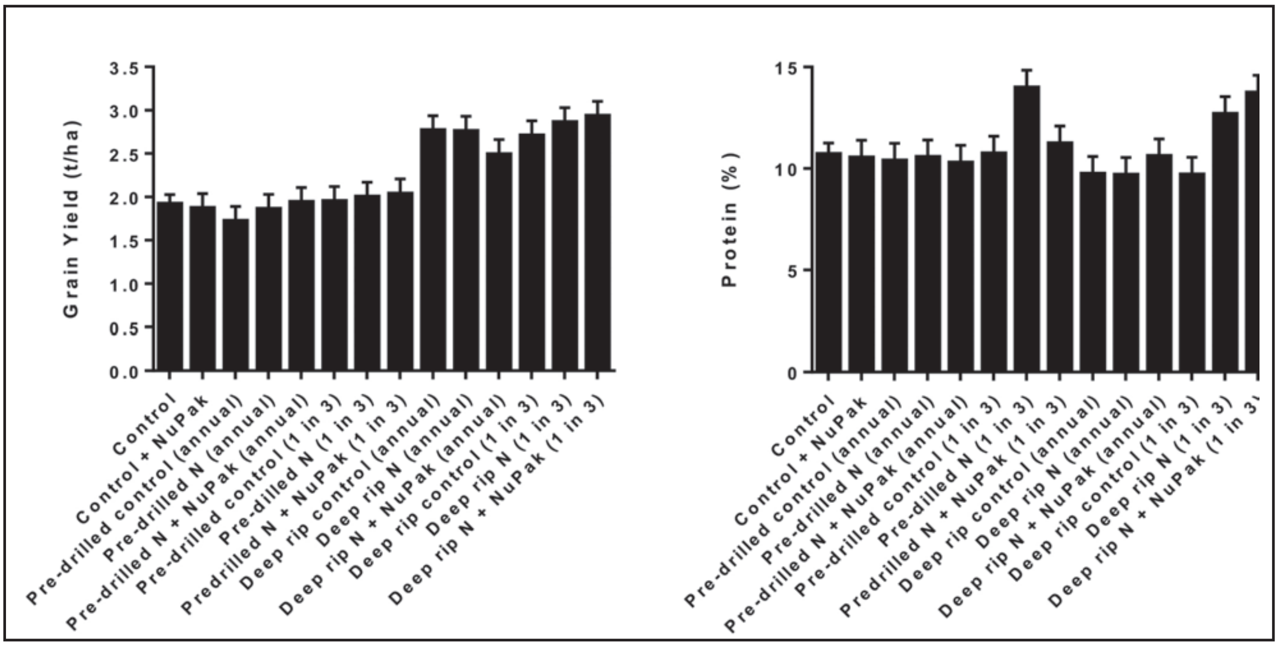


***Figure 2. Grain yield and protein responses to fertiliser placement treatments. Data are average of 4 replicates, with error bars represent standard error.***

Deep ripping resulted in a significant increase in yield of 0.85 t/ha (Figure 2). Pre-drilling did not alter yield, therefore there was a clear link that reducing the penetration resistance of the soil increased production.

Fertiliser treatments did not impact on yield, however applying urea at the 1 in 3-year rate (90 kg N/ha) resulted in a 3 % increase in protein compared to the annual rate (30 kg N/ha) (Figure 2). There was no impact of either the differing depth of fertiliser placement or the addition of the nutrient package on either grain yield or protein.

***Spading and organic matter quality (amelioration)***

Incorporating N rich organic matter such as vetch hay, chicken litter compost and compost significantly increased yields by up to 1 t/ha (Figure 3). All treatments increased yield relative to the non-spaded control, except for spaded oaten hay. Establishment was variable in the spaded treatments which were sown using a spade and sow system and establishment in the spaded treatments was 50-60 plants/m$^2$ while the non-spaded control established 110 plants/m$^2$. The higher establishment variability in the spaded treatments may have limited the ability to detect significant effects of spading against the control.

Grain protein was also significantly increased in the spaded vetch, urea and chicken litter compost treatments (Figure 3).

We were unable to find any evidence that the organic matter treatments resulted in “haying off”, which is often a concern of applying high fertility treatments. All organic matter treatments significantly improved harvest index (ratio of grain yield to biomass) by 5-8% relative to the control which had a harvest index of 38%.

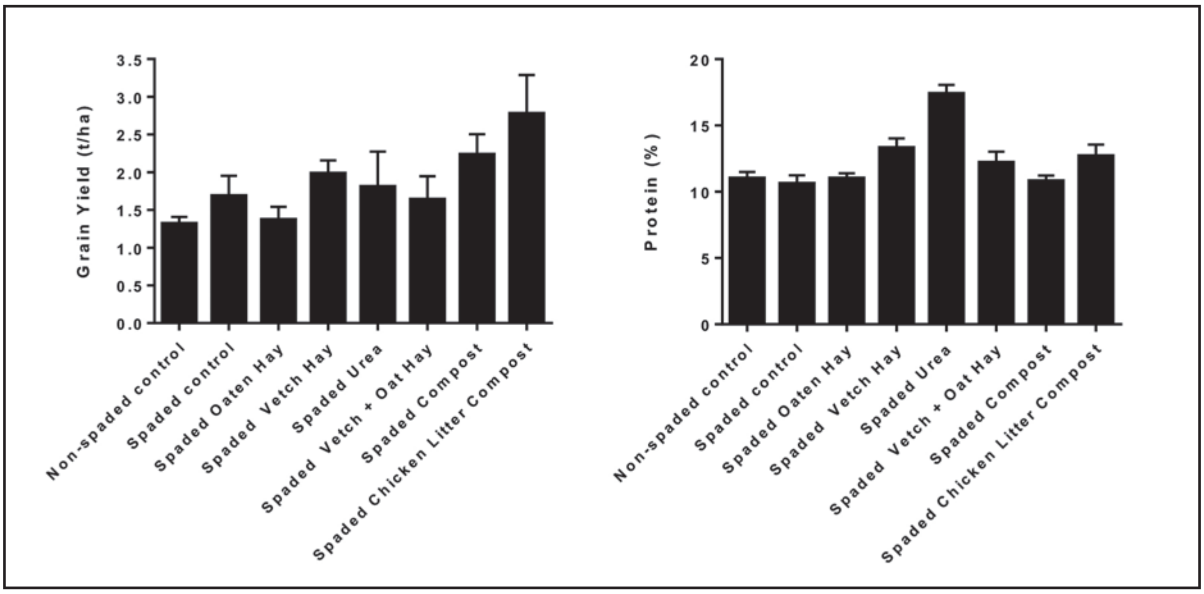


***Figure 3. Grain yield and protein responses to spaded organic matter treatments. Error bars represent standard error.***

## What does this mean?

The first-year results have shown that there is potential to significantly improve production on Mallee sandy soils using both mitigation and amelioration approaches. In this first year of the trial, deep ripping alone resulted in a 0.85 t/ha increase in yield, while benefits of up to 1 t/ha were measured with higher cost treatments where N rich organic matter was incorporated using a spader. Both trials will continue for at least two more seasons (2018-19) to measure the longer-term benefits of the treatments, which is important to determine the most economic options for improving production on Mallee sands.

## Acknowledgements

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Section
8

# Livestock

## Livestock supplementary feeding in mixed farming systems

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INFO


### Key messages

- **Supplementary feeding is a useful option in mixed farming systems to meet livestock production requirements that are lacking in the natural feedbase and to overcome enterprise reliance on annual pastures.**
- **The mixed farming management calendar, livestock health and husbandry, nutrition and enterprise logistics are important considerations when undertaking supplementary feeding programs.**

### What is the issue?

In mixed farming areas in the southern region of Australia, annual pastures are one of the main sources of nutrition for livestock, however there is generally a short window of opportunity in the growing season in which this feedbase can be utilised for grazing due to the abruptness of change in both pasture quantity and quality. Variable weather, as well as the severity and prevalence of dry seasons and droughts affects the productivity and longevity of pastures in this Mediterranean climate region. These fluctuating conditions need to be planned for, and carefully managed within current farming systems for the sustainability of the natural feedbase and for the productivity and profitability of mixed enterprises.

Supplementary feeding is often used in grazing systems to help meet livestock production requirements (energy, protein, vitamins and/or minerals) that may be lacking in the natural feedbase and can also be used as a regular part of the production cycle to help match feed demand to supply which is necessitated by prolonged summer/autumn periods without pasture growth. The extent to which supplementary feeding is used depends on seasonal conditions, physiological status of the animal and enterprise or target market objectives.

This article will inform livestock producers and advisors about the essential nutritional, health and practical knowledge that is required when undertaking supplementary feeding programs.

### Why is this important?

Supplementary feeding can be used to meet the nutritional needs of livestock at different stages of their life. Animal requirements can vary significantly depending on age, size, and whether the animal is growing, dry, pregnant or lactating. Feed quality and quantity will also differ according to whether livestock are being fed for production, maintenance or survival purposes.

Before starting a supplementary feeding program, the potential benefits and risks need to be addressed to determine if it is worth the time and cost to undertake, as opposed to alternatives such as agistment or selling stock. It is important to set enterprise and animal objectives in order to analyse the cost-benefit ratio, particularly in mixed farming operations, where benefits will largely depend on how much supplementary feed can be sourced on farm versus what needs to be purchased.

Key factors that need to be considered include:

- opportunities to sell or agist stock (current sale price, wool price, agistment cost/logistics)
- current stocking rate and flock structure (number and type of sheep, physiological status, breeding stock)
- quantity and quality of the existing feed base (pastures/ stubbles)
- current supplementary feed reserves on farm and cost/availability of off-farm supplementary feed (grain/ hay/silage quantity and quality)
- short/long term climate/ weather forecast (time of year, expected rainfall/ temperatures)
- existing equipment and infrastructure (containment areas, feed storage, mixing machinery, feeding equipment)
- joining/lambing, shearing and weaning times (altering to suit current season or environment better i.e. matching feed demand to supply)
- long-term enterprise outcome (productivity vs. profitability, sustainability of natural resource base i.e. pasture)

## What can be done?

### *Management calendar*

One of the most important management decisions in mixed farming enterprises is how the timing of the livestock reproduction cycle fits in with the growing season to match animal physiological state to feed on offer, which can sometime present challenges associated with the cropping program. The livestock management calendar (joining, lambing/calving, shearing, weaning, husbandry) will determine feed quantity and quality required as well as the scheduling of supplementary feeding programs.

