GRAINS RESEARCH UPDATE

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Wudinna

Tuesday 27 July

9.00am to 1.00pm

Wudinna Community Centre

43 Medley Terrace Wudinna

#GRDCUpdates

Wudinna GRDC Grains Research Update
convened by ORM Pty Ltd.

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GRDC Grains Research Update
WUDINNA
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Program

9.00 am	**Announcements**	***Tim Bateman,*** *ORM*
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9:55 am	**New pre-emergent herbicides - opportunities and challenges**	***Chris Preston,*** *The University of Adelaide*
10:35 am	**Morning tea**	
11.05 am	**Russian wheat aphid thresholds - insect density, yield impact and control decision making**	***Maarten van Helden*** *SARDI*
11:45 am	**Phosphorus application recommendations based on soil characterised zones – Does it pay?**	***Sean Mason,*** *Agronomy Solutions*
12.25 pm	**Low rainfall production - one pulse does not fit all**	***Sarah Day,*** *SARDI*
1.05 pm	***Close and evaluation***	***Tim Bateman,*** *ORM*
1.10 pm	***Lunch***	

On Twitter? Follow **@GRDCSouth** and use the hashtag **#GRDCUpdates** to share key messages

What is AIR EP?

Formation

Agricultural Innovation & Research Eyre Peninsula (AIR EP) was officially incorporated on 26 May 2020, with the aim of creating a single entity for farmer driven applied research, local validation and extension of agricultural technologies and innovations on the Eyre Peninsula.

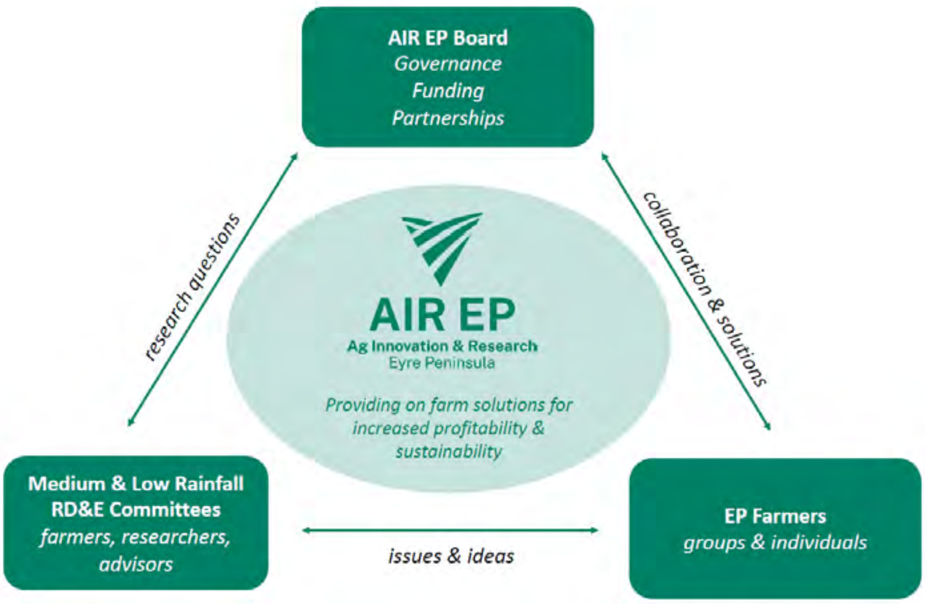
AIR EP is the result of a merger between the Eyre Peninsula Agricultural Research Foundation (EPARF) and the Lower Eyre Ag Development Association (LEADA) farming systems groups, who have been very effective in providing local research, development and extension (RD&E) outcomes for upper and lower Eyre Peninsula respectively over the past 15 years. By joining forces, the new organisation will create efficiencies in administration and operations, and provide a stronger face for regional RD&E to future funders, partners, members and supporters.

The vision for AIR EP is a professional farmer owned and directed organisation that drives the advancement and practical application of agricultural scientific research, development and extension in dryland farming systems relevant to Eyre Peninsula and like environments across Australia.

The organisation will access funds to support projects that address key issues and opportunities that will increase the profitability and resilience of farming businesses in the region.

Structure

The AIR EP Board provides governance oversight and sets the strategic direction for the organisation. The Board is supported by two RD&E Committees, one with a focus on the medium rainfall zone (lower EP) and one on the low rainfall zone (upper EP). These committees focus on setting priorities for RD&E investment in the region, reviewing projects and providing input into events for farmers.



Medium Rainfall RD&E Committee

Covers lower and parts of Eastern Eyre Peninsula and comprises:
John Richardson (Chair, AIR EP Board member rep), Dan Adams, George Pedler, Billy Pedler, Dustin Parker, Jacob Giles, Denis Pedler, David Davenport, Lochie Siegert, Brett Masters, Daniel Puckridge.

Low Rainfall RD&E Committee
Covers central, eastern and western Eyre Peninsula and comprises:
Symon Allen (Chair), Greg Scholz (AIR EP Board member rep), Andy Bates, Andrew Ware, Rhiannon Schilling, Amanda Cook, Daniel Bergmann, Matthew Cook, Rhys Tomney, Leigh Scholz, Kevin Dart.

Staff
Executive Officer - Naomi Scholz, Finance Officer - Alanna Barns, Regional Agricultural Landcare Facilitator (RALF) - Amy Wright, Sustainable Agriculture Officer - Josh Telfer.

2020/2021 Focus
AIR EP is leading the new 'Resilient EP' project, where new and emerging technologies will be used to assist farmers make efficient use of soil moisture. The Eyre Peninsula has an extensive soil moisture probe network which is underutilised. A Regional Innovators group of farmers and advisers will engage researchers and link with the region's farmers to develop techniques to integrate information generated from the probe network, satellite imagery, climate and yield models. Farmers will be able to make more informed, timely decisions underpinned by innovations in agronomy and livestock management in order to optimise the region's productive potential whilst protecting soil and water resources in a changing climate. This project is funded by the Australian Government's National Landcare Program 2, Smart Farming Partnerships Program, and we are partnering with CSIRO, Regional Connections, SARDI, Square V and EPAG Research to deliver this exciting and ambitious project.

AIR EP is also excited to be partnering with SAGIT and EPAG Research to improve the capacity of grains research, development and extension in the Eyre Peninsula region by annually engaging a recent graduate to work as an intern – this program will expose two new graduates to a wide range of opportunities and experiences across EP and beyond.

AIR EP has a range of other projects that will be continuing in 2021 including:
- Developing knowledge and tools to better manage herbicide residues in soil (Soil CRC)
- More profitable crops on highly calcareous soils by improving early vigour and overcoming soil constraints (GRDC/Soil CRC)
- Increasing production on sandy soils (GRDC)
- Demonstrating and validating the implementation of integrated weed management strategies to control barley grass (GRDC)
- Taking South Australian Canola profitability to the next level (SAGIT)

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For more information or to find out about coming events, visit our website **www.airep.com.au**, follow us on Twitter **@ag_eyre**, join us on Facebook **@aginnovationep**, subscribe to our newsletter and **become a member** via the AIR EP website.

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Harvest Weed Seed Control – getting the best results

***Chris Davey*[1,2].**

[1]YP AG; [2]WeedSmart.

Keywords

- chaff lining, chaff decking, weed seed impact mill, positive straw discharge, stripper front.

Take home messages

- Regardless of your choice of tool for harvest weed seed control (HWSC), it will only deal with the weed seeds that enter the front of the harvester.
- The amount of weed seeds that enter the header front depends on the season, the weed phenology and crop growth, and weed competition.
- Chaff lining is an entry point into HWSC.
- Chaff decking is best suited for a controlled traffic farming (CTF) system.
- The choice of seed impact mill will be based around many considerations, including header model and make, and local supply and service of the mill.
- Stripper fronts have the ability to capture as much weed seed in their chaff component as draper fronts.

Background

Harvest weed seed control (HWSC) is a key component of the WeedSmart Big 6 (https://www.weedsmart.org.au/big-6/). It is our final chance to non-chemically reduce the amount of problematic weed seeds that are returned to our weed seed bank.

HWSC options include chaff carts, narrow windrow burning, direct baling, and the more recent options of chaff lining, chaff decking and the use of a seed impact mill.

The decision of which HWSC tool to implement on your farm is a difficult one, as no one tool suits all farms. Weed type, crops grown, rainfall, yield potential, local machinery dealers – all of these things and more, influence the decision of what HWSC tool to utilise.

Options

Chaff carts rely on weed seeds being collected through the harvester before being transported off the back of the sieves via a conveyor belt to the cart. Chaff dumps are then either lined up for ease of burning before the next seeding or grazed if in a mixed farming system. Some growers have also experimented with baling the chaff and have reported great success.

Originally known as ‘windrow rotting’, chaff lining has been championed by Western Australian (WA) growers, including Mic Fels. The concept involves funnelling the chaff fraction of crop residue (containing weed seeds) into a confined row directly behind the harvester using a narrow chute. The chaff and weed seeds are then left to rot down over time. To promote rotting, the chaff lines need to be placed in the same location year after year.

Chaff decking is a form of chaff lining, which combines dual chute placement of the chaff onto the wheel marks with the hostile environment that compaction and the constant traffic of a controlled traffic farming (CTF) system creates on the line.

Seed impact mills have been around for a couple of decades now, initiated by the work of Ray Harrington in the late 1990s. It is only in the last five years, that they have been available as integrated units. Seed impact mills work by crushing, grinding and impacting the weed seeds contained in the chaff fraction of the harvest residue.

Discussion

Analysis of chaff carts as a HWSC tool

Strengths

- Capture of problematic weed seeds that can be dealt with.
- Dual purpose chaff – salinity management, livestock grazing.
- Can be baled.

Weaknesses

- Percentage of weed seeds entering the header – weed type, difference within a species, harvest timing (same for all HWSC strategies!).
- Relies on burning to completely remove/reduce weed seeds.
- Grazing chaff heaps can result in weed seed spread through the paddock, via chaff spread or animal faeces.
- Extra fuel consumption.
- More time consuming.
- Nutrient loss.

Analysis of chaff lining as a HWSC tool

Strengths

- Capture of problematic weed seeds that can be dealt with.
- Cheaper than other HWSC options – can make your own or buy a retro fit model.
- Concentration of weed seeds into a localised, known area.
- Non-chemical.
- No burning involved.

Weaknesses

- Percentage of weed seeds entering the header – weed type, difference within a species, harvest timing (same for all HWSC strategies!).
- Ideally, the header is required to follow the same marks each year.
- Lack of decomposition.
- Volunteer grain germinating in the line (e.g., wheat in barley).
- Nutrient concentration.
- Potential nutrient loss.
- Crop establishment through the chaff line in subsequent years.

Analysis of chaff decks as a HWSC tool

Strengths

- Same as those listed for chaff lining.
- More hostile environment for weeds on the tram lines/tracks – soil compaction, competition, physical damage from wheels.
- Better summer weed control through reduced dust which impedes herbicide uptake.

Weaknesses

- Same as those listed for chaff lining.
- Reliant on having CTF set up.

Analysis of seed impact mills as a HWSC tool

Strengths

- Percentage kill/control rate.
- No burning.
- Organic matter back into the ground.
- Fast-paced development of impact mill technology.

Weaknesses

- Capital outlay.
- Fuel consumption/efficiency.
- One make and model doesn't currently suit all situations.
- Crop moisture/greenness.
- Blockages.
- Wear and tear (maintenance).
- Snails, rocks/dirt.

The choice of seed impact mill will be determined by the header type and make, local dealer, back-up service available and what the best fit is in the farming enterprise.