### *Health and husbandry*

Another significant consideration is planning livestock husbandry around feed type and availability. Condition scoring is a vital measurement to understand animal condition and is useful to assist with feed budgeting for production, maintenance or survival. It is imperative to maintain stock in a minimum condition score of two (ideally maintain score three) and to follow published guidelines when supplementary feeding in order to meet livestock requirements. It is crucial to have husbandry programs up to date as certain deficiencies, toxicities, diseases and other health issues can be more prominent in dry conditions (see EPFS Summary 2017 article '*Sheep health issues in dry years*').

### *Nutrition*

Feed budgeting is an important tool that utilises pasture growth rates and animal intake information to help make informed decisions about management of livestock nutrition. To maintain good rumen function and animal health, supplementary feeding should satisfy the animal's need for protein, energy, fibre, vitamins and minerals for all regulatory necessary functions.

Key factors affecting these functions include:

- **Water:** Clean, cool, fresh water is the most important requirement for sheep, regardless of feed type. The amount of water livestock consume depends on many factors, including the weather, type of feed, quality of water and the animal's physiological stage. High flow rate is important for accessibility.
- **Energy:** The energy component of the diet is responsible for an animal's ability to maintain internal stability to compensate for environmental changes and is the major driver of livestock performance. Energy is also critical for fat deposition as well as overall meat and wool production and reproduction. It can be sourced from pasture, grains and hay and is measured as megajoules of metabolisable energy (MJ of ME).
- **Protein:** The amount of protein in the livestock diet determines growth; muscle and wool growth and milk production. Therefore it is a vital element for young, growing animals and pregnant or lactating stock. Protein can be sourced from pasture, grains (particularly legumes), hay and silage and is measured as crude protein (CP%).
- **Fibre:** Fibre is the part of a plant that cannot be digested and is essential for normal rumen function, as it ensures mechanical and chemical breakdown of feed. Roughages, such as hay or straw, have high fibre content and need to be supplied as part of the supplementary diet in order for livestock to digest other key nutrients.
- **Vitamins:** Vitamins are organic compounds that are required by animals in very small amounts. Vitamin deficiencies rarely occur in livestock if being fed a balanced ration, as most of the key vitamins (A, D, E and B) are sourced from the environment (sunlight, plant matter, hay, grain) or are produced by the animal themselves (i.e. B complex vitamins are received through milk to activate the microbial population in the rumen in order to aid digestion).

- **Minerals:** Macro minerals required by livestock include calcium, phosphorous and sodium, which are generally sourced from feed or water resources, however certain rations (such as grain-based diets), regions and animals at particular physiological stages can become deficient whereby a supplement is required. Micro minerals include selenium, copper and cobalt, which may have to be supplemented in small amounts in deficient regions.

***Logistics***

The feed chosen to use in supplementary programs should be selected according to what on-farm feed is available, off-farm feed that is readily accessible and affordable, and fodder types that are easy to store and handle. It is also important to consider the enterprise's production objectives (e.g. weight gain, meeting pregnancy/lactation requirement, maintenance rations etc.) and align the most suitable feed source with this productivity and/or profitability target to minimise the cost of the supplementation program.

There are many different types of machinery, technologies and equipment existing to make supplementary feeding timelier and more labour efficient, however the cost-benefit analyses of these improvements to livestock enterprises should be calculated according to how often this feeding system will be used.

In the absence of paddock feed for long periods of time, it is worthwhile considering using containment areas to remove livestock from paddocks due to the risk of erosion. These fenced areas can be quite beneficial, as the infrastructure can be utilised for other operations throughout the year, particularly if they are located near yards and sheds.

## What does this mean?

Feeding livestock is a significant financial and labour cost to any mixed enterprise, which is usually managed by sourcing feed on-farm through the natural feedbase. However, the reliance on annual pastures as a consistent feed source is becoming more risky due to climate variability and changes in farming system practices, making it even more important to understand how supplementary feeding programs can fit into mixed farming enterprise operations.

Feed budgeting is imperative to assess supplementary feed requirements under a range of seasonal outcomes. Farmers should consider having enough supplementary feed stocks obtainable for up to two years of marginal pasture availability. The ultimate supplementation feed strategy undertaken will depend on the livestock type, enterprise objective and seasonal timing (i.e. scheduling of the intended market or within the animal production calendar). All approaches will require an increased labour commitment to the mixed enterprise, therefore the impact from an economic and social perspective will have to be considered also.

## Useful resources

Feeding and managing sheep in dry times, Department of Agriculture Western Australia (DAWA), Primary Industries and Resources South Australia (PIRSA) and Australian Wool Innovation Limited (AWI), 2005.

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# Sheep health issues in dry seasons

**Jessica Crettenden**
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INFO


## Key message

- **It is imperative for livestock producers to monitor animal health and welfare during dry seasons and to understand nutrition and husbandry requirements in the absence of the regular feedbase.**

## What is the issue?

Problems with sheep health during dry seasons tend to be concentrated to a small number of factors, specifically nutrition and husbandry, which can end up causing substantial issues if not managed well. Adequate feed quality and quantity is one of the main reasons for poor animal health when the regular paddock feedbase is lacking, as supplementary feed is required in larger amounts, over a longer period of time and can be fed to livestock classes that are in different production stages than what some farmers are used to managing. The right balance of supplementary feed at the right time is imperative during dry years, as sheep cannot balance the deficiencies and/or toxicities in their diet with the regular feedbase. This, coupled with an insufficient husbandry program can lead to greater short-term health issues for sheep during dry periods and can lead to longer-term implications for the wellbeing of the flock, even after seasonal conditions improve. This article will address some of the key health issues that sheep producers may face, particularly in dry seasons, and how they can overcome and prevent such problems in the future.

## Why is this important?

Sheep that are in good condition during dry seasons generally experience very little disease or health concerns, including deficiencies/toxicities. However, if stock are stressed, then health issues are much more likely to occur and problems may be exacerbated. Therefore, it is important to regularly assess livestock condition, particularly if animals are in the production phase of their lifecycle i.e. growing (lambs, weaners) or pregnant (joining, pregnancy and lactation) and have greater nutrition and husbandry requirements. Properly condition scoring animals in the yards, as opposed to visually assessing them in the paddock is essential, in particular for sheep with more than two month's wool growth, as this gives the best indication of their health.

## What can be done?

***Acidosis (grain poisoning)***

Grains (particularly wheat and barley) are carbohydrate rich foods and if too much is consumed by ruminants, there can be sudden changes in the microbial population in the rumen leading to the formation of large amounts of lactic acid, which causes grain poisoning. Introducing sheep too quickly to diets high in starch can also cause acidosis. Symptoms can vary significantly depending on how much grain is consumed and previous exposure to grain. Signs include scouring, acute lameness and in extreme cases, death. Treatment is based on neutralising the excessive rumen lactic acid whereby animals should be removed from the grain source, fed good quality hay and be provided with fresh water. Drenching affected sheep with sodium bicarbonate dissolved in water (approximately 10 g to 1 L of water) can assist with recovery, however some animals may not recover. To prevent the risk of grain poisoning, it is important to introduce sheep gradually to grain and any dietary changes should be made slowly, ensuring adequate palatable roughage is available.

***Enterotoxaemia (pulpy kidney)***

Pulpy kidney is a clostridial disease that mostly affects lambs grazing lush feed, but can occur in all ages of sheep that are heavily grain fed. Changing diets from low to high quality feed, particularly when different feed is introduced too quickly, may lead to pulpy kidney. Initial symptoms include dullness in animal behaviour, followed by sheep going down with convulsions (leg paddling) and frothing at the mouth, then most likely death. Most sheep with pulpy kidney are found dead as the disease develops rapidly (within hours after initial signs) and carcasses will quickly decompose (animal kidneys become 'mushy' or 'pulpy'). There is no treatment for the disease, however an adequate vaccination program (given at marking, weaning and an annual booster) will prevent this issue occurring in flocks (enterotoxaemia is included in 3-in-1, 5-in-1 and 6-in-1 vaccinations).

### *Vitamin E and vitamin A deficiency*

A lack of Vitamin E and A is associated with young animals that have had limited access to green feed or have been off green feed for over three months. White muscle disease can be a secondary outcome of vitamin E deficiency and this deficiency can also induce symptoms similar to selenium deficiency. Affected animals will go down, appear bright and alert but will be reluctant to stand and there may be sudden deaths. Symptoms of vitamin A deficiency include night blindness, eye discharges and ill-thrift. Grains and hays are particularly low in vitamin A. Treatment can be provided through a Vitamin A, D & E injection and prevention includes provision of green feed (one day of grazing is generally enough to sustain animals for approximately three months), importantly at a young age.

### *Calcium deficiency*

Grains are low in calcium and sheep fed on grain rations for an extended time over dry periods can develop a deficiency. Symptoms include poor growth, milk fever (hypocalcaemia) in ewes, water belly and can cause an imbalance of calcium and phosphorus, which can lead to reduced appetite, soft bones and fractures. Providing 2% lime, mixed with 1% salt (grains are also deficient in sodium) to rations or ad lib in containers near water sources over dry periods and throughout pregnancy and lactation will prevent this issue.

### *Pneumonia*

Pneumonia is generally associated with cold and wet conditions, however it can be a common occurrence in livestock in dry and dusty seasons. Yard work, eroded paddocks and young stock being fed dry and dusty feeds (milled grain and hay) can trigger bacterial infections in sheep, which may lead to nasal discharge, coughing, ill-thrift and sudden death. Pneumonia can also be detected in the abattoir, whereby there may be lasting adhesions between the lungs and chest wall, resulting in trimming and subsequent weight penalties. Prevention includes managing paddock ground cover, avoiding feeding dry and dusty feeds, and wetting yards down.