Summary of the Yorke Peninsula seed impact mill experience

- Don't rush the harvest, particularly after frosts and/or a wet spring that has resulted in re-growth.
- Ensure crop is as dry as possible to prevent blockages.
- Mills do not efficiently process lentils that have stems that remain green at harvest.
- Seed impact mills are increasing in their longevity.
- Great results can be achieved with a stripper front and a seed impact mill.
- 'Drive to the mill' – I like this phrase!

Further considerations regarding HWSC options

- Cash flow – what you can afford and the return on investment (ROI)?
- Continuous cropping versus mixed farming – can chaff be used elsewhere on the farm?
- Phenology of the problematic weed/s – dormancy, maturity, growth habit, etc.
- Burning permits in your local council – tighter restrictions regarding burning.
- Rainfall and yield potential – how much chaff will you be dealing with?
- Ongoing expenses – repairs and maintenance.
- What is my soil nutritional health like? For example, what are the nutritional costs to me to replace the nutrients lost? Potassium (K) makes up a big part of the nutritional cost in places like WA.
- Can I adopt other components of the WeedSmart Big 6, other than HWSC?

Conclusion

- All HWSC strategies only deal with the weed seeds that enter the harvester front.
- Not all strategies will suit everyone.
- Labour will also play an integral part of your decision making.
- Peter Newman's HWSC calculator is a great starting point to compare the cost of the different strategies (https://www.weedsmart.org.au/big-6/harvest-weed-seed-control/).
- Chaff lining/decking is an economic/low-cost entry into HWSC. It relies heavily on the decay of weed seeds within the line as a means of weed control and reduction of weed seed into the soil bank. However, during the past few seasons, particularly in South Australia (SA), dry summers with minimal rain have occurred, which has led to little or no decomposition of the weed seeds in the chaff line. Evidence of this has been measured in trials by Gurjeet Gill (SA) and John Broster and Annie Ruttledge (NSW) through their trial work on weed seed decay in chaff lines.

Acknowledgements

The author would like to thank the following people for their work that has contributed to this report: Gurjeet Gill, University of Adelaide; Michael Walsh, University of Sydney; Greg Condon and Peter Newman, WeedSmart; John Broster, Charles Sturt University and Annie Ruttledge, Department of Agriculture & Fisheries. WeedSmart is financially supported by its numerous partners with the GRDC being the principal investor.

Useful resources

AHRI, 2019, What's the cost of harvest weed seed control for YOU? https://ahri.uwa.edu.au/whats-the-cost-of-hwsc-for-you/

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Notes

TOP 10 TIPS

FOR REDUCING SPRAY DRIFT

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01 **Choose all products in the tank mix carefully**, which includes the choice of active ingredient, the formulation type and the adjuvant used.

02 **Understand** how product uptake and translocation may impact on coverage requirements for the target. Read the label and technical literature for guidance on spray quality, buffer (no-spray) zones and wind speed requirements.

03 **Select the coarsest** spray quality that will provide an acceptable level of control. Be prepared to increase application volumes when coarser spray qualities are used, or when the delta T value approaches 10 to 12. Use water-sensitive paper and the Snapcard app to assess the impact of coarser spray qualities on coverage at the target.

04 **Always expect** that surface temperature inversions will form later in the day, as sunset approaches, and that they are likely to persist overnight and beyond sunrise on many occasions. If the spray operator cannot determine that an inversion is not present, spraying should NOT occur.

05 **Use weather forecasting** information to plan the application. BoM meteograms and forecasting websites can provide information on likely wind speed and direction for 5 to 7 days in advance of the intended day of spraying. Indications of the likely presence of a hazardous surface inversion include: variation between maximum and minimum daily temperatures are greater than 5°C, delta T values are below 2 and low overnight wind speeds (less than 11km/h).

06 **Only start spraying** after the sun has risen more than 20 degrees above the horizon and the wind speed has been above 4 to 5km/h for more than 20 to 30 minutes, with a clear direction that is away from adjacent sensitive areas.

07 **Higher booms increase drift**. Set the boom height to achieve double overlap of the spray pattern, with a 110-degree nozzle using a 50cm nozzle spacing (this is 50cm above the top of the stubble or crop canopy). Boom height and stability are critical. Use height control systems for wider booms or reduce the spraying speed to maintain boom height. An increase in boom height from 50 to 70cm above the target can increase drift fourfold.

08 **Avoid high spraying speeds**, particularly when ground cover is minimal. Spraying speeds more than 16 to 18km/h with trailing rigs and more than 20 to 22km/h with self-propelled sprayers greatly increase losses due to effects at the nozzle and the aerodynamics of the machine.

09 **Be prepared** to leave unsprayed buffers when the label requires, or when the wind direction is towards sensitive areas. Always refer to the spray drift restraints on the product label.

10 **Continually monitor** the conditions at the site of application. Where wind direction is a concern move operations to another paddock. Always stop spraying if the weather conditions become unfavourable.
Always record the date, start and finish times, wind direction and speed, temperature and relative humidity, product(s) and rate(s), nozzle details and spray system pressure for every tank load. Plus any additional record keeping requirements according to the label.

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New pre-emergent herbicides – opportunities and challenges

Christopher Preston.

School of Agriculture, Food & Wine, University of Adelaide.

Keywords

- pre-emergent herbicide, barley grass, dry sowing.

Take home messages

- There are many old and new pre-emergent herbicides available, but most are designed for annual ryegrass control
- Choice of herbicide should consider soil type, seeding system, dry seeding, soil organic matter and likely rainfall after application
- Dry conditions around sowing make pre-emergent herbicides performance variable, mixing products with different behaviour can improve performance.

Choosing between new and old pre-emergent grass herbicides for grass control

Pre-emergent herbicides have become the main tool for annual ryegrass control in cereals and there are now many products available. This presents a range of opportunities as well as challenges. Choosing the correct product for the circumstance requires understanding the main factors that influence pre-emergent herbicide behaviour.

Soil type

Soil type and organic matter content both influence pre-emergent herbicide behaviour. Herbicides move with soil water, so will move further in lighter soils due to the larger size of spaces between the soil particles. Lighter soils also tend to have lower organic matter. Herbicide binding to organic matter is variable. Some herbicides bind tightly, which slows their movement through the soil. Other herbicides bind weakly and so will move further, but also move further in soils of low organic matter.

Non-wetting sands cause specific problems for pre-emergent herbicides. As most herbicides move through the soil in water, their distribution in non-wetting sands tends to be uneven. Where water penetrates, it will carry the herbicide with it. Where water does not penetrate, there will be less herbicide present.

Herbicide chemistry

The key elements of herbicide chemistry to be concerned about are water solubility, binding to organic carbon and persistence. More water-soluble herbicides will tend to move further into soil with rainfall, whereas less soluble herbicides will move less. Herbicides that bind tightly to organic carbon will tend to be held up by organic matter in the soil, whereas those that have low binding will move through the soil with every rainfall event.

When considering herbicide persistence, what we are interested in is the effective persistence of the herbicide. That is how long the herbicide will continue to control weeds. There is not really a value that captures this, other than experience. Persistence is influenced by the herbicide rate used, the chemistry of the herbicide, soil organic matter, soil moisture and temperature. The aim is to have herbicides persist long enough to control weeds, but not to harm subsequent crops.

Table 1. Behaviour of some pre-emergent herbicides used for grass weed control.

Pre-emergent herbicide	Trade name	Solubility (mg L^{-1})		KOC (mL g^{-1})	
S-metolachlor	Dual Gold®, Boxer Gold®*	480	High	226	Medium
Metazachlor	Butisan®	450	High	45	Low
Cinmethylin	Luximax®	63	Medium	300	Medium
Bixlozone	Overwatch®	42	Medium	400	Medium
Atrazine	Gesaprim®	35	Medium	174	Medium
Prosulfocarb	Arcade®, Boxer Gold®*	13	Low	2000	High
Propyzamide	Edge®	9	Low	840	High
Simazine	Gesatop®	5	Low	130	Medium
Triallate	Avadex Xtra®	4.1	Low	3000	High
Pyroxasulfone	Sakura®	3.5	Low	223	Medium
Trifluralin	Triflur-X®	0.2	Very low	15,800	Very high

Boxer Gold contains two ingredients, prosulfocarb and s-metolachlor.

Rainfall

Herbicides with low solubility require more rainfall to activate them than more soluble herbicides. The exception to this is trifluralin, which becomes a gas on contact with water. Too much rainfall can move more soluble herbicides into the crop root zone and result in crop damage. However, it is not just the amount of rainfall, but also when it falls that matters. Herbicides applied to dry soil will move further with rainfall than those applied to wet soil. This makes some more water-soluble herbicides risky for use with dry seeding. Particular care needs to be taken choosing herbicides for dry sowing conditions. Dry conditions after herbicide application can make performance of herbicides more variable, depending on whether there is already moisture in the soil.

Seeding setup

Much of the crop tolerance to pre-emergent herbicides is due to positional selectivity. That is the herbicide is applied in a way that limits its interaction with the crop seed. Typically, this is done with a knifepoint and press-wheel seeding system where herbicide treated soil is thrown out of the crop row. For several the pre-emergent herbicides, this is the only safe way to use them. Where crop tolerance is higher, such as wheat tolerance to Sakura®, other seeding setups are also safe, such as knife points and harrows, where some herbicide treated is moved into the crop row. Only a few pre-emergent herbicides are safe for use in disc seeding systems. On the other hand, for some herbicides, like Luximax®, there is a need to ensure crop seeding depth is adequate to achieve safety.

Efficacy on weeds other than annual ryegrass

The pre-emergent herbicides we have for grass weed control in Australia is largely dictated by whether they will control annual ryegrass. Control of other grass weeds is variable. Figure 1 shows the efficacy of several pre-emergent herbicides used at the field rate on control of barley grass in pots under ideal conditions. TriflurX®, Butisan® and Ultro® provided good control in these experiments, but the other herbicides were variable. This means that choosing herbicides where multiple grass weeds are present is more difficult.

The situation becomes more complex when conditions are not ideal for herbicide activity. Figure 2 shows the same experimental design, except there was no watering for 7 days after herbicide application, when watering was resumed. In this trial, all the herbicides performed less well than if there was watering immediately after herbicide application. Some of the variation in performance of pre-emergent herbicides is due to dry periods after application. This may make herbicides perform less well on weeds like barley grass that are able to bury themselves in the soil than for annual ryegrass.

One way of achieving better performance under dry conditions is to mix pre-emergent herbicides that have different properties. Due to its lack of movement through the soil profile and ability to be activated by low amounts of rainfall, trifluralin is often a good choice for dry seeding conditions. It is also less affected by dry conditions after seeding than some other pre-emergent herbicide choices. However, generally trifluralin provides limited control

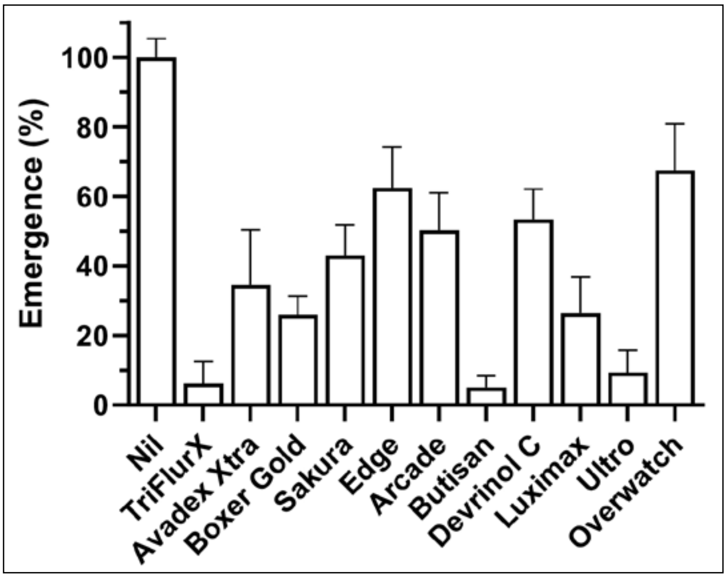

Figure 1. Emergence of barley grass in well-watered pots after application of various pre-emergent herbicides at the field rate.

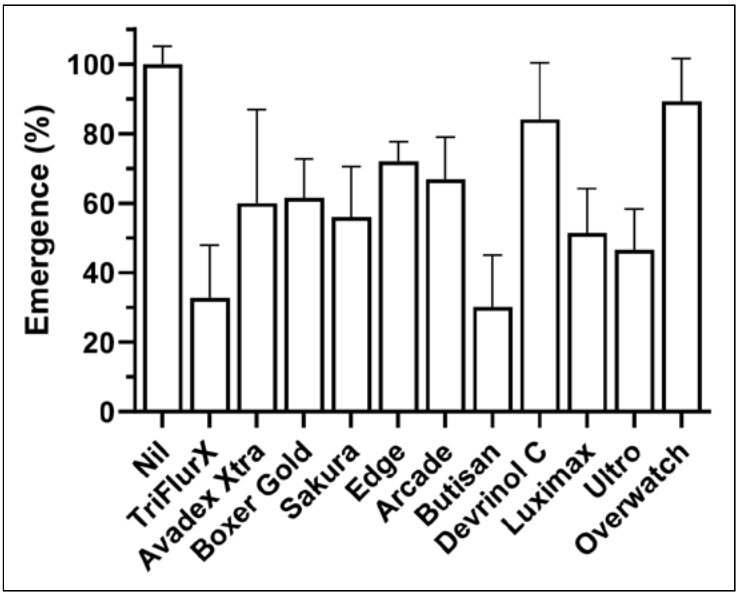

Figure 2. Emergence of barley grass in pots kept dry for 7 days after application of various pre-emergent herbicides at the field rate.

of weeds like barley grass and brome grass. In our trials on barley grass, mixtures of trifluralin and Sakura have generally performed well.

Pre-emergent herbicides often only provide control for a limited period after sowing. It is essential that other tactics, such as enhancing crop competition, are used to reduce the seed set of weeds that escape the herbicide.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

Useful resources

https://grdc.com.au/resources-and-publications/all-publications/publications/2018/soil-behaviour-of-pre-emergent-herbicides

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Notes

LOOK AROUND YOU.

1 in 5 people in rural Australia are currently experiencing mental health issues.

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The GRDC supports the mental wellbeing of Australian grain growers and their communities. Are you ok? If you or someone you know is experiencing mental health issues call *beyondblue* or Lifeline for 24/7 crisis support.

beyondblue
1300 22 46 36
www.beyondblue.org.au

beyondblue
Depression. Anxiety.

Lifeline
13 11 14
www.lifeline.org.au

Lifeline
13 11 14

Looking for information on mental wellbeing? Information and support resources are available through:

www.ifarmwell.com.au An online toolkit specifically tailored to help growers cope with challenges, particularly things beyond their control (such as weather), and get the most out of every day.

www.blackdoginstitute.org.au The Black Dog Institute is a medical research institute that focuses on the identification, prevention and treatment of mental illness. Its website aims to lead you through the logical steps in seeking help for mood disorders, such as depression and bipolar disorder, and to provide you with information, resources and assessment tools.

www.crrmh.com.au The Centre for Rural & Remote Mental Health (CRRMH) provides leadership in rural and remote mental-health research, working closely with rural communities and partners to provide evidence-based service design, delivery and education.

Glove Box Guide to Mental Health
The *Glove Box Guide to Mental Health* includes stories, tips, and information about services to help connect rural communities and encourage conversations about mental health. Available online from CRRMH.

www.rrmh.com.au Rural & Remote Mental Health run workshops and training through its Rural Minds program, which is designed to raise mental health awareness and confidence, grow understanding and ensure information is embedded into agricultural and farming communities.

www.cores.org.au CORES™ (Community Response to Eliminating Suicide) is a community-based program that educates members of a local community on how to intervene when they encounter a person they believe may be suicidal.

www.headsup.org.au Heads Up is all about giving individuals and businesses tools to create more mentally healthy workplaces. Heads Up provides a wide range of resources, information and advice for individuals and organisations – designed to offer simple, practical and, importantly, achievable guidance. You can also create an action plan that is tailored for your business.

www.farmerhealth.org.au The National Centre for Farmer Health provides leadership to improve the health, wellbeing and safety of farm workers, their families and communities across Australia and serves to increase knowledge transfer between farmers, medical professionals, academics and students.

www.ruralhealth.org.au The National Rural Health Alliance produces a range of communication materials, including fact sheets and infographics, media releases and its flagship magazine *Partyline*.

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Russian wheat aphid thresholds - insect density, yield impact and control decision making

Maarten van Helden[1,2], Thomas Heddle[1], Elia Pirtle[3], Jess Lye[3], James Maino[3].

[1]South Australian Research & Development Institute; [2]The University of Adelaide; [3]Cesar Australia.

GRDC project code: UOA1805-018RTX

Keywords

- Russian wheat aphid, yield loss, action threshold.

Take home messages

- Natural Russian Wheat Aphid (RWA) risk was nonsignificant in all 28 trials in 2018 and 2019
- RWA Yield impact is 0.28 % yield loss per percent of tillers with RWA (%TwRWA)
- After GS30 the %TwRWA doubles about every 35 days
- The RWA action threshold calculator is now available on-line and allows an IPM approach.

Background

This project studied the risk of infestation by the Russian Wheat Aphids (RWA, *Diuraphis noxia* Kurdjimov) and its effect on yield to develop best management practices in an Australian context of winter cropping of short cycle cereals. Risk of yield loss depends on aphid invasion, subsequent pest development and sensitivity of the crop to the pest.

Previously, there were no data available for quantitative and qualitative yield effects of RWA and the development of intervention thresholds in Australian cereal growing conditions. Overseas data, from North America and South Africa, where RWA has been present for many decades (Archer and Bynum 1992, Du Toit and Walters 1984, Du Toit 1986, Bennett 1990 a and b, Kieckhefer and Gellner 1992, Girma et al 1990 and 1993, Mirik et al. 2009, Legg and Archer 1998, Chander et al 2009), report a wide range of potential damage levels (yield loss and qualitative losses) and derived economic injury levels. Losses of around 0.5% of yield loss per percentage of RWA infested tillers during stem elongation and grain filling are most frequently reported (Archer and Bynum 1992).

These knowledge gaps were addressed through

1. 28 natural RWA infestation field trials in 2018 (15) and 2019 (13) in South Australia, Victoria, New South Wales, and Tasmania (Table 1)
2. 15 RWA inoculated field trials in 2018 (5) and 2019 (10) where 50 RWA/m^2 (500,000 RWA/ha) were applied at GS12-14 (2-4 leaf stage, Table 1)
3. Green Bridge sampling of grasses during the non-cropping period in both years in all states and extensive continuous sampling of grasses in SA over 26 months (March 2018-May 2020)

Outcomes

Risk of RWA invasion of crops

Overall RWA risk was very low during these two (very dry) years with no significant RWA infestation occurring in any of the non-inoculated field trials. This shows that the largely adopted use of prophylactic seed treatments against RWA was not justified.

Table 1. Location of trial sites in 2018 and 2019.

Site Name	State	Lat	Long	Inoculation	Irrigation
2018					
Birchip	VIC	-35.9666	142.8242	Y	N
Cummins	SA	-34.3050	135.7189	N	N
Griffith	NSW	-34.1902	146.0920	Y	N
Hillston	NSW	-33.5482	145.4408	N	Y
Inverleigh	VIC	-38.1805	144.0390	N	N
Keith	SA	-36.1299	140.3233	Y	N
Lockhart	NSW	-35.0837	147.3280	N	N
Longerenong	VIC	-36.7432	142.1135	N	N
Loxton	SA	-34.4871	140.5891	Y	N
Minnipa	SA	-32.8398	135.1642	N	N
Nile DRY	TAS	-41.6759	147.3140	N	N
Nile IRR	TAS	-41.6759	147.3140	N	Y
Piangil	SA	-35.0519	143.2758	N	N
Riverton	SA	-34.2193	138.7350	Y	N
Yarrawonga	NSW	-36.0484	145.9833	N	N
2019					
Birchip	VIC	-35.9666	142.8242	Y	N
Bundella	NSW	-31.5851	149.9064	N	N
Cressy	TAS	-41.7854	147.1134	Y	N
Eugowra	NSW	-33.4944	148.3192	N	N
Griffith	NSW	-34.1902	146.0920	Y	N
Horsham	VIC	-36.7432	142.1135	Y	N
Inverleigh	VIC	-38.0497	144.0104	Y	N
Loxton	SA	-34.4871	140.5891	Y	N
Minnipa	SA	-32.8398	135.1642	Y	N
Mildura	VIC	-34.2627	141.8535	Y	N
Pt Broughton	SA	-33.5757	137.9987	Y	N
Thule	NSW	-35.6491	144.3914	Y	N
Yarrawonga	NSW	-36.0484	145.9833	N	N

Yield loss in inoculated trials

Regional and varietal differences were large (Figure 1). In some, but not all, of the inoculated field trials RWA populations reached population levels (maximum observed between GS40 and 50) resulting in yield loss. The best predictor of yield loss of various aphid pressure metrics was the maximum percentage of tillers with RWA present (%TwRWA) and a percentage of the potential yield loss with a 0.28% yield loss observed for every %TwRWA. This simple relationship applied to all the different cereal types (wheat, barley, durum wheat), years and regions (through the adjustment of potential yield); Oat did not allow RWA development. This yield impact is significantly lower than described for the USA (0.46-0.48%, Archer and Bynum 1992).

From this equation, the economic threshold (the break-even point of yield loss and control measures) can be calculated depending on the costs of control (pesticide, applications costs), the expected yield (region and year dependant) and the farm-gate price of the crop as parameters (Figure 2).