### *Pinkeye*

Pinkeye is a common bacterial disease of sheep, especially when conditions are dusty and there are a large number of flies. It can be a major problem with livestock in confinement systems, as it can spread quickly. Weepy and cloudy eyes that appear irritated are a key sign of pinkeye and in severe cases affected sheep can go blind. Animals with pinkeye should be removed from the flock (to prevent transmission to other sheep through dust or flies) and treated regularly with pinkeye spray or powder until healed. Prevention strategies are to avoid yarding sheep in dusty conditions and monitor the flock on a regular basis.

### *Urinary calculi (water belly or bladder stones)*

The common predisposing cause of water belly is limited water intake, which can occur as a result of poor quality water availability (faecal contamination, high salt levels, stagnant water etc.). Losses can also occur when sheep are fed on grain rations without a calcium supplement, and is more common in wethers and rams. Symptoms include straining to urinate, swelling of the abdomen and death in severe cases. Treatment is rarely successful and prevention is through ensuring livestock have constant access to good quality water and adding calcium to grain rations.

### *Ammonia toxicity (urea poisoning)*

This problem can be caused by intake of excess amounts of urea from blocks or in mixed feed (over 15 g/animal in one feed or more than 3% of the ration). Affected sheep may tremble, walk with a proppy gait, appear bloated and may struggle to breathe. Treatment needs to be quick by drenching with water and equal parts vinegar. Urea poisoning is prevented by thoroughly mixing urea in with the supplementary feed and not exceeding 2% of the ration. Avoiding urea blocks getting wet or soft will also reduce the chance of ammonia toxicity.

***Plant poisoning***

In dry seasons, plants that are not generally considered toxic may be eaten in excessive amounts and can cause health issues or mortalities. One example is long-term intake of copper in the diet, or as a result of a build-up of copper associated with liver damage caused by grazing on heliotrope (potato weed), Salvation Jane (Patterson's Curse) or caltrop, whereby the disease can be brought on by some form of stress (e.g. nutritional or lactation stress). Poisoning can also show up in sheep as chronic ill thrift or photosensitisation (see EPFS Summary 2017 article on '*Primary photosensitisation in sheep in South Australia*').

***Containment areas***

Some diseases and health issues are more likely in concentrated mobs, such as in feedlots or containment areas. Risks such as increased internal parasites, coccidiosis and salmonella are predisposed by confining sheep and livestock producers need to be aware of these issues, monitor animals and maintain a sufficient husbandry program to prevent disease outbreak or health issues in these areas.

## What does this mean?

Livestock producers in areas that are experiencing dry seasons need to be aware of the risks to animal health and welfare imposed by absence of the regular feedbase, supplementary feeding and managing stock in containment areas, and continually monitor sheep and undertake a regular and thorough husbandry program to ensure optimum wellbeing for their flocks.

## Useful resources

Contact local veterinary clinics or local animal health officers for more information regarding any of these issues. Pat Lawler is the Eyre Peninsula Animal Health Officer contact located in Port Lincoln (0408 539 060 or patric.lawler@sa.gov.au).

Feeding and managing sheep in dry times, Department of Agriculture Western Australia (DAWA), Primary Industries and Resources South Australia (PIRSA) and Australian Wool Innovation Limited (AWI), 2005.



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# Shearing twice a year – is it worth it?

**Jessica Crettenden**
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DEMO

Searching for answers

## Key messages

- **More frequent shearings add a further layer of complexity to management planning of the operations calendar, particularly when both livestock and cropping enterprises are involved.**
- **There is no clear answer to whether shearing every six or nine months is more advantageous than annual shearings, as many factors must be considered to weigh up the whole farming system costs vs. benefits.**

## Why do the trial?

Good seasonal conditions, improved genetics and/or well-managed nutrition has increased the staple length in Merino sheep on Eyre Peninsula in the past decade. This coupled with discounts for staples outside the current market optimal measures of 63-100 mm for 17 micron wool, and 58-110 mm for 21 micron wool, is prompting some farmers to shear their sheep more often than their regular yearly operation. A growing number of producers are opting to shear sheep every six or eight months to not only target the latest requests for a shorter staple from wool processors, but also with the aim to manipulate their management programs to eliminate or reduce crutching requirements, and to assist with cash flow throughout the year.

The question is – is it worth it? There are a number of anecdotal experiences across Australia that suggest there are benefits to wool production and quality, and even lamb survival, however there is no solid research that quantifies the benefits of more frequent shearing systems.

Shifting annual shearing to every six or eight months requires analysis of current and future production and profitability, but also involves careful planning to avoid clashing with other farm operations. The sheep management calendar must be planned around key events including joining and lambing dates, and timing of husbandry treatments, whilst keeping in mind cropping operations and seasonal conditions that may affect the livestock production year, to decide if the change can fit into your business and lifestyle.

To address the question 'is it worth it', the Minnipa Agricultural Centre (MAC) research sheep flock changed from an annual shearing to shearing every six months, to determine if the production benefits were evident in the 2017/18 season.

## How was it done?

The Minnipa research flock had been benchmarked for adult ewe greasy fleece weight (GFW) from 27 May 2013 to 30 January 2018 (Table 1).

In 2017 the flock was shorn twice in one calendar year for the first time, with fleece weights recorded to determine differences between six and 12 month shearing schedules. In order to fit the timing of shearing in with other flock husbandry and research activities, as well as the cropping program, it was necessary to shear ewes at nine months first in January 2017, to then be able to undertake six month shearing at optimal times.

## What happened?

The average GFW of the adult (2 to 6 year olds) ewes shorn over these five years/six shearing events was 6.64 kg, which did not include belly fleece weight (weighing approximately 200-500 g). Fleece growth averaged approximately 0.55 g per month.

Due to the timing of joining for the MAC research flock (undertaken for six weeks from February to the middle of March), and because the last shearing occurred at the end of August in 2017, it was necessary to shear ewes with less than six months wool growth. Unfortunately, this meant that fleece staple length was below the ideal minimum length measuring an average of only 48 mm, which was not optimal for market requirements.

For a more accurate understanding of the difference between six and 12 months wool growth, the aim will be to shear ewes in mid-late September 2018 and mid-late March 2019, then to continue with this six month schedule.

As these results show no in-flock comparison within a particular shearing or season due to the whole Minnipa flock being shorn, additional data from other sheep enterprises on Eyre Peninsula will be collated for a more rigorous study of the evaluation of annual versus more frequent shearing.

*Table 1. Minnipa Agricultural Centre research flock adult (2 to 6 year old*) ewe shearing 2014-2018.*

| Year | Ewe number | Date (day/ month/ year) | Av. months of fleece growth | Ave. greasy fleece weight (kg) ** | Greasy fleece weight range (kg) ** | Av. production/ month (kg)** | Staple length (mm) | Av. ewe production stage |
|---|---|---|---|---|---|---|---|---|
| 2014 | 342 | 28/04/2014 | 13 | 6.5 | 3.4-9.0 | 0.50 | na | 2nd trimester pregnant |
| 2015 | 418 | 04/06/2015 | 13 | 6.8 | 4.4-9.6 | 0.52 | na | 3rd trimester pregnant |
| 2016 | 400 | 19/04/2016 | 11 | 6.2 | 3.5-9.5 | 0.56 | na | 2nd trimester pregnant |
| 2017 (1) | 386 | 23/01/2017 | 9 | 3.8 | 3.0-5.6 | 0.42 | na | Dry |
| 2017 (2) | 346 | 28/08/2017 | 7 | 3.9 | 2.4-8.6 | 0.54 | 61 | Lactating |
| 2018 (1) | 335 | 30/01/2018 | 5 | 3.3 | 1.6-5.4 | 0.66 | 48 | Dry |

**adult ewe shearing does not include maiden ewes (i.e. ewe hoggets)*
***does not include belly fleece weight*
*(#) Shearing event that year*
*na: not available*

## What does this mean?

The MAC research flock's attempt at six month shearing encountered issues that most livestock producers will face if they attempt a more regular shearing schedule than the common annual timing. The major problem was the transition; planning the extra shearing event around other sheep activities and the cropping program, that eventually achieves a six month shearing schedule that meets the ideal staple length for the current market (between 65 mm and 110 mm).

Woolgrowers must research and carefully plan before moving to more frequent shearing. It is important to not chase market requirements wholly, as requirements can change regularly, and discounts for slightly long or short staple lengths can be negligible. Factors to consider with more frequent shearing involve management (shearing clashing with other livestock or cropping activities), wool production and quality benefits and risks, additional labour and shearing costs, availability of shearers and the time associated with the change. Other associated dynamics of more regular shearing include animal health benefits (reduced flystrike), elimination of crutching, and more regular flock contact to monitor ewe body condition and subsequently improve livestock health and welfare.

As to whether or not it is worth changing from an annual to a more regular shearing will depend on individual enterprise location and operations, seasonal differences, flock genetics, and weighing up the costs and benefits. More research is needed before there is a clear answer.

## Acknowledgement

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## Related articles

http://www.farmonline.com.au/story/4770261/penalties-trim-twice-yearly-shearing/



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# Primary photosensitisation in sheep in South Australia

SURVEY

**Jeremy Rogers[1] and Patrick Lawler[2]**

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## Introduction

An extensive outbreak of photosensitisation in sheep was observed across South Australia's Eyre Peninsula and Northern Adelaide Plains from late September through the month of October 2017. Large numbers of producers reported lambs and older sheep with swollen ears and faces, some with visibly sunburnt facial skin. These sheep had been grazing a variety of pasture types, but predominantly pastures with a high content of legumes such as medic and vetch species. Some flocks grazing cereals were also affected.

Affected producers contacted PIRSA, livestock agents, farm advisors and nutritionists for information and advice. Most producers moved affected sheep from the pasture and the syndrome rapidly resolved, although a small number of severely affected sheep died. Some testing was conducted on affected sheep, and this indicated some raised liver enzyme levels, and hepatopathy (liver damage) was noted in two severely affected animals.

In some areas producers observed heavy infestations of aphids on the pastures and the theory that aphid consumption was contributing to the condition gained some acceptance. Other producers observed black smut like fungal growth near and on some plant species and a suspicion of mycotoxin induced hepatopathy has also been discussed. However, some affected producers did not report either a heavy aphid infestation or fungal issues. The possibility of aphids being involved is not well understood.