RWA population development

After inoculation, the highest RWA populations developed in drier regions, through a combination of increased RWA establishment during inoculation and increased population increase. Less tillering in dry areas also contributed to higher %TwRWA. The maximum population of RWA and the maximum %TwRWA was reached between GS40 and 50 (Figure 3) followed by a decrease. Between the end of tillering (GS30) and GS50 an increase in the

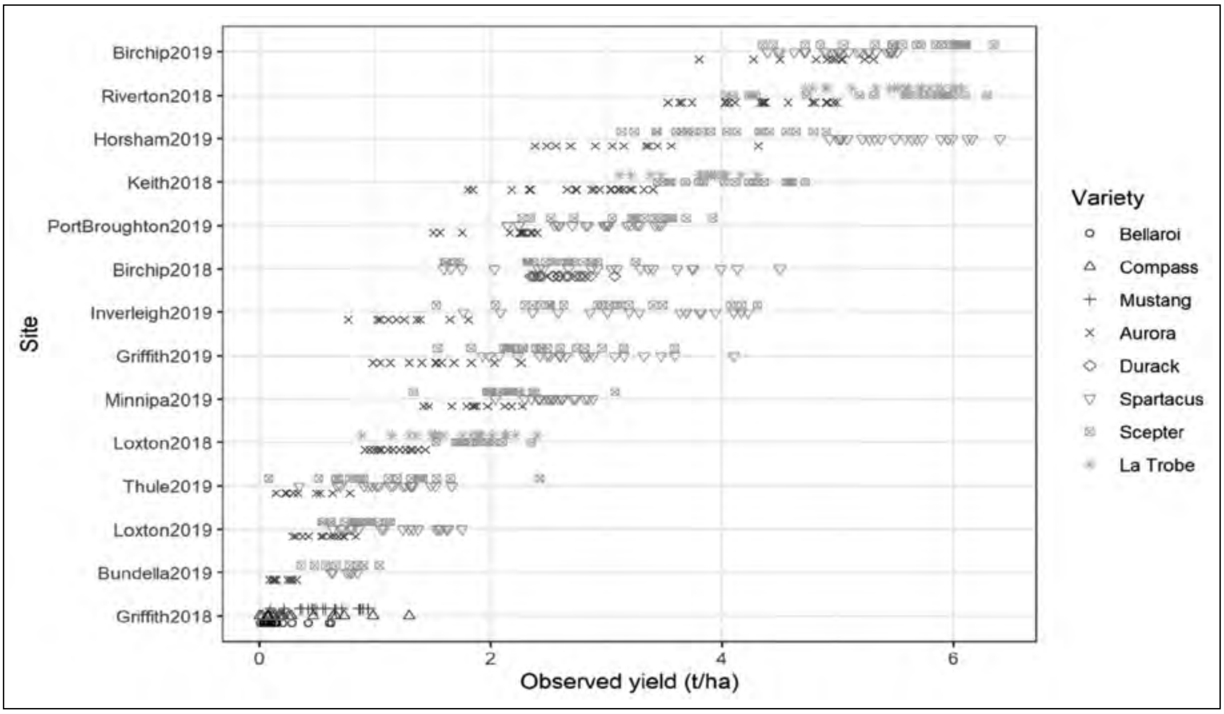

Figure 1. Yield across all trial sites and years with different cereal type/variety denoted by different markers. Varieties used: Barley: Compass$^{\phi}$; Spartacus CL$^{\phi}$, La Trobe$^{\phi}$; Durum wheat: EGA Bellaroi$^{\phi}$, DBA Aurora$^{\phi}$; Wheat: Scepter$^{\phi}$, Mustang$^{\phi}$; Oat: Durack$^{\phi}$.

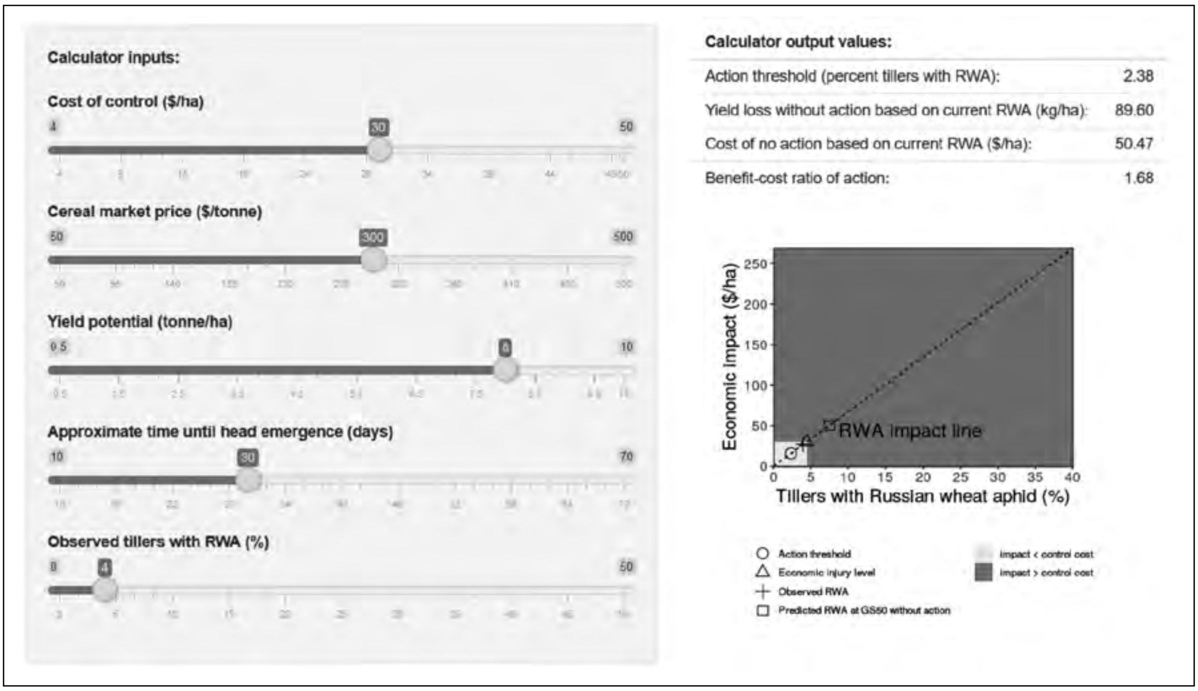

Figure 2. RWA Action Threshold calculator (example).

%TwRWA of 0.021%/%/day was observed. This would result in a doubling of the %TwRWA every 35 days.

Action threshold calculator

Based on these observations and equations, we propose a decision rule (action threshold, Figure 2) for RWA management using an observation of the percentage of tillers with symptoms and the %TwRWA at GS30. This observation and the expected increase in %TwRWA (based on the expected time to ear emergence GS50) inform the need for management action, which can (if needed) be combined with existing treatments at GS 32-35, reducing application costs. Growers and advisers

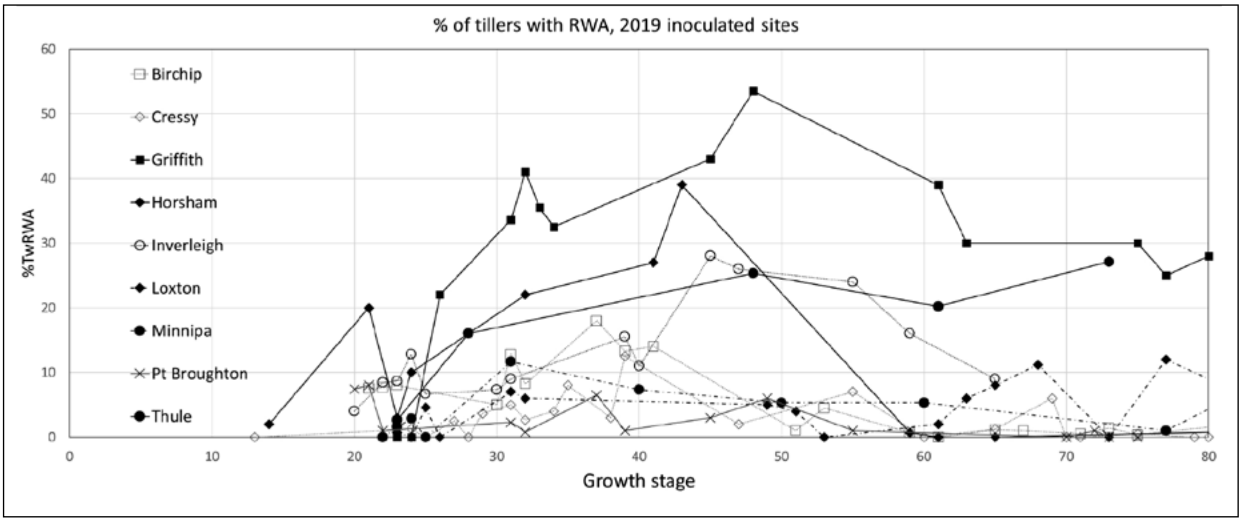

Figure 3. Percentage of tillers with RWA (%TwRWA) against growth stage for the inoculated untreated control plots (AI-UTC) in all inoculated trial sites in 2019.

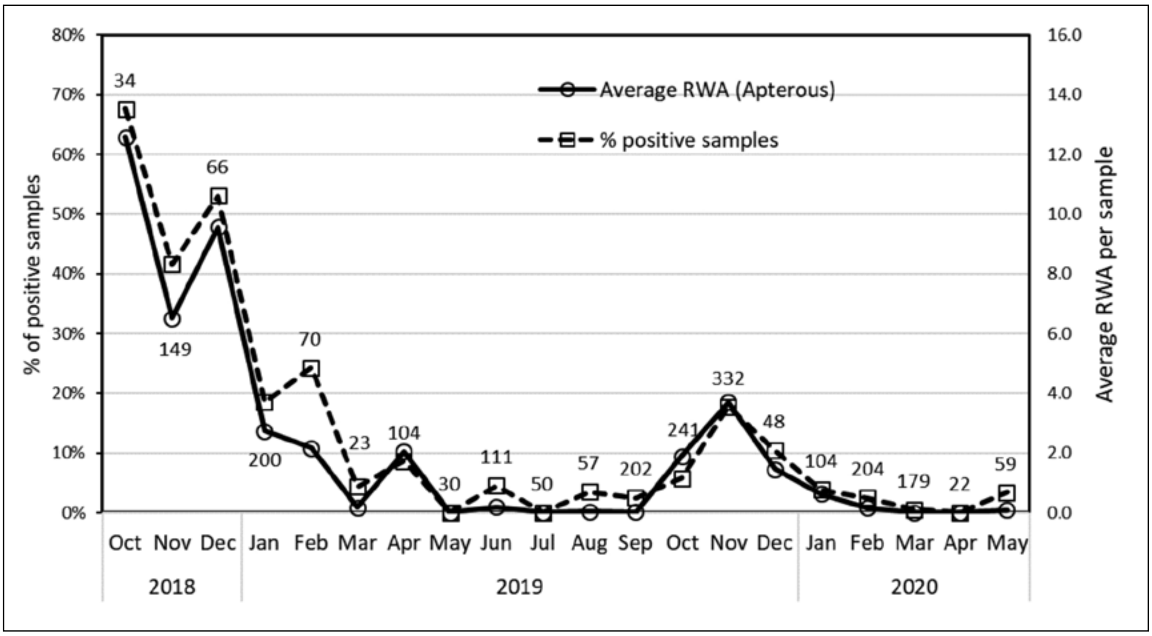

Figure 4. Dynamics of the percentage of positive samples (dotted line, left axis) and average RWA per sample (Solid line, right axis) over time in SA. Numbers above markers show number of samples taken per month. n = 2285.

are directed to the GRDC calculator (see additional resources) to calculate thresholds for their growing conditions".

Green bridge risk

The environmental conditions over summer that form a "green bridge" of suitable (grass) habitat between winter crops were expected to determine the risk of early colonisation events.

Field surveys during the spring to autumn periods (when no crops were present in the field) demonstrated RWA detections being particularly common and with high populations during spring in the warm dry grain growing regions of northern Victoria, southern New South Wales, and South Australia. During the summer green vegetation for most grass species disappeared and RWA populations declined (Figure 4). Apart from volunteer cereals (wheat and barley), the majority of RWA detections were on five grass genera (barley grass, *Bromus* sp, phalaris, ryegrass and wild oat.

Barley grass (*Hordeum leporinum*) and (to a lesser extent) Brome grasses (*Bromus* sp.) are the host plants that showed the highest combination of abundance, positive RWA detection frequency and aphid numbers. These introduced species are not summer active in low rainfall areas, where the native *Enneapogon nigricans* (bottlebrush) is the most important summer refuge in low rainfall areas, because of its widespread distribution (207 samples collected from 135 sites) and summer growth pattern. Grazing and water availability (irrigation) can make some host grass populations, including prairie grass, couch grass, ryegrass, and volunteer cereals, persist in summer. The presence of irrigated crops increased the likelihood of RWA detections 1.6-fold over the green bridge.

Early rainfall in late summer/ autumn, 2-3 months before sowing, could cause RWA population to build up on grasses and cereal regrowth, potentially exacerbating early crop invasions. A 250 mm intense rainfall event in the Birchip area (Vic) in December 2018 did cause significant development of a green bridge but did not seem to result in increased RWA risk. Reports in 2020 from the Port Augusta area (SA), where a significant summer rain occurred on February 1st, suggested an increase in RWA pressure. This shows that observations, especially in early break years and better understanding of aphid population dynamics and migration on the green bridge before and after sowing, are needed to obtain more precision on the impact of the green bridge and the risk and times of invasion of crops.

A ‘wetter’ year with a longer green bridge, or if immigration of aphids occurs at a higher level for some other reason, will not automatically result in higher impact of RWA. Wetter and colder conditions will be less favourable for RWA development in the crop, slowing down population development. and improving the crop development and resistance to RWA. This can be seen by comparing the Tasmanian trials with the two experimental years.

Crop sensitivity

We show similar yield impact and aphid population development for all crops tested except for oat, not an RWA host. However, crop and varietal differences in RWA establishment are likely to exist and have been reported. Also, the crop condition (growth stage, level of tillering, drought stress, nutritional stage) will play a role in RWA development and could result in a different risk for reaching population levels above thresholds.

Conclusion

RWA ecology and yield impact in Australia are now somewhat better understood. This allows growers and agronomists to manage RWA more sustainably and economically. Management based on observations and regionally adapted decision rules, rather than prophylactic seed treatments, will increase profitability, minimise chemical inputs and reduce off-target risks and resistance development.

The two years during which this study was conducted were very dry hot summers and growing seasons, unfavourable for RWA survival over summer, but favourable for the development of RWA in the inoculated trials (Baugh and Phillips 1991, De Farias et al 1995). Some anecdotal observations in 2020, and in the few years that RWA is known to be present (since 2016, Ward et al. 2020, Yazdani et al. 2018), do suggest that the population levels will be very different, but not necessarily more damaging, with different rainfall patterns. More experience and research are needed to better understand RWA ecology and would allow management guidelines to be improved.

The geographical distribution of RWA is expected to increase further into northern NSW and Queensland (Avila et al. 2019), and RWA was detected in Western Australia in 2020. Different growing conditions (temperature, drought) and presence of other cereal crops, including summer cereals (rice, corn, sorghum, millet), and other grass hosts could alter the risk of RWA in those regions.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support. Trials were run through multiple contractors requiring long hours of careful observations. Special thanks to Courtney Proctor, Bonnie Wake and Millie Moore for data management and long trips required for aphid inoculations and scoring trials, and Farah Al-Jawahiri for aphid rearing.

Useful resources

https://grdc.com.au/resources-and-publications/resources/russian-wheat-aphid

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Notes

Dealing with the Dry

As grain growers across Queensland and New South Wales and parts of Victoria and South Australia continue to be challenged by drought conditions, the GRDC is committed to providing access to practical agronomic advice and support to assist with on-farm decision making during tough times.

Visit our 'Dealing with the Dry' resource page for useful information on agronomy in dry times and tips for planning and being prepared when it does rain.

www.grdc.com.au/dealingwiththedry

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Herbicide MoA alignment: Stage 1

Herbicide Mode of Action (MoA) classifications have been updated internationally to capture new active constituents and ensure the MoA classification system is globally relevant.

The global MoA classification system is based on numerical codes which provides infinite capacity to accommodate new herbicide MoA coming to market, unlike the alphabetical codes currently used in Australia.

Farming is becoming increasingly global. Farmers, agronomists and academics around the world are now, more than ever, sharing and accessing information to assist them to grow crops, while managing sustainability issues such as herbicide resistant weeds.

It's important then that the herbicide MoA classification system utilised in Australia be aligned with the global classification system. This will ensure more efficient farming systems into the future and allow Australian farmers and advisors to access the most up-to-date information relating to managing herbicide resistance.

CropLife Australia is working with key herbicide resistance management experts, advisors and the APVMA to ensure farmers and agronomists are aware of the planned changes.

Growers can expect to start seeing herbicide labels with the new mode of action classification system from early 2022. There will be a transition period during which herbicide labels will exist in the supply chain, some bearing the legacy alphabetical MoA classifications, and others transitioned to the global numerical system.

The numerical classification system should be fully implemented by the end of 2024.

A mobile app compatible with Android and Apple systems is available via the **HRAC website** (hracglobal.com) at no cost to users. It will cross reference the herbicide active ingredient with its former MoA letter and new MoA number. Printed materials will also be made available to enable cross referencing of the changes.

CropLife Australia

Frequently asked questions

Q. Why change from letters to numbers?

A. A numerical code system is more globally relevant and sustainable, compared to the current alphabetic code used in Australia. Today there are 25 recognised MoAs. Over the next 10 years we anticipate up to four new modes of action to be commercialised, which will exceed the 26-letter maximum in the English alphabet.

Q. What is going to change?

A. The current alphabetical codes for herbicide active ingredients will change to numerical codes, in alignment with the global MoA classification system. For example, Group A herbicides will be labelled as Group 1 herbicides and Group M (glyphosate) will become Group 9.

Some new MoA will be introduced to accommodate some of the new chemistry being introduced world-wide. Some active ingredients will also be reclassified into different groups to better reflect their actual mode of action, not chemical structure.

A complete summary of the changes is available via the mobile app. More detailed information regarding the changes will be available in mid-2021.

Q. What are the main changes?

A. The main changes are outlined in the free mobile app, which you can download from the **HRAC website**. We are still working with industry experts to identify the consequences of these changes regarding how products fit into an integrated weed management program and will provide more specific guidance on the changes in mid-2021.

Q. How will the changes affect what we do?

A. The way growers use herbicides in the field will not change. The science hasn't changed and the mix and rotate messages remain correct. It is just the classification codes used on product labels and literature that will change from a letter to a number. Continue to follow your current IWM strategy and rotation plans.

Q. When will the changes take place?

A. There will be a transition period starting from July 2021, with growers likely to begin to see labels bearing the new MoA numbering system in the marketplace in early 2022.

Q. Does this mean the current MoA are wrong?

A. The science has not changed. Stick with your current IWM strategy and plans to rotate herbicides. In this era of multiple cross resistance, there is no magic bullet amongst the new modes of action.

Q. How will I know which products to rotate?

A. The science hasn't changed – stick with your current IWM strategy and plans to rotate herbicides. If in doubt, particularly with newer herbicides recently introduced, consult the manufacturer or your local agronomic advisor.

A summary of the changes is available via the mobile app. More detailed information regarding the changes will be available in mid-2021.

Q. Can I still use product on hand which has the old MoA printed on the label?

A. Yes. Legacy labels will be phased out over the next few years and will continue to be legally valid, although growers are encouraged to familiarise themselves with the new MoA classification system and corresponding resistance management strategies from 1 July 2021.

Q. Where can I find out more information?

A. You can find more information at the **CropLife website** and the free mobile app is available on the **HRAC website**.

Download the Global HRAC Herbicide MOA Classification app via Google Play or the App Store.

To find out more visit:

croplife.org.au/MoA

@CropLifeOz E info@croplife.org.au P 02 6273 2733

Phosphorus application recommendations based on soil characterised zones – does it pay?

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GRDC project code: ASO1805-001RTX

Keywords

- phosphorus availability, phosphorus buffering index, precision phosphorus applications, replacement phosphorus.

Take home messages

- Optimal phosphorus (P) applications for maximising gross margins vary significantly within a paddock and have been linked to varying soil properties.
- Soil P status, phosphorus buffering index (PBI), normalized difference vegetation index (NDVI) images and in-season plant analysis have identified poor performing areas where higher than replacement P rates are required.
- P replacement strategies based on estimated P removal in grain only work on soils where P is not limiting growth i.e. those with high soil P and low PBI.
- Poor performing areas should be ground-truthed to ensure soil P is not limiting crop production before implementing a replacement P strategy.

Background

Most growers in the southern region use a P replacement strategy based on the amount of P removed in the grain (i.e. 3 kg P/t grain) to determine fertiliser P application rates. Recent response trial work in the broad acre cropping regions of South Australia (SA) has highlighted that some soils with moderate to high PBI levels (>100) tend to be P deficient and require relatively high P rates (>20kg P/ha) to maximise both yields and gross margins. Phosphorus fixation at these selected locations is associated with the presence of low to moderate levels of calcium carbonate (5-20%) and is marked by high soil pH values. Data from these soils which often occur in areas within a paddock suggest that current P application rates are not sufficient at meeting crop P demands when soil characteristics are factored in. Through more extensive data measurements it has also been found that these areas are quite often marked by poor early growth and vigour of cereals and can be identified by in-season NDVI images. Where variable rate fertiliser technology is used, based on replacement P strategies determined by P removal in grain yield, these poor areas receive lower amounts of P fertiliser which amplifies the P deficiency.

Typically, P deficiency through replicated trials has been assessed on small, selected regions of a paddock with little data quantifying variations in P requirements across the whole paddock. With an aim to improve P applications determined by soil characteristics and in-season NDVI imagery (rather than the 'traditional' replacement P strategies), a SAGIT funded project (TC219) tested zonal strategies in five paddocks across the past two growing seasons. Broader approaches have been used in the current GRDC project to assess responses to different starter P applications across the length of a paddock utilising strip trial methodology.

Method

Intensive paddock sampling for soil pH limitations, combined with satellite imagery identified different production zones across five paddocks located in the Mid North of SA. These zones can also be linked to soil properties which drive P availability, including soil pH, soil carbonate levels and the P fixation potential (measured by PBI) which can change dramatically over short distances within a paddock. Through the SAGIT funded project (TC219), the implication of these soil attributes on economic P rates has been tested by running 21 replicated field P response trials in different soil pH, PBI and NDVI zones split across the five paddocks. Wheat or barley responses to P applications were assessed at each of the 21 sites and optimal P rates determined at: 1) maximum grain yield and 2) maximum partial gross margins. The maximum partial gross margins obtained were related back to the partial gross margins that would have been obtained if a variable rate P replacement strategy was used. The replacement P rate was determined retrospectively by using the maximum yield obtained at each site and multiplying by 3kg P/ha, which is the rule of thumb for P removal per tonne of grain exported.

Partial gross margins were calculated by using the same price for monoammonium phosphate (MAP), urea and grain across both seasons which were $650/t, $500/t, and $300/t, respectively.

Results and discussion

Site soil characteristics

Site selection was based on NDVI imagery taken early in the growth season (< GS31) from the cereal phase during the previous season and soil pH mapping performed using a Veris® soil pH mapper by Trengove Consulting. In all five paddocks tested, areas of the paddock with low early vigour and biomass correlated to high pH (driven by the presence of calcium carbonate), higher P fixation potential (PBI) and lower soil P availability, identified through Colwell P with PBI interpretation and diffusive gradients in thin films (DGT) analysis (Table 1).

Cereal response to P applications

From the 21 sites across the five paddocks, 11 sites had a significant grain response to P applications (Table 1). This highlights that previous P applications

Table 1. Soil pH and P availability values for the 21 P trials performed in five paddocks across two growing seasons (2019-2020).