Primary photosensitisation in livestock usually occurs sporadically in association with some *Brassica* species and sometimes on lucerne pasture. Occasionally the condition occurs in small numbers of sheep on other legumes, particularly in monocultures. On this occasion, an estimated 25,000 sheep on mostly legume pastures were affected over a short period. This condition has never been reported on this scale in South Australia. Disease investigations ruled out exotic diseases such as bluetongue and confirmed most cases as primary photosensitivity.

## History

Cases of photosensitisation in sheep began to be reported to PIRSA in late September 2017. Reports and alarm escalated through October as more sheep and properties were reported.

PIRSA Animal Health collected data and blood and plant samples from eight properties on the Eyre Peninsula. Another 17 affected properties were reported via Landmark agents and anecdotally there were many more properties affected than this.

The syndrome was reported in ewes, lambs and wethers grazing rye grass, vetch, vetch and medic, and medic pastures. Six of nine producers interviewed reported aphids present, but with varying levels of infestation. One producer reported a black smut or mould growing underneath or near medic plants.

Lesions observed included swollen ears, swollen lips and face, scabby lips and ears, severe conjunctivitis and blindness in some sheep and deaths in a small number of sheep. Most affected sheep recovered quickly when removed from the affected pasture. Some affected sheep responded to injected corticosteroids and confinement in shearing sheds, away from sunlight. Some severe cases had crusty, thickened skin on the face, lips and ears and failed to grow well after being affected.

Some producers reported that they managed the problem by controlling aphids in pastures using insecticides such as LeMat 290 (Bayer) before reintroducing sheep. Aphids were identified as cow pea aphids, *Aphis craccivora*.

## Test results

Four post mortem examinations were conducted by PIRSA, and a private Veterinary clinic conducted one investigation. Eleven blood samples were collected from nine properties.

***Primary photosensitivity:***

Most blood samples submitted showed only mildly elevated levels of the enzymes which indicate hepatic (liver) damage. This suggests that liver damage was not severe, and therefore primary photosensitivity is suspected in most cases.

***Secondary photosensitivity:***

Preserved liver samples in two cases of severely affected sheep did show evidence of hepatopathy with changes consistent with those observed with secondary photosensitisation. This suggests that in at least some of the severely affected sheep, liver damage was likely to have exacerbated the photosensitivity symptoms.

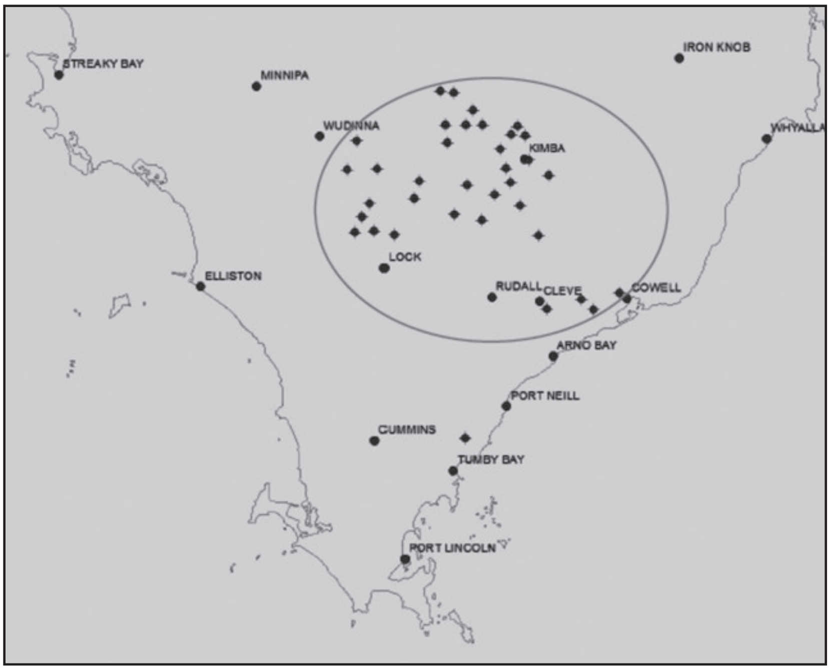


***Figure 1. Some of the Eyre Peninsula properties with reported photo-sensitivity cases in 2017.***

## Discussion

Sporadic primary photosensitisation in sheep is well documented and known to be associated with particular plants and crops at specific stages of development. The condition normally affects small numbers of animals within a group, some more severely than others, and is often associated with very good growing conditions (Salmon *et al*. 2015). Growing conditions across most of the Eyre Peninsula had generally been poor prior to spring, with well below average biomass production across the region. Above average rainfall in August with a warm spring produced good fodder growth on some of the affected properties, particularly in the Kimba area. Not all affected properties experienced this above average fodder growth.

Sporadic, individual cases of primary photosensitization associated with fast growing, high protein pastures are reported in this area from time to time. The scale of this outbreak and the concurrent severe aphid infestations have not been reported previously in SA.

In this event an estimated 20,000-30,000 sheep were affected across a wide area, with face and ear lesions in young and adult sheep the predominant characteristics. In contrast, the Salmon *et al*. report noted feet lesions as well. Understandably there was some confusion about the co-involvement of parapox virus infection (scabby mouth), and in one case this virus was confirmed. Some exotic diseases involving face lesions (vesicular diseases and bluetongue) were excluded on six properties using serology. Only sheep were reported to be involved in this event, and mainly merino or merino cross-bred sheep.

Primary and secondary photosensitisation have been described from a wide variety of green leafy plants: *Brassicas*, millets, medic species, lucerne and grasses (Radostits *et al*. 2000). Primary photosensitisation is described as "…ingestion of plants containing light sensitive substances" (Robson, 2007). These substances are ingested in amounts that exceed the animal's ability to detoxify through liver activity, and metabolites accumulate in the skin and are transformed into phylloerythrin by sunlight, and this damages the skin. Livestock are generally affected 4-5 days after going on to pastures and new cases cease when removed from the pasture affected. All grazing species may be affected, but there can be individual and species susceptibilities.

In some of these cases, some sheep appeared to respond to injected corticosteroids and/or being confined out of sunlight in shearing sheds to reduce symptoms. Some lambs appeared to be severely affected (possibly some secondary liver damage) and lost considerable condition and value when sold one month later (pers. comm.).

Secondary photosensitisation occurs following liver damage, often due to fungal or plant toxins such as those occurring in lupinosis or in *Heliotrope* (potato weed) poisoning. These toxins damage the liver and allow metabolites to circulate that are activated by sunlight, like they do in primary photosensitivity. Typically, severe cases of secondary photosensitivity do not respond well to treatment, they involve liver damage detectable on blood tests (significant elevation of GGT and AST) and are often fatal. Livestock disease investigations on the Eyre Peninsula sometimes confirm cases of secondary photosensitisation, usually associated with lupinosis or *Heliotrope* poisoning (pyrrolizidine alkaloid toxicity). The history of such cases occurring in the region and the occasional reports of jaundice or cirrhosis from abattoirs suggest that flocks sometimes include sheep with underlying or chronic liver damage. In cases of predominantly primary photosensitisation, individual sheep or even individual mobs may present with more severe symptoms of secondary photosensitivity, possibly due to underlying chronic liver pathology from their earlier grazing history.

While there is no peer reviewed literature describing any causative association between aphid consumption and photosensitivity in sheep, there are some papers that do propose it as a possibility. Ferrer *et al*. (2007) actually investigated whether photosensitivity in sheep grazing lucerne was due to *Aphis craccivora* and/or seven-spot ladybirds (*Coccinella septempunctata)* larvae. These authors concluded that the aphids were not implicated in the photosensitisation cases, while the ladybird larvae were. McClymont and Wynne (1955) proposed the possibility of aphids causing photosensitisation in sheep in NSW, but no research was conducted to establish this.

Other theories of fungal or mycotoxin involvement associated with aphid excretions were circulating during this event, but were not investigated. Not all photosensitivity events were reported and while some cases reported an associated aphid infestation, others did not.

The biochemical and other defence mechanisms that plants have evolved to protect themselves from insect and mammalian herbivores are well reported (War *et al*. 2012; Launchbaugh *et al.* 2001). These anti-grazing attributes in plants reduce their palatability, reduce their digestibility, or induce toxic effects when consumed. Some of these attributes are induced by particular seasonal conditions or by grazing pressure (including herbivorous insects), or by an interaction between these factors and growth stage. Launchbaugh *et al*. (2012) describe how grazing animals have developed mechanisms to contend with the anti-grazing attributes of plants. They discuss how grazing animals manage potentially harmful plant compounds by:

1. Grazing selectively. Diet selection skills involve cautious sampling, consuming a varied diet and consuming plants in a cyclic, intermittent or carefully regulated pattern.
2. Possessing internal systems to detoxify or tolerate ingested plant toxins.

The ecological interactions which may have contributed to this animal health event are not well understood. In contrast, the ability of sheep and other grazing animals to protect themselves from the harmful aspects of plants has been studied at length (Launchbaugh *et al*. 2001). These protective grazing strategies tend to be less available to animals grazing pastures with less species diversity. The mix of plant species available to grazing livestock varies with seasonal conditions, agronomy, ecology, soil nutrition or interactions between any of these.

In cases where animals have chronic liver damage (possibly by longer term exposure to toxins) their ability to detoxify recently ingested material will be compromised, and toxicity symptoms will be more pronounced and slower to resolve. Cereal hay without green matter is suggested as the safest feed for any photosensitivity affected animals (Robson, 2007). To safeguard against photosensitivity risk situations, one option may be to background livestock onto cereal hay prior to grazing risky fodder, and to continue feeding palatable hay throughout the risk situation.

In this event affected producers contacted a range of industry sources for advice and assistance, although there were many producers who did not. If this had been an exotic or new disease incursion, it is pleasing that producers could refer to informed sources. Stock agents quickly contacted PIRSA and producers were able to access funding to assist with investigations and testing. PIRSA Animal Health liaised with producers and collected samples for subsidised veterinary pathology testing and diagnosis. SA Sheep Connect (an industry/government partnership) organised a helpful webinar at short notice with a presentation from Dr Colin Trengrove, and this benefitted regional producers across South Australia.

## References


Ferrer, Ortín, Loste, Fernández, Verde & Ramo Photosensitisation in sheep grazing alfalfa infested with aphids and ladybirds; Veterinary Record: 161, 312-314 (2007).