Paddock	Site	pH CaCl2	Colwell P mg/kg	PBI	DGT P ug/L	Response to P (grain)
Koolunga	1	7.55	24	126	20	**
	2	7.58	28	141	25	**
	3	6.19	44	44	93	NS
	4	5.87	58	73	71	NS
Bute 19	5	4.94	36	25	150	NS
	6	5.96	33	61	51	NS
	7	7.67	25	90	20	**
	8	7.67	19	73	35	**
Brinkworth	9	6.65	50	105	92	NS
	10	7.63	96	64	198	NS
	11	7.69	44	120	21	**
	12	6.22	93	66	168	*
Bute 20	13	5.75	32	19	135	NS
	14	7.82	49	66	70	**
	15	6.11	67	85	71	*
	16	7.63	39	108	47	**
Kybunga	17	Tbc	27	53	69	NS
	18	Tbc	28	108	25	**
	19	Tbc	27	23	158	NS
	20	Tbc	31	50	58	NS
	21	Tbc	34	119	16	**

*The significance of grain yield response to P applications of each site is indicated by ** ($p < 0.01$), * ($p < 0.05$) and non-significant response (NS).*

were enough to build soil P reserves and no significant reliance on P inputs was observed to increase grain yields at 48% of sites. The average soil PBI in the non-responsive sites was 52 with an average soil pH of 6.14. The highly significant ($p < 0.001$) responses to P were found on sites with an average PBI of 106 and soil pH of 7.66.

Identifying soil characterised zones for phosphorus management

The trial sites that were highly significant and responsive to P applications had P requirements of more than 30kg P/ha to maximise yields. This P input is a large investment, and its economic advantage needs to be tested before implementation at large scales. Comparing partial gross margin analysis for two categories (Maximum gross margin (Max GM) point with P rate versus gross margin (GM) at replacement P rate) indicates that there are considerable improvements that can be made in productivity and GM by identifying soil zones prone to P deficiency and requiring higher P rates than recommended by replacement P calculators. The magnitude of the improvement in productivity will be determined by the proportion of the paddock that expresses these soil characteristics. Identification

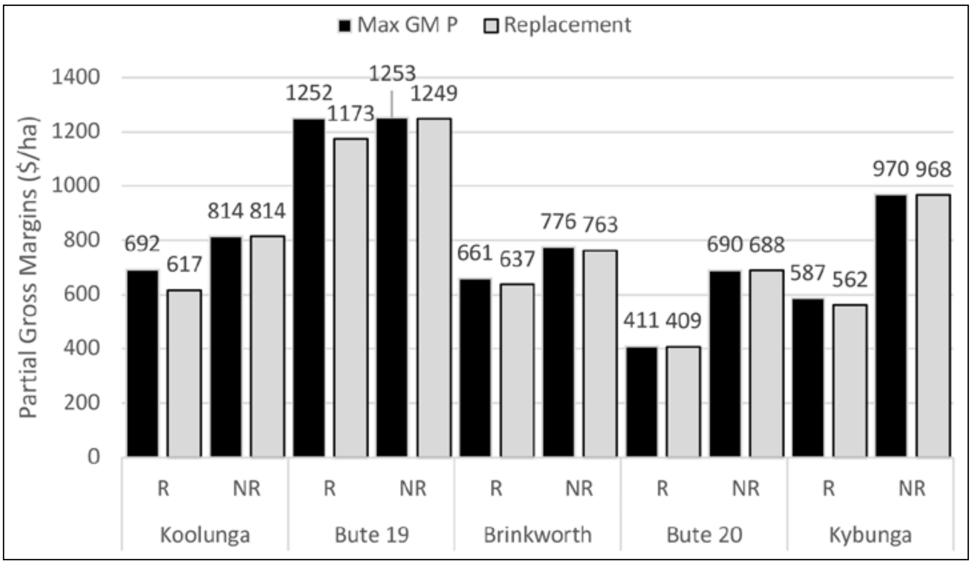

Figure 1. Comparison of partial gross margins if P response was optimised with identification of responsive sites (R (sites merged)) compared to partial gross margins obtained if replacement P rates were used for each paddock. Corresponding analysis for non-responsive sites (NR).

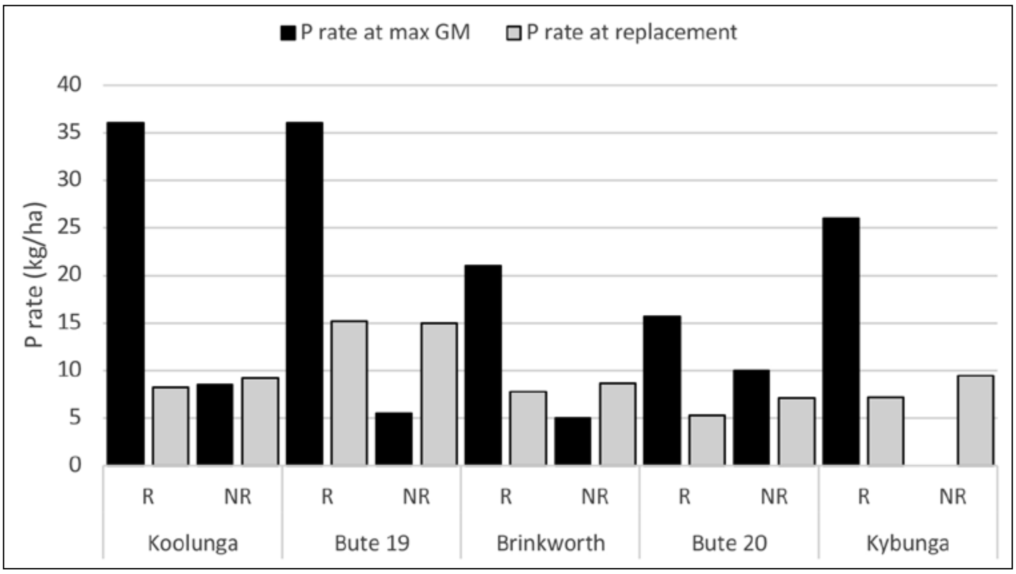

Figure 2. Phosphorus rates obtained at maximum GM for responsive and non-responsive zones in five paddocks compared to replacement P rates at each zone.

of responsive sites at Koolunga and Bute (during the 2019 season, Bute 19) improved partial gross margins (for those soil types) by $75 and $79/ha, respectively over replacement P scenarios (Figure 1). However, benefits of only $24/ha, $2/ha and $25/ha were obtained for Brinkworth, Bute 20 and Kybunga, respectively, highlighting the varying circumstance within each paddock (Figure 1). As expected, Max GM was obtained at near replacement P rates for non-responsive sections of each paddock. In theory, for non-responsive sites Max GM would be obtained at 0kg P/ha. As expected, the P rates which corresponded to Max GM were considerably higher for responsive areas compared to replacement P rates and apart from Bute 20, Max GM P rates were lower than replacement P for non-responsive sites (Figure 2).

The locations of the paddocks analysed in the SAGIT project) were targeted in the Mid North of SA while previous selected P trial work on similar soil zones occurred through the Yorke Peninsula. Through the GRDC investment project (9176604), similar paddock variation has been recorded through the northern Mallee of Victoria, parts of the Wimmera and on the Eyre Peninsula. Validation via the grower scale fertiliser strip treatments has shown very similar variation in P rates to maximise GM which have been associated with high soil pH and PBI, low P availability, and low NDVI. From 213 paddocks sampled in the southern region prior to the 2020 growing season, 51% of paddocks reported lower soil test P and higher PBI values in the low production zone compared to high production zones, as outlined by in-season NDVI and grain yield maps. Overall, 36% of paddocks had soil test values low enough to indicate that their yields would potentially improve from a boost in P input application within these zones.

Variation in grain yields and in-season NDVI images across a paddock can be driven by multiple soil constraints (e.g., acidity, low water holding capacity, high soil strength and poor structure) and climatic interactions. In some instances, production could be improved by targeting P inputs in lower production zones as identified through soil characterisation. It is important to ground-truth yield variability and constraints to production through soil testing and interpretation before moving to replacement P programs.

Conclusion

Phosphorus availability is controlled by inherent soil properties and often the variation across a paddock will impact the optimum P input application strategy. Increases in gross margins can be obtained by identifying zones that express high PBI, high soil pH, low early biomass, and low plant P tissue contents and increasing the P rates accordingly. In SA these poor zones within a paddock are often associated with high pH and calcium carbonate content. These zones can change quite quickly over a landscape within 100-200m. Classifying zones via soil analysis and characterisation will build confidence that current P management practice is providing maximum returns.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support. We would also like to acknowledge the growers involved in SAGIT funded project TC219 for allowing multiple trial sites within one paddock.

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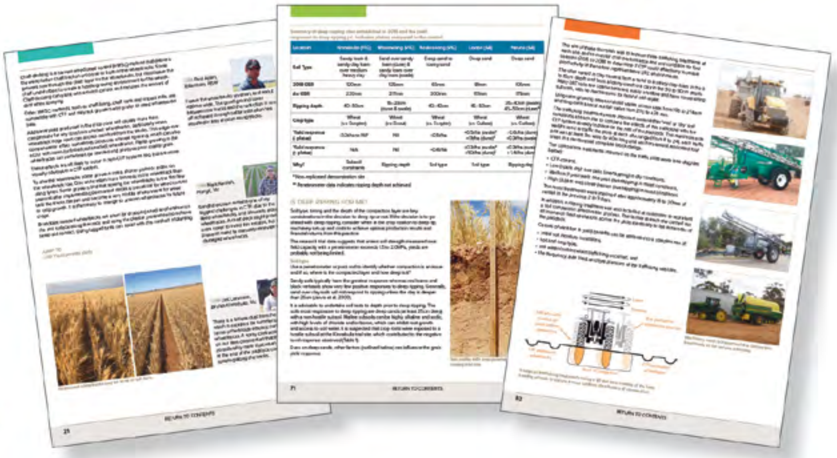

Low rainfall pulse production with - one pulse does not fit all

Sarah Day*[1,2]*, Penny Roberts*[1,2] *and Amy Gutsche*[3]*.

[1]*SARDI, Clare;* [2]*University of Adelaide;* [3]*SARDI, Pt Lincoln.*

GRDC project code: DAS00162A, DAV00150

Keywords

- Break crop, legume, farming system, rotation, variety, disease, time of sowing.

Take home messages

- PBA Samira⁽ᵇ⁾ faba bean, Volga vetch, PBA Bolt⁽ᵇ⁾ lentil, PBA Hallmark XT⁽ᵇ⁾ lentil, PBA Butler⁽ᵇ⁾ field pea, and PBA Wharton⁽ᵇ⁾ field pea have shown improved crop performance in low rainfall environments compared to other varieties of their respective crop species.
- It is important to follow an integrated disease management approach, select varieties with disease resistance, monitor pulse crops for disease infection and apply foliar fungicides at the first sign of disease prior to rain.
- Faba bean and chickpea show a consistent trend in response to time of sowing – this information allows growers flexibility in their seeding program. The grain yield response in lentil to time of sowing is complex, with location and environmental limiting factors having an impact on the yield response.
- Pulse-oilseed intercropping has the potential to increase both productivity and gross margin return in low rainfall environments of South Australia.

Background

Grain producers have become more proficient aPulse crop production has expanded into the low rainfall cropping regions of South Australia in the last decade, as adoption of direct drilling and continuous cereal cropping has increased the need to include break crops. The production shift also reflects recent high grain prices for some pulse crops and the developments in pulse breeding, particularly the introduction of varieties with improved herbicide tolerance characteristics and those better adapted to low rainfall environments. Faba bean, chickpea, lentil, vetch and lupin production in the low rainfall zone has increased since 2012, with the largest increases in area sown to chickpea, lentil and vetch (Figure 1). Field pea is the only pulse that has seen a reduction in production area, with this in part due to the disease risk for field pea and higher grain prices for alternative pulse options. The western and eastern Eyre Peninsula regions have seen a decrease in field pea production, while production of vetch and lentil has increased (Figure 2). Whilst growers in low rainfall regions have increased their production area to pulses, the challenge of best management strategies for resource and economic efficiency remains.

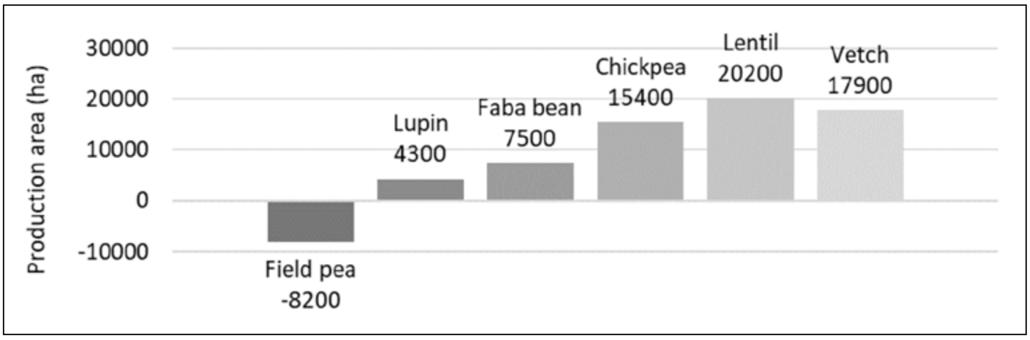

Figure 1. Change in total production area (ha) of pulse crops in the South Australian low rainfall regions (western Eyre Peninsula, eastern Eyre Peninsula, Upper North, Lower Murray, Murray Mallee), shows an increase in lentil, chickpea and vetch production, 2012 to 2020 (PIRSA 2012-2020).

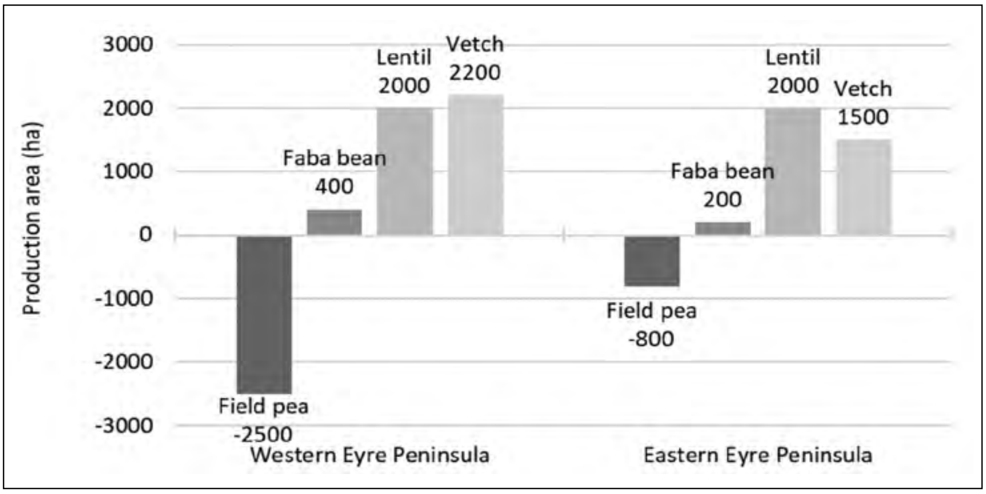

Figure 2. Western and eastern Eyre Peninsula regions have seen a reduction in the area (ha) sown to field pea and increases in area of lentil and vetch, 2012 to 2020 (PIRSA 2012-2020).

The majority of pulse management strategies, including plant densities, fertiliser rates, disease and weed options have been developed based on production in the medium and high rainfall zones. Strategies developed in these environments are often not viable or economical for growers in low rainfall regions. To improve grower confidence in increasing pulse production within the low rainfall region there is a need for pulse management strategies developed specifically for low rainfall environments. In particular, novel approaches and management strategies to reduce or diversify economic risk, as well as strategies to reduce input costs without compromising production potential are needed.

This paper highlights research findings in low to medium rainfall environments in South Australia, 2015-2020, including variety selection and time of sowing. A comparison between vetch and lentil production potential and optimum seeding rate is also discussed, in view of the expansion of these two crops and an increased interest in the potential of lentil production for grazing or hay.

Results and discussion

Crop adaptation and variety selection

Lentil

PBA Hallmark XT⦶ and PBA Bolt⦶, with improved tolerance to boron and salt over other lentil varieties, have shown improved adaptation in low rainfall environments (Day, Oakey et al. 2019). PBA Bolt⦶ offers early to mid-flowering and maturity, lodging resistance, improved boron and salt tolerance, and high grain yield in drought years and dry areas. PBA Hallmark XT⦶, progeny of PBA Bolt⦶ crossed with PBA Herald XT⦶, offers improved herbicide tolerance to conventional lentil varieties, and would be well suited to areas or seasons where Group B herbicide residues are an issue. PBA Jumbo2⦶ is the highest yielding red lentil variety in South Australia and would be a good fit in farming systems free of herbicide residues and soil constraints. New lentil variety releases may have improved adaptation in these environments compared to the former varieties, however evaluation has been somewhat limited. PBA Highland XTⓓ is a medium seed size red lentil with improved herbicide tolerance and is showing adaptation to drier lentil-growing regions of the Victorian Mallee and South Australia.

Common vetch

Early maturing vetch variety Volga has high grain and biomass yield potential and has proven to be a top performing vetch variety across low rainfall environments. Studenica is a new white flowering common vetch variety that has been bred for low rainfall areas and is particularly well suited to short seasons (Nagel, Kirby et al. 2021). Studenica can play a key role in a mixed farming system by offering early feed to fill the winter feed gap.

Faba bean

PBA Samiraⓓ has performed better than PBA Bendocⓓ for grain and biomass yield across low rainfall environments. When sown in May, production from PBA Samiraⓓ is similar, or better than, PBA Marneⓓ, a low rainfall or short season adapted variety. However, when sown early, PBA Marneⓓ and PBA Bendocⓓ show better adaptation than PBA Samiraⓓ.

Field pea

Conventional field pea varieties have high biomass production potential and are better suited to alternative end-uses to grain production. However, conventional field pea types have not offered improved biomass production over semi-leafless varieties in low rainfall environments (Day, Oakey et al. 2019). Additionally, conventional type field pea, such as PBA Percyⓓ, are more susceptible to lodging, therefore, semi-leafless varieties may be a more suitable option regardless of target end use. PBA Butlerⓓ, PBA Twilightⓓ and PBA Whartonⓓ have been the higher yielding field pea varieties in low rainfall environments (Day, Oakey et al. 2019).

Chickpea

Desi chickpea variety PBA Strikerⓓ recorded higher grain yield across low rainfall environments compared to kabuli varieties. Desi chickpea is generally earlier maturing than kabuli chickpea and may be better suited to short seasons and low rainfall environments. Newer chickpea variety releases may have improved adaptation to the low rainfall zone, however evaluation has been limited in these environments. PBA Royalⓓ is an early to mid-flowering kabuli chickpea that is well adapted to the medium-rainfall chickpea growing regions of south-eastern Australia (greater than 1.5 t/ha).

Time of sowing

Lentil

The grain yield response in lentil to time of sowing is complex, with location and environmental limiting factors having an impact on the yield response. The broad range of agronomic characteristics in commercial lentil varieties compared to other pulses in southern Australia contributes to this complexity. An understanding of the differences in the agronomic characteristics and how they interact with the environment and potential constraints is important for variety selection. In general, early sowing is beneficial, with the newer varieties better adapted to early sowing than traditional varieties such as Nugget (Roberts, Walela et al. 2019). However, constraints including weeds, disease, high biomass, and frost during reproductive phases will reduce the benefits of early sowing. Mixed responses to time of sowing were observed on the Eyre Peninsula in 2020 (Figure 3 & 4). At Wudinna, grain yield of PBA Boltⓓ increased by 81% from early sowing on 31 March compared to 7 May, however, PBA Jumbo2ⓓ and PBA Highland XTⓓ did not benefit from early sowing. Early sowing of lentil on 2 April did not alter grain yield compared to sowing on 6 May at Tooligie in 2020, likely due to frost events during reproductive growth stages.

Faba bean

There is a consistent positive yield response to early sowing for faba bean in the medium rainfall zone, providing there is an early season break and adequate soil moisture. Some varieties, including Nura and PBA Samiraⓓ, showed greater yield stability across all times of sowing (Roberts, Walela et al. 2019). Therefore, if later sowing times are required to fit into the seeding program, these varieties would be better options than PBA Bendocⓓ. Similar responses were observed at two sites on the Eyre Peninsula in 2020 (Figure 3 & 4). At Tooligie, a yield increase of between 36 and 78% was achieved from early sowing, while an increase of 32-193% from early sowing was observed at Wudinna, with the greatest response for PBA Bendocⓓ and PBA Marneⓓ (Gutsche, Roberts et al. 2021). Where an early season break did not occur, and soil moisture levels were low at the early sowing time there was no yield advantage as the faba beans were unable to establish early (data not shown).

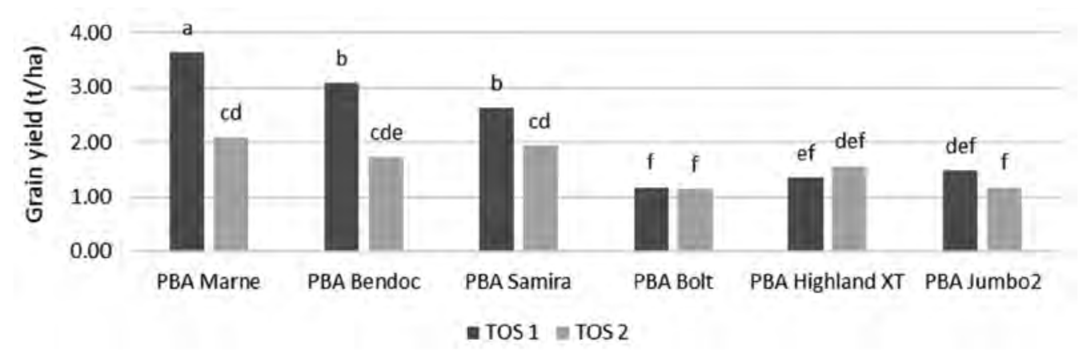

Figure 3. Grain yield (t/ha) of faba bean and lentil varieties sown over two times of sowing (ToS 1 = 2 April, ToS 2 = 6 May,) at Tooligie, 2020. Bars labelled with the same letters are not significantly different (P<0.05). 10 mm of supplementary irrigation was provided via dripper irrigation in-furrow immediately post -April sowing and pre-May sowing within a couple of days to simulate a singular rainfall event.

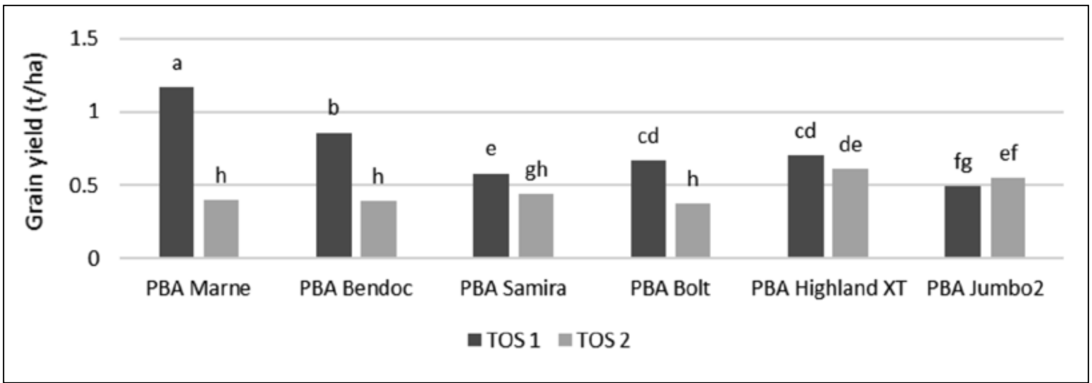

Figure 4. Grain yield (t/ha) of faba bean and lentil varieties sown over two times of sowing (ToS 1 = 31 March, ToS 2 = 7 May) at Wudinna, 2020. Bars labelled with the same letters are not significantly different (P<0.05). 10 mm of supplementary irrigation was provided via dripper irrigation in-furrow immediately post -April sowing and pre-May sowing within a couple of days to simulate a singular rainfall event.