Launchbaugh, Provenza & Pfister; Herbivore response to anti-quality factors in forages; J. Range Manage: 54: 431–440 July 2001.

McClymont & Wynne The possibility of photosensitisation due to ingestion of aphids; Australian Veterinary Journal: April, 1955.

Radostits, Gay, Blood & Hinchcliff Veterinary Medicine- A textbook of the diseases of cattle, sheep, pigs, goats and Horses; WB Saunders 2000.

Robson, S. Photosensitisation in Stock; Prime Facts NSW DPI, Feb 2007. https://www.dpi.nsw.gov.au/animals-and-livestock/sheep/health/other/photosensitisation-stock.

Salmon, Searle, Farrant, McRae, Corrigan & Ison Flock and Herd Case Notes; NSW DPI November 2015 www.flockandherd.net.au.

War, Paulraj, Ahmad, Buhroo, Hussain, Ignacimuthu & Sharma Mechanisms of Plant Defense against Insect Herbivores; Plant Signaling & Behavior: 7:10, 1306-1320; October 2012.


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## Section Editor:
## Jessica Crettenden

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# Section 9

# Pastures

# Identifying the causes of unreliable nitrogen fixation by medic based pastures

RESEARCH

**Fiona Tomney[1], Brian Dzoma[2], Ross Ballard[2], Nigel Wilhelm[1, 2], Ian Richter[1] and Brett Hay[1]**

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

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**Location**
Minnipa Agricultural Centre - Airport
**Rainfall**
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 282 mm
2017 GSR: 155 mm
**Paddock History**
2016: Mace wheat
2015: Pasture
2014: Kord CLPlus wheat
**Soil Type**
Red sandy loam
**Plot Size**
8 m x 1.5 m x 3 reps

**Location**
Piednippie - Brent Cronin & Family
**Rainfall**
Av. Annual: 379 mm
Av. GSR: 304 mm
2017 Total: 247 mm
2017 GSR: 199 mm
**Paddock History**
2016: Mace wheat
2015: Mace wheat
2014: Pasture - oats
**Soil Type**
Calcareous grey sand
**Plot Size**
8 m x 1.5 m x 3 reps (medic)
6 m x 1.5 m x 3 reps (wheat)

## Key messages

- **Applying phosphorus (P) to a soil with low P reserves when establishing a medic pasture boosts shoot and root dry matter, improves root health and improves nitrogen (N) fixation.**
- **The addition of urea at seeding can reduce nodulation in medic pastures.**
- **Applying a full label rate of Agritone 750 (late) decreases pasture production and N fixation in actively growing medic pastures.**
- **Residues of the herbicide Logran can severely stunt medic growth.**

## Why do the trial?

The broad aim of this three year SAGIT funded project was to investigate if current management tools for medic based pastures, such as herbicides, fertilisers and rhizobial inoculants, are affecting N fixation by medic pastures under field conditions typical of the upper Eyre Peninsula (EP). These results should also be relevant to other low rainfall Mallee systems where medics are used.

Annual medics (*Medicago spp.*) are self-regenerating legumes that are well suited to crop rotations on neutral to alkaline soils in the low to medium rainfall areas of southern Australia. They provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens and improve soil fertility through N fixation. However, it has become apparent that some of these pastures are not providing sufficient N reserves (farmer observations) for the following cereal crops, even where the medic has been quite productive. Thus, the longer term decline of protein levels in cereal crops are of concern. Medic pastures are now often sprayed with a range of herbicides and pesticides, both to ensure their productivity as pasture for livestock, and that minimal weed seeds are carried into the following cereal crop. This project examined if commonly used management strategies reduced N fixation by the medic pasture, and consequently mineral N supply to the following crop.

This article mostly reports on the third and final year of these trials. For a detailed summary of the results from the first and second years, please refer to the Eyre Peninsula Farming Systems (EPFS) Summary 2015 p209 and EPFS Summary 2016 p142 respectively.

| |
|---|
| **Location**<br>Pinbong - Greg Scholz & Family<br>**Rainfall**<br>Av. Annual: 321 mm<br>Av. GSR: 227 mm<br>2017 Total: 307 mm<br>2017 GSR: 150 mm<br>**Paddock History**<br>2016: Medic<br>2015: Barley<br>2014: Mace wheat<br>**Soil Type**<br>Red sandy loam<br>**Plot Size**<br>6 m x 1.5 m x 3 reps |

## How was it done?

Two replicated field trials were established on EP in 2017. One on a red sandy loam, representative of typical Mallee environments in SE Australia (Minnipa Agricultural Centre Airport) and the other on a grey highly calcareous sandy soil (Brent Cronin's property at Piednippie).

The 2017 medic trials were dry sown with inoculated Herald strand medic at 10 kg/ha, on 6 June at Minnipa and 7 June at Piednippie. All nutrition treatments were applied at sowing (Table 1). Treatments to simulate herbicide residues were imposed immediately after sowing.

The early post emergent herbicide treatments were applied when the medic plants reached their third trifoliate leaf stage on 21 August (Minnipa) and 24 August (Piednippie). Due to the lack of early season rainfall and poor seasonal conditions this was much later on the calendar than when these herbicides would normally be applied in an average season.

The late herbicide treatments were applied when the medic plants were 5-7 cm in diameter on 11 September at both sites. At the Piednippie site only, there was an extra treatment of Agritone 750 Late at 100 ml/ha.

Plots were sampled on 15 September (Piednippie) and 18 September (Minnipa) to determine dry matter (DM) as an estimate of medic productivity. A further sampling of medic plants and roots was done on 5-6 October for assessment of nodulation and $^{15}N$ fixation by the natural abundance method. Soil mineral N will be measured in autumn 2018 to estimate the impact of treatments on soil N reserves for the following crop. Plots were kept weed free as much as possible.

***Table 1. Treatment details in 2017.***

| Treatment | Active ingredient | Chemical group | Application rate (units/ha) |
|---|---|---|---|
| **Nutrition** | | | |
| Phosphorus | Phosphoric acid | | 10 kg P |
| Phosphorus + Tigrex | Phosphoric acid<br>250 g/L MCPA as the ethylhexyl ester;<br>25 g/L Diflufenican | F<br>I | 10 kg P<br>100 ml +200 ml<br>*wetter |
| Phosphorus + LVE Agritone | Phosphoric acid<br>570 g/L MCPA as the 2-ethylhexyl ester | I | 10 kg<br>250 ml + 200 ml<br>*wetter |
| Phosphorus + Late Agritone 750 | Phosphoric acid<br>750 g/L MCPA (as dimethylamine salt) | I | 10 kg P<br>200 ml |
| Zinc | Zinc Sulphate | | 2 kg Zn |
| Herbicide residues | | | |
| Intervix | 33 g/L Imazamox; 15 g/L Imazapyr | B | 45 ml |
| Logran | 750 g/kg Triasulfuron | B | 1.75 g |
| Lontrel | 300 g/L Clopyralid (as triisopropanolamine salt) | I | 7.5 ml |
| **Post emergent herbicides** | | | |
| Tigrex Early | 250 g/L MCPA as the ethylhexyl ester;<br>25 g/L Diflufenican | | 100 ml + 200 ml<br>*wetter |
| Tigrex Late | 250 g/L MCPA as the 2-ethylhexyl ester; 25 g/L Diflufenican | F<br>I | 100 ml +200 ml<br>*wetter |
| LVE Agritone Early | 570 g/L MCPA as the 2-ethylhexyl ester | I | 250 ml + 200 ml<br>*wetter |
| LVE Agritone Late | 570 g/L MCPA as the 2-ethylhexyl ester | I | 250 ml + 200 ml<br>*wetter |
| Agritone 750 Early | 750 g/L MCPA (as dimethylamine salt) | I | 200 ml |
| Agritone 750 Late | 750 g/L MCPA (as dimethylamine salt) | I | 200 ml |
| Control | Inoculated with rhizobia | | |

**Wetter = BS1000*

## What happened?

Due to the dry start, the medic was sown nearly a month later than in the two previous years, and took nearly another month to establish. Growth continued to be slow, with the growing season rainfall (GSR) at Minnipa measuring only 155 mm, with most of that rain falling in July and August. At Minnipa Airport and Piednippie, the mean site plant densities were 223 plants/m$^2$ and 218 plants/m$^2$, respectively. Plant density was not affected by herbicide residues, nor nutrition. However, once plants reached the 1-2 trifoliate leaf stage, it became apparent that Logran, applied after sowing to simulate herbicide residues in the soil, was causing stunted growth, with the effect more pronounced at Minnipa, where most plants failed to develop beyond the first leaf stage. For other treatments, once plants had progressed to the 2-3 trifoliate leaf stage, phosphorus and zinc were observed to have a positive early growth effect, with the effect more visible at Piednippie; but this was not consistent across all treatment replicates. The other residual herbicide treatments of Intervix and Lontrel did not appear to have had any early effect on medic growth.

At Minnipa, shoot biomass (DM) prior to flowering, in the control was 446 kg/ha. Biomass was decreased by the residual Logran treatment to only 34 kg/ha, with the stunted plants never recovering. All other treatments produced biomass similar to the control at this site. At Piednippie, shoot biomass (DM) prior to flowering in the control was 134 kg/ha. No treatments reduced biomass compared to the control. In sharp contrast to Minnipa, plants initially stunted by the residual Logran treatment, recovered to be similar to the control by the time of sampling. Biomass was increased by P to 283 kg/ha compared to the control. P + Late Agritone 750 also increased the shoot biomass to 305 kg/ha.

At Minnipa the total number of nodules per plant averaged 6.3. Nodulation and root weights were not affected by any treatment. Levels of root disease (based on a visual score) were reasonably low (4.5 out of 15) and did not differ between treatments. At Piednippie the total number of nodules per plant averaged 7.4. Although treatments had no effect on total nodule number per plant, there were treatment differences in the effectiveness and distribution of nodules on the roots. Generally, LVE Agritone Early and LVE Agritone Late decreased the proportion of effective nodules. Similar to Minnipa, the levels of root disease at Piednippie were reasonably low with a score of 5.6 out of 15, and did not differ between treatments.

***Plant nitrogen (2016 trial results)***

In 2016 the amount of N in medic shoots derived from fixation was estimated using the $^{15}$N natural abundance method. At Pinbong, Agritone 750 Late and urea both decreased the amount of fixed N. The two controls averaged 23 kg of fixed N/ha, but the late application of Agritone 750 reduced this to 13 kg of fixed N/ha. Applying urea to the medic reduced the amount of N fixed to only 7 kg/ha. Urea also decreased the amount of N fixed per tonne of DM.

At Piednippie Agritone 750 Late and urea also decreased the amount of fixed N. The two controls averaged 25 kg of fixed N/ha, but the application of Agritone 750 Late reduced this to 17 kg of fixed N/ha. Urea reduced the amount of fixed N to 15 kg/ha. At Piednippie the addition of 10 kg/ha of P increased the amount of fixed N to 39 kg/ha.

The percentage of N in medic tops which had been fixed was 92% at Pinbong and 83% at Piednippie. At Pinbong the average amount of N fixed in tops was 20 kg N/ha; similar to the amount measured in 2015, whereas at Piednippie, the average amount of fixed N (kg/ha) more than doubled in 2016, from 11 kg/ha to 25 kg/ha. The 2017 results are not yet available.

***Soil mineral nitrogen***

The 2016 trial sites were sampled for mineral N in the root zone in March 2017. Soil mineral N was not affected by treatments in the 0-10 cm or the 10-60 cm nor the combined 0-60 cm soil zone, at both sites. Similarly, there were no treatment effects on soil mineral N in 2016, after the 2015 medic trials. The average total mineral N (0–60 cm) was 32 kg N/ha at Pinbong and 50 kg N/ha at Piednippie in March 2017. These totals are substantially lower than those measured in the autumn 2016 following the 2015 trials. In 2016, Pinbong and Piednippie measured 101 kg N/ha and 89 kg N/ha, respectively. The 2017 results are not yet available.

***Wheat***

In the 2017 season, the 2016 medic trial sites were sown with Scepter wheat on 18 May (Pinbong) and 7 June (Piednippie) at a rate of 60 kg/ha. At Pinbong the average yield was 1.36 t/ha, average protein was 10.8% and the average screenings were 7.4%. At Piednippie the average yield was 0.79 t/ha, average protein was 10.8% and the average screenings were 7.4%. The previous year's medic treatments had no effect on plant emergence, late dry matter, or grain protein. At Pinbong the 2016 applications of LVE Agritone + Verdict and Agritone 750 (2) decreased the yield of wheat, even though these treatments had not affected the amount of N fixed by the medic in 2016, nor the amount of soil N present in March 2017.

In 2016, the wheat sown onto the 2015 medic trial sites also had no differences in yield, protein and screenings.

## What does this mean?

The dry start this year meant that the medic was sown late, was slow to emerge and produced less than 500 kg/ha shoot dry matter. Continuing low rainfall and high spring temperatures meant that the medic was stressed at the time of the nodulation assessment, which may have increased the numbers of ineffective nodules recorded. At Minnipa the plants were podding and their nodules were generally senescent, so very few nodules were recorded as effective, making it difficult to discern herbicide effects. At Piednippie plants were less mature with some treatment effects on nodulation measured.

As shown in the previous years' trials, P increased medic growth. While the increased biomass would have been beneficial to grazing, this year it did not appear to provide any benefit to N fixation in terms of nodulation, although we are yet to receive the N fixation results.

At Minnipa residual Logran severely stunted early medic growth, with the plants never recovering. In contrast to previous results, the post emergent herbicides had no effect on medic productivity, almost certainly due to the dry conditions and the plants not actively growing. Piednippie received extra early rainfall which would have increased the activity of soil microbes, allowing them to break down the Logran residue. The extra rain may have washed the residues down through the sandy soil, hence the Logran affected medic seedlings were able to recover. LVE Agritone applied early and late decreased the percentage of effective nodules at Piednippie, but this percentage was already very low on the controls. Therefore, we can conclude that in a dry growing season, when medic plants are already moisture stressed, herbicides will have little impact on medic productivity and N fixation.

Regardless of seasonal conditions, the management of newly established medic pastures with respect to herbicides and fertilisers, appears to have no influence on the yield and protein level of the wheat crop in the following year.

In general, biomass production and total N contribution from the medic pastures has been low in the establishment year, and likely explains why no significant differences in soil mineral N were able to be measured in the years following the medic pasture. In regenerating medic pasture, the treatment impacts on medic growth and N fixation would be greater due to the increased biomass, and therefore likely to have greater impacts on the following cereal crop.

These trials have shown that applying P when establishing medic pastures can substantially increase their productivity, whereas using certain herbicides can significantly damage them, by reducing their ability to grow, maintain effective nodules and fix nitrogen. Herbicides are an essential part of weed management, but their negative effects on medic pasture growth for N production and livestock feed, must be considered from a whole farming systems perspective in relation to the value of the weed control they provide.

## Acknowledgements

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SAGIT

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# Dryland legume pasture systems

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

RESEARCH


## Why do the trial?

A new five-year Rural Research and Development for Profit funded project supported by GRDC, MLA and AWI, and involving Murdoch University, CSIRO, SARDI, Department of Primary Industries and Regional Development, Charles Sturt University and grower groups will begin in 2018 across the low-medium mixed rainfall farming systems region. The project is titled "*Boosting profit and reducing risk of mixed farms in low and medium rainfall areas with newly discovered legume pastures enabled by innovative management methods*", or Dryland Legume Pasture Systems (DLPS) for short.

Legume pastures have been pivotal to sustainable agricultural development in southern Australia. They provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens, and improve fertility through nitrogen (N) fixation. Despite these benefits pasture renovation rates remain very low and the quality of the pasture base is very poor on many low to medium rainfall mixed farms. Over the past three decades there has also been a shift towards continuous cropping in dry areas. Continuous cropping is prone to herbicide resistant weeds, requires large N fertiliser inputs and is prone to major financial shocks due to frost, drought or low grain prices. The reason for farmers not improving pastures include a lack of suitable pasture options for some environments, the high opportunity costs of pasture renovation, changing labour resources and difficulty in quantifying the benefits provided by new cultivars, particularly where pastures are grazed.

This new project will develop recently discovered pasture legumes together with innovative management techniques that benefit animal and crop production and farm logistics, and promote their adoption on mixed farms in over one million hectares in the low and medium rainfall areas of WA, SA, Vic and southern NSW by 2026. As a result, average farm profit will be boosted by 10% and economic risk will be halved over a range of seasons, compared to intensively cropped farms.

## Proposed research outcomes

**Output 1:** Two novel pasture legumes options identified and promoted, that are adapted to soils in dry areas. Novel legumes will require hard seed profiles suited to low cost establishment methods and/or persistence in contemporary farming systems.

**Output 2:** Quantify the key benefits (eg nitrogen, soil water, weeds, pests and diseases) of the novel pastures to following crops, generate data to inform economic models, and promote outcomes to growers in paddock scale trials.

**Output 3:** A large-scale integrated grazing and cropping experiment to assess the impacts of novel self-regenerating pasture legumes on animal production.

**Output 4:** Use simulation modelling to estimate the economic and biological value of two pasture types on crop, pasture and animal productivity across seasons and soil types.

**Output 5:** Develop an extension and evaluation plan to provide the effective dissemination of project results in collaboration with grower groups and to monitor the adoption and benefit of the new pasture technologies on mixed farms in dry areas.

## MAC's involvement

The Minnipa Agricultural Centre (MAC) will have a key role in Outputs 1, 3 and 5.

From 2018-2020 there will be small plot germplasm evaluation and trials at MAC to assess which novel legumes are adapted to the southern region. Chosen legumes will include pre-releases, legumes with new traits and pasture genebank selections based on their likely adaptation to rainfall and soil type. Based on the trial results, three legumes will be prioritised for establishment studies and demonstration trials. Hard seed studies will be conducted from February 2018 to determine which legumes have suitable hard seed levels.

In 2018-2019 there will be a field experiment aiming to improve N fixation by 20%. In 2020 there will be trials at Minnipa to assess whether next generation legume genotypes provide further benefit.

From 2018 a large-scale multi-year grazing/cropping experiment will be established at MAC, with treatments imposed on 2 ha plots to assess what novel pasture options can beat current autumn sown vetch or medic options. The pasture phase of two years (2018 and 2019) will be grazed and then allowed to regenerate after being sown to wheat in 2020. Soil N, soil water, weeds, pests and diseases will be measured before pasture establishment, and pasture legume performance quantified. Primary livestock data will also be measured, including liveweights, meat quality, wool quality/quantity, reproduction, pasture palatability and animal health. Ewe ovulation may also be measured.

MAC's extension work will include presentations at the EP Farmer Meetings and the annual MAC Field Days. Demonstration sites for different species and establishment techniques will also be set up across Eyre Peninsula and the Upper North in conjunction with EPARF, LEADA and UNFS grower groups, to give farmers an opportunity to see how the innovations may fit in their local farming systems.

The project is planned to conclude in 2022.

Australian Government Department of Agriculture and Water Resources
GRDC Grains Research & Development Corporation
mla Meat & Livestock Australia
awi Australian Wool Innovation Limited
SARDI South Australian Research and Development Institute
Murdoch University
CSIRO
Western Australia Department of Primary Industries and Regional Development
Charles Sturt University

# Sheep fertility issues when grazing medic pastures

**Jessica Crettenden**
SARDI, Minnipa Agricultural Centre

RESEARCH


## Key messages

- ***Medicago* legume pasture species play a major role in low rainfall mixed farming systems on Eyre Peninsula, however, may lower livestock fertility due to hormones (phytoestrogens) produced when exposed to stressors (pests or diseases).**
- **More research is needed to quantify the affect phytoestrogens have on reproduction in livestock, in particular the extent of plant damage, timing and duration of grazing *Medicago* legume pastures required to induce oestrogenicity.**

## What is the issue?

Poor reproductive performance in sheep can be caused by consumption of oestrogenic hormones (oestrogens), which can be produced by pasture legumes (phytoestrogens); or by soil-borne fungi that live on growing pasture plants; or on decomposing or dead organic matter at the base of legume plants (mycoestrogens). In *Medicago* pasture species (medic and lucerne), phytoestrogen compounds known as coumestans are produced in response to stress, such as the impact of pests or diseases. Livestock sufficiently exposed to coumestans, which can be from pasture, hay, silage, pellets or meal sources produced from Medicago species, prior to conception have been associated with reduced fertility.

Medic pastures on Eyre Peninsula (EP) have been quite productive in recent years after a series of above average seasons in low rainfall mixed farming regions. A combination of significant rainfall and warm temperatures during the growing season has resulted in substantial growth in medic pastures, which has attracted more diseases and pests than usual in the legume stands, including powdery mildew and aphids. Anecdotal evidence of poorer than usual lamb marking percentages on EP have coincided with medic pastures that have been affected by pests or diseases. This indicates that oestrogenic hormones, such as coumestans, may be of concern for livestock producers and the reproductive potential of their flocks.

## Why is this important?

Legume pastures, such as medic, are a vital element of mixed farming system on EP and make up a substantial component of the feedbase for livestock over the growing season. Most self-replacing sheep enterprises rely on this type of grazing system at key times in the reproductive calendar of their animals and the timing of pre-conception and joining generally occurs during, or not long after the growing season and pasture senescence.

Stage of plant growth and environmental factors (stressors) influence the concentration of phytoestrogens in *Medicago* pastures. Coumestans are often not detected in healthy, vegetative plants, however the concentration of hormones that may be produced in these legumes has the potential to increase when the plant is stressed. In medic pastures, coumestans usually accumulate during senescence and death of the plant, so concentrations are generally higher in dry pastures.

The production of these oestrogenic hormones is associated with the suppression of oestrus (the period in the sexual cycle of ewes during which they are cycling i.e. when they are 'on heat') and inhibition of ovulation. Phytoestrogens can mimic the biological activity of oestrogens, which means that they can compete with these hormones that are vital for healthy reproductive cycling in ewes and negatively influence the oestrous cycle in animals that ingest medic pastures containing coumestans (Reed 2016). This means that ewes grazing these pastures immediately prior to or during joining may exhibit a lowered frequency of multiple births, and in extreme cases they can become temporarily infertile, depending on the dose and timing of exposure to these phytoestrogens.

## What can be done?

Coumestan infertility has not attracted as much attention as isoflavone infertility (hormones that affect the *Trifolium* species, namely clovers), which has been greatly reduced by genetic improvement and by the de-commercialisation of 'highly oestrogenic' cultivars of *Trifolium* species (Reed 2016). This could be due to the widespread reliance on clover as the preferred pasture legume compared to areas where *Medicago* species dominate, and may also be associated with resources allocated to different legume plant genetic breeding programs. The new strand medic cultivar PM250 is the exception to this statement, as due to its resistance to powdery mildew, it has low levels of phytoestrogens (up to a 10-fold reduction in coumestrol levels (Howie *et al.* 2015), compared to powdery mildew susceptible cultivars), which may have a positive influence on ewe fertility.

Coumestans have been reported as producing only sporadic outbreaks of infertility and there is currently no evidence to suggest permanent effects of these phytoestrogens on fertility in sheep (Reed 2016). The extent of reduction in reproductive efficiency in livestock exposed to coumestans produced in *Medicago species* is yet to be determined, in particular the level of this damaging phytoestrogen that is required to cause significant fertility issues. Additional research needs to be undertaken to gain a greater understanding of the effect these hormones are having on sheep reproduction in predominantly medic-based pasture mixed farming areas, such as EP, before any recommendations can be given to livestock producers.

## What does this mean?

More research needs to be undertaken to separate the phytoestrogenic effect of legume pastures on fertility from the beneficial effects on reproduction, improvements in live weight gain and wool growth, and the efficiency of feed conversion due to the legumes' nutritive value. With high value animals or significantly stressed legume pastures, there may be a case to maximise fertility by removing or avoiding phytoestrogens, however more investigations to determine concentrations of coumestans in *Medicago species* at different growth stages and exposed to a range of stressors, to understand the extent of plant damage required to induce oestrogenicity in livestock is required.

## References

Howie J. (2015) Barrel Medic, Medicago truncatula "Sultan-SU". IP Australia Plant Varieties Journal 28, 132-135.

Reed K. (2016) Fertility of Herbivores Consuming Phytoestrogen-Containing *Medicago* and *Trifolium* species. MDPI Agriculture Journal 2016, 6, 35.

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Section 10

# Sharing Info

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Naomi Scholz
SARDI, Minnipa Agricultural Centre

## Baiting round snails prior to egg laying in accordance to environmental conditions on lower EP, 2017

**Jacob Giles[1] and Michael Nash[2]**
[1]SARDI, Minnipa Agricultural Centre, [2]formerly SARDI, Waite

**Searching for answers**

**Location**
Greenly - Dusty Parker
**Rainfall (Wanilla)**
Av. Annual: 523 mm
Av. GSR: 419 mm
2017 Total: 457 mm
2017 GSR: 298 mm
**Paddock History**
2016: Wheat
**Soil Type**
Red sand - grey calcareous sand
**Yield Limiting Factors**
Sub-soil constraints

### Key messages

- **Baiting can be successful during warmer months if snails are active and feeding.**
- **Relative humidity >90% triggers snail activity.**
- **Periods of activity are not linked just to rainfall but also dew which can be forecast to some extent.**
- **Snail activity around rainfall events is dependent on significance of rainfall event as well as temperatures pre and post event.**
- **Do not cut bait rates as increase in bait number = increase in incidence.**
- **Decrease potential alternative food sources and refuge through summer weed management.**

### Introduction

Previous SARDI work, including at Coulta (Gontar 2016), established critical points regarding the effective baiting of snails prior to egg laying. Firstly, if you plan on spreading bait at seeding, it is highly likely that egg laying has already taken place and snail issues will continue into the season. Figure 1 outlines this as the size of a snail's albumen gland reflects its level of preparedness leading up to egg laying (14 April). It is clear that control prior to egg laying is the most effective way of limiting population growth. It was also well established that cultural methods of control such as rolling were highly effective and not to be disregarded.

### How was it done?

A Brinno TLC100 time lapse camera and HOBOware Pro data logger were assembled in the paddock alongside the trial site. Pestmaster bait (15 g/kg metaldehyde, 2.5 mm diameter) was placed under the camera every 7-10 days to enable the constant monitoring of feeding activity. Two baiting treatments at 7.5 kg/ha took place, one in February and one in March. Each treatment saw two 50 m strips baited, with 30 quadrat counts to assess the snail density in each strip. Counts were split into ten quadrat counts at each of the three marked positions. Pre-treatment counts took place 1-2 days prior to baiting followed by post-treatment seven days after bait application. Live samples were also taken in two paddocks, with gland dissections performed.

### What happened?

Figures 2 and 3 demonstrate a steady increase in albumen gland size from early March. Such trends could be indicative of an increase in opportunistic feeding and hydration to allow gland size increase, however at this stage such conclusions are anecdotal.

Table 1 demonstrates the poor result produced by baiting over warmer months through a period that did not facilitate snail activity. During the week post baiting only two hours of significant snail movement were observed. Such a period is seen when conditions are dry, which is usually linked to hot, windy weather with a lack of rainfall. Baiting during such a period is ineffective. Table 2 shows greater bait efficacy (56%) as a result of 15 hours of significant activity during ideal conditions linked mainly to dew events (only two hours due to rainfall at the end of this period). This clearly shows baiting of snails as an effective means of snail control in early autumn.

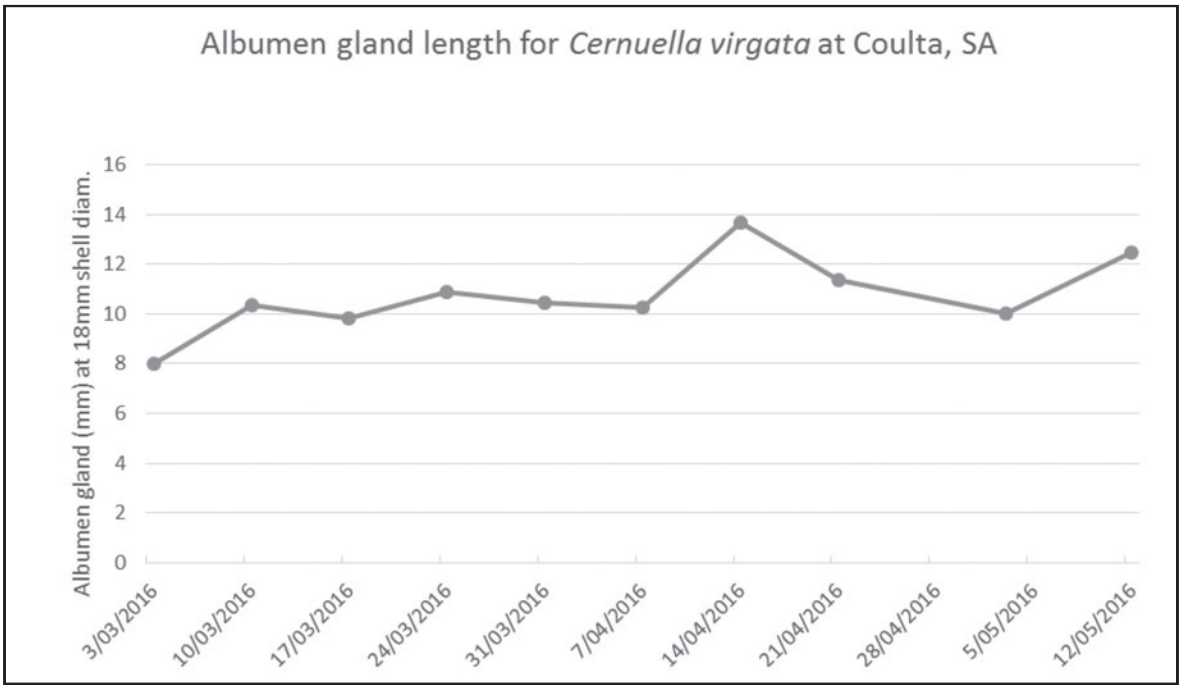


***Figure 1. Albumen gland size variation over time at Coulta in 2016 (Gontar, Nash 2016).***

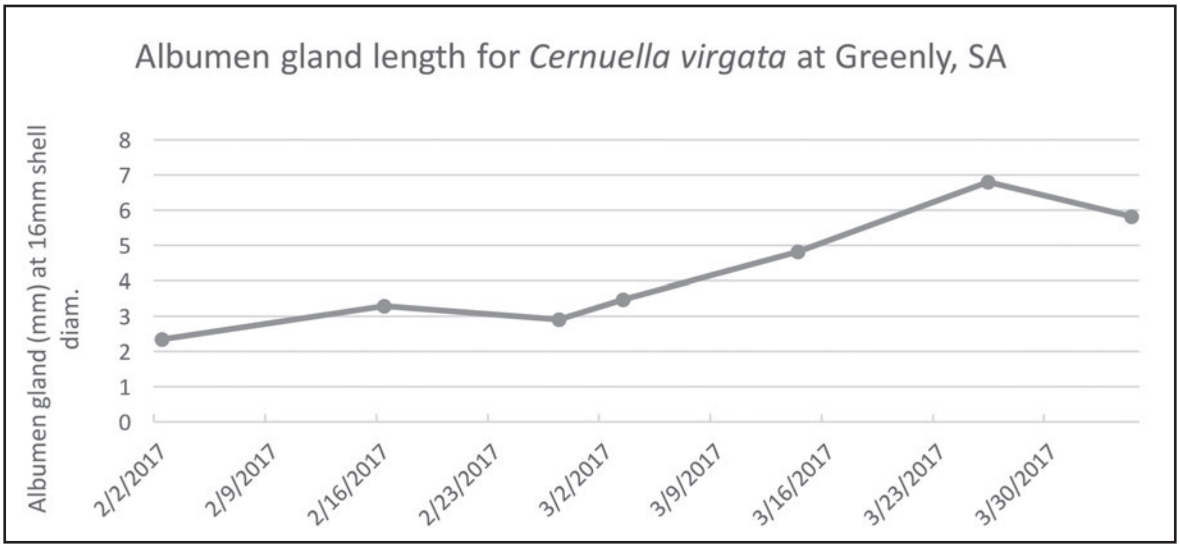


***Figure 2. Albumen gland size variation over time in canola stubble at Greenly in 2017.***

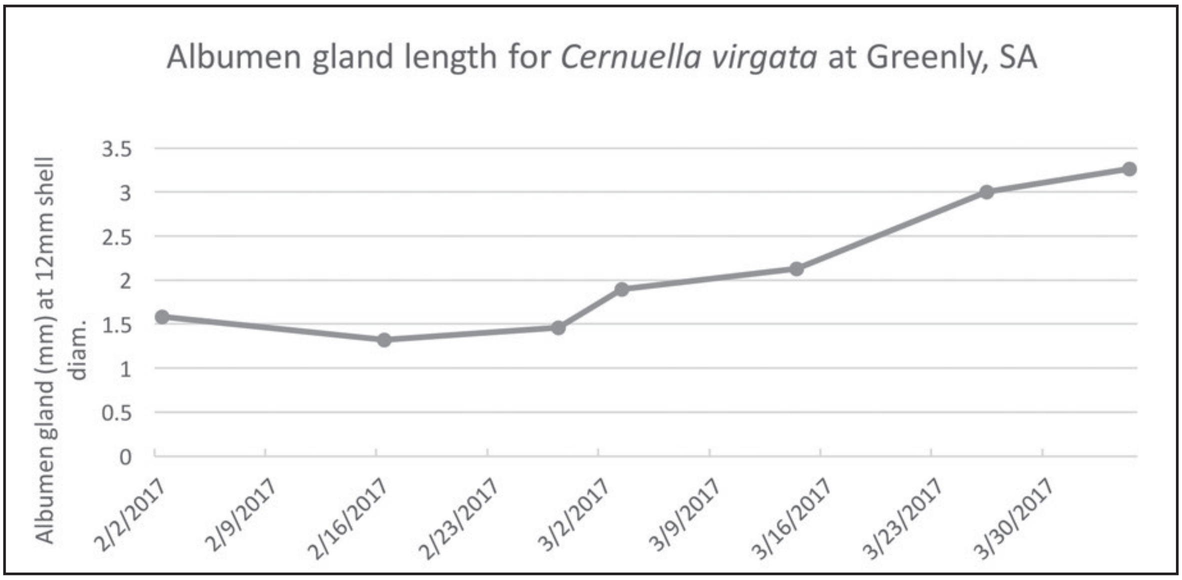


***Figure 3. Albumen gland size variation over time in wheat stubble at Greenly in 2017.***

*Table 1. Snail population counts before and after bait treatment on 6 February 2017. Bait efficacy is the decrease in population accounted for by baiting.*

| Baiting treatment | | | | | | | Average |
|---|---|---|---|---|---|---|---|
| Monitoring point | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | |
| Snails/$m^2$ before | 40 | 68 | 64 | 27 | 37 | 46 | 47 |
| Snails/$m^2$ after | 25 | 39 | 39 | 24 | 28 | 35 | 32 |
| Popn change (%) | -38 | -43 | -39 | -11 | -24 | -24 | -30 |
| Bait efficacy (%) | 27 | 31 | 29 | 08 | 18 | 18 | 22 |

*Table 2. Snail population counts before and after bait treatment on 6 March 2017. Bait efficacy is the decrease in population accounted for by baiting.*

| Baiting treatment | | | | | | | Average |
|---|---|---|---|---|---|---|---|
| Monitoring point | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | |
| Snails/$m^2$ before | 25 | 37 | 33 | 29 | 22 | 27 | 29 |
| Snails/$m^2$ after | 3 | 12 | 10 | 5 | 7 | 1 | 6 |
| Popn change (%) | -88 | -68 | -70 | -83 | -68 | -96 | -79 |
| Bait efficacy (%) | 62 | 48 | 49 | 59 | 48 | 68 | 56 |

## Discussion

Cultural methods of snail control such as cabling and rolling can be a highly effective method of snail control (Gontar and Nash, 2016). Such methods are well known to provide the best control on hot days when the chances of desiccation of snails are greater.

Monitoring and research has now shown that snails respond to short-term weather change rather than calendar-based seasonal change. This provides growers with an opportunity to bait during periods of high activity prior to egg laying. High levels of activity are seen as a ground inversion (dew) or rainfall event results in >90% relative humidity (RH), and coincides with low daytime temperatures. Dew is driven by moisture near the soil surface from recent rainfall events, as well as ground inversion which is common on clear nights going into/during autumn. A combination of surface soil moisture, low wind speed and day time temperatures below 27–30 °C will greatly increase the chance of a ground inversion or dew. Daytime temperatures over 30°C will severely hamper snail activity. The more favourable conditions are, the greater the length of time snails will remain active each night. A heavy dew will facilitate around eight hours of activity in a night. BOM current weather observations, while not perfectly accurate, are a very good guide of periods when RH>90%.

Baiting efficacy is further increased if ground cover and alternative food availability is decreased (Baker, 2015). The autumn period also correlates with a greater snail mortality when baits are consumed, however there is still some un-accounted for variability (Brodie, 2017). Snails have been observed to move without feeding. This will clearly decrease baiting efficacy and must be taken into account.

## What does this mean?

Cultural methods play an integral role in snail control over the summer months. With increasing knowledge and a level of predictability in the weather, baiting is another means by which snails can be effectively controlled prior to egg laying. However, if conditions do not facilitate snail activity and summer weeds are present baiting efficacy will be compromised.

## Acknowledgements

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## References

Gontar and B Nash, M. 2016 'Improved Snail Management on Lower Eyre Peninsula' SARDI

Baker, G. 2015, 'Stubble retention: A barrier to snail management'.

Brodie, H. 2017 'Integrated approach best for snail control', Nov-Dec 2017, GRDC Groundcover.

BOM Current weather observations: http://www.bom.gov.au/sa/observations/saall.shtml#WC

# 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
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# 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 |
| **DUL** | Drained Upper Limit |
| **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 |
| **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 |
| **LSD** | Least Significant Difference |
| **LW** | Live weight |
| **MAC** | Minnipa Agricultural Centre |
| **MAP** | Monoammonium Phosphate (10:22:00) |
| **ME** | Metabolisable Energy |
| **MED** | Molar Ethanol Droplet |
| **MIR** | Mid infrared |
| **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 |
| **pg** | Picogram |
| **PGR** | Plant growth regulator |
| **PIRSA** | Primary Industries and Regions South Australia |
| **RD&E** | Research, Development and Extension |
| **RDTS** | Root Disease Testing Service |
| **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 |
| **UEP** | Upper Eyre Peninsula |
| **UNFS** | Upper North Farming Systems |
| **WP** | Wilting Point |
| **WUE** | Water Use Efficiency |
| **YEB** | Youngest Emerged Blade |
| **YP** | Yield Prophet |

# NOTES:

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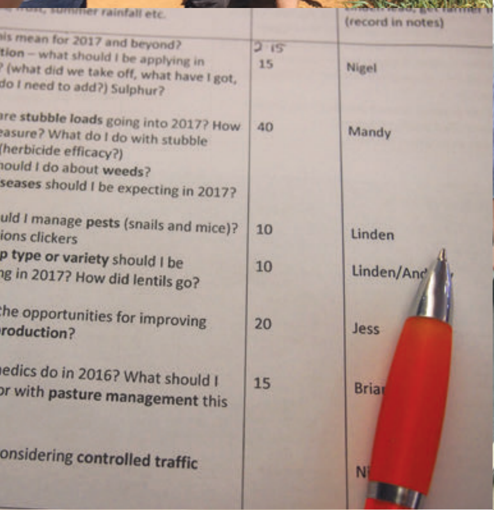
(record in notes)
is mean for 2017 and beyond?
tion – what should I be applying in
? (what did we take off, what have I got,
do I need to add?) Sulphur?
15
Nigel
are stubble loads going into 2017? How
easure? What do I do with stubble
(herbicide efficacy?)
hould I do about weeds?
seases should I be expecting in 2017?
40
Mandy
uld I manage pests (snails and mice)?
ions clickers
10
Linden
p type or variety should I be
ng in 2017? How did lentils go?
10
the opportunities for improving
production?
20
Jess
edics do in 2016? What should I
or with pasture management this
15
onsidering controlled traffic