Vetch

Time of sowing for vetch is dependent on the target end-use. Early sowing is vital for grazing and green or brown manure, to allow the crop to establish early while the soil is warm (Nagel, Kirby et al. 2021). Time of sowing for hay production is dictated by when the cutting and drying window will occur for the specific variety, while early canopy closure is important to out-compete weeds. Variety response to time of sowing was varied due to differences in phenology characteristics (Figure 5 & 6). Very early maturing vetch variety Studenica benefitted from later sowing, as sowing too early exposed early pods to cold and frosty temperatures, while late maturing variety Morava benefitted from early sowing. Volga showed the greatest stability in production across time of sowing, however sowing early was not beneficial to early biomass production in this variety (data not shown).

Field pea

Sowing field pea early can increase the exposure to blackspot spores over a longer period and increase vegetative growth leading to increased risk of leaf disease resulting in yield loss. Sowing early also exposes flowers and early pods to frosty conditions, and just one frost event is enough to significantly reduce grain yield, as seen at Eudunda in 2020, where early sowing reduced field pea grain yield by 15-28% (Figure 6). Hence, field pea is better suited to May sowing, to reduce disease risk and avoid pod development during cold temperatures.

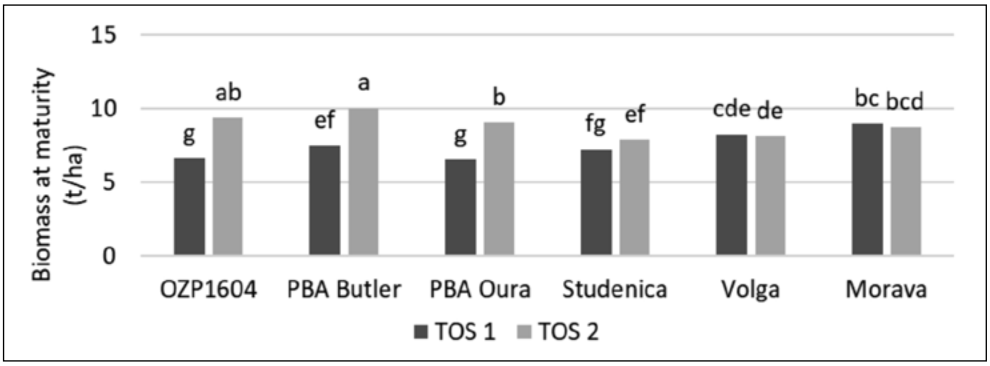

Figure 5. Biomass production (t/ha) of field pea and vetch varieties with varying phenology characteristics sown across two times of sowing (ToS 1 = 2 April, ToS 2 = 4 May), Eudunda 2020. Bars labelled with the same letters are not significantly different (P<0.05). 20 mm of supplementary irrigation was provided via dripper irrigation in-furrow immediately post -April sowing and pre-May sowing within a couple of days to simulate a singular rainfall event.

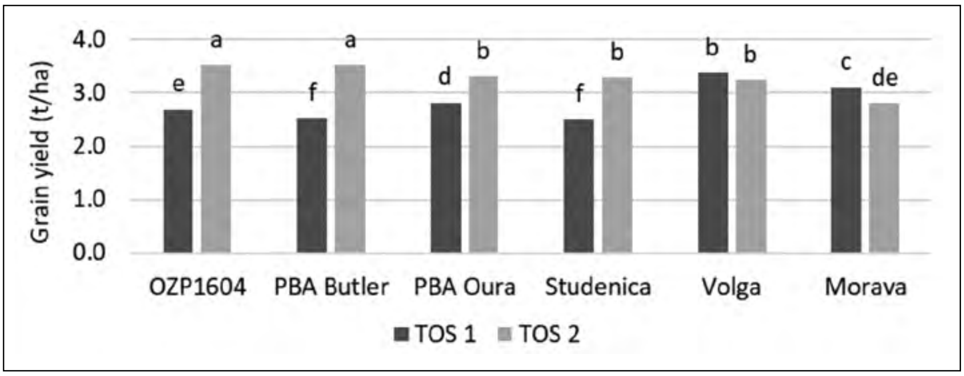

Figure 6. Grain yield (t/ha) of field pea and vetch varieties with varying phenology characteristics sown across two times of sowing (ToS 1 = 2 April, ToS 2 = 4 May), Eudunda 2020. Bars labelled with the same letters are not significantly different (P<0.05). 20 mm of supplementary irrigation was provided via dripper irrigation in-furrow immediately post -April sowing and pre-May sowing within a couple of days to simulate a singular rainfall event.

Disease management

Lentil

Lentil crops should be monitored for Ascochyta Blight (AB), as well as Botrytis Grey Mould (BGM) in higher rainfall seasons or where crops have large canopies. Growers should monitor lentil crops for disease infection and plan to spray infected crops ahead of rain fronts during podding to protect the developing seed. Fungicides may be required in wet springs to control BGM. There are lentil varieties with high disease resistance ratings (e.g. PBA Jumbo2) that can be utilised to reduce the need for fungicide applications without compromising yield potential.

Vetch

An integrated disease management program is very important for vetch production as there are few fungicides registered for use in this crop. Some of these registered fungicides have long withholding periods, and therefore, should be avoided if the vetch crop is being cut for silage or hay destined for the dairy industry (GRDC 2018). It is important to consider the ability to control AB in vetch, as well as BGM and rust in higher rainfall seasons or where crops grow large quantities of biomass. There are fungicides registered for the control of BGM but the need for multiple sprays in conducive seasons may not be economical (Davidson and Noack 2018). Grazing vetch will open up the canopy allowing it to dry out and prevent disease infection. Rust can impact vetch growth and yield and it is very important not to graze or cut infected vetch crops for hay or silage as it can induce abortions in pregnant stock (Davidson and Noack 2018, GRDC 2018).

Field pea

For field pea, the control of blackspot with fungicides is not economically viable where grain production is less than 1.5t/ha. Where grain production potential is greater than 1.5t/ha, newer fungicide options have been effective in reducing disease and improving grain yield in early sown crops and high disease situations (Walela, Roberts et al. 2018). Blackspot can be reduced using a fungicide strategy of P-Pickel T® seed dressing combined with two foliar fungicide sprays (four to nine weeks post sowing and again at early flowering). In seasons where disease infects a crop that is unlikely to achieve 1.5 t/ha grain yield potential, growers should consider crop salvage options, such as grazing, that may improve economic outcomes. Predictions of blackspot risk and spore release times in each field pea growing district can be obtained through 'Blackspot Manager' online (https://agric.wa.gov.au/n/7658).

Faba bean

Faba bean crops need to be monitored for AB and chocolate spot (CS) as well as rust. Growers should monitor faba bean crops for AB infection and plan to spray infected crops ahead of rain fronts during podding to protect the developing seed. There are faba bean varieties with high AB resistance (e.g., PBA Samira⚖) that reduce the need for fungicide applications. Flowers are particularly susceptible to CS and fungicides may be required during wet springs to protect against this disease. Growers should monitor crops for rust and spray at the first sign of disease.

Chickpea

In recent years high levels of AB infection have been found in chickpea crops across South Australia, even in lower rainfall environments. This has seen a reduction in resistance ratings in commercial varieties, leading to all varieties being rated as either susceptible or moderately susceptible. Growers need to carefully consider their risk of AB infection and their ability to effectively control the disease prior to making the decision to grow chickpea in the southern region. It is essential that all chickpea seed is treated with a thiram-based fungicide seed dressing to prevent early infection on seedlings, as the disease will survive on stubble and organic matter for numerous years. It is important to monitor crops for signs of infection and apply fungicides ahead of rain, particularly during reproductive growth stages, to protect developing seeds.

Lentil vs. vetch – reducing inputs and diversifying production

With a reduction in area sown to field pea in South Australia, growers are choosing to grow vetch, a versatile break crop, and are considering the potential of other pulse break crop options for alternative end uses. There are many unfavourable aspects of vetch production, including poor early weed competition, limited herbicide options, hard seediness of some varieties, poor harvestability and market access. Using lentil for grazing or hay is growing in interest among low rainfall growers, which initiated research trials comparing biomass and grain production of vetch and lentil sown at multiple seeding rates, at four trials sites in 2020. The seeding rates compared recommended target plant density (120 plants/m^2 for lentil and 60 plants/m^2 for vetch) with a target density of half and three-quarters of the recommended rate, to assess whether input costs could be reduced without compromising production potential. Higher than recommended rates were not included, as high plant density crops increase the risk of disease infection and lodging and reduce the resource efficiency due to larger canopies. At three of the four sites seeding rate could be reduced by a quarter without compromising biomass or grain production in 2020 (Table 1). Reducing the seeding rate further to half of the target density did reduce production at some sites. A seeding rate that is too low exposes the crop to aphid infestation and weed establishment and the crop is more difficult to harvest. Previous preliminary trials on seeding rate in lentil at Melton, and vetch at Willowie, support these findings that seeding rate can be reduced (to a point) without compromising production under some seasonal conditions.

Table 1. Biomass and grain production (t/ha) responses to multiple seeding rates of lentil and vetch at four sites, 2020. LSD = least significant difference (P<0.05). n.s. = not significant (>0.05)

Seeding rate	Eudunda		Booleroo		Kimba		Stokes	
	Biomass yield	Grain yield	Biomass yield	Grain yield	Biomass yield	Grain yield	Biomass yield	Grain yield
Recommended	5.2	3.0	5.2	2.6	1.7	0.8	2.6	1.7
Three-quarter	4.8	3.0	4.8	2.7	1.6	0.7	2.2	1.6
Half	4.4	2.8	4.5	2.6	1.5	0.7	2.0	1.5
LSD (P<0.05)	*0.5*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*0.36*	*n.s.*

Table 2. Frequency of break crop trials where vetch biomass and grain production and profit from grain production was equal, greater than, or less than lentil, 2017-2020.				
	Biomass	Grain	Profit (grain)	TOTAL
Lentil ≥ Vetch	7	10	9	26
Lentil < vetch	7	4	1	12

Table 3. Feed analysis results of lentil and vetch cut for hay at early pod development growth stage.		
	Lentil	Vetch
Crude Protein (% of dry matter)	19.2	21.2
Digestibility (% of dry matter)	77.6	78.2
Metabolisable Energy (MJ/kg dry matter) 11.7	11.8	

Where vetch is not favoured as a break crop, lentil can be a versatile option. Lentil hay could be cut to salvage a financial return where the crop is severely affected by frost, heat, or drought. For the 15 break crop trials in the southern region, lentil was better than or equal to vetch (vetch = lentil) for biomass production in 7 trials, for grain production in 10 trials and for profit in 9 trials (Table 2). Lentil production and profit was greater than vetch at two sites and in these cases, crops were affected by frost or dry spring seasonal conditions. Lentil can be utilised as a lower risk and versatile crop option as an alternative to vetch, with greater market access for lentil grain and increased interest in lentil hay. Feed analysis shows minimal difference in the feed quality of lentil and vetch hay (Table 3), and in recent years lentil crops have been profitable where hay was cut due to severe frost damage.

Intercropping

Pulse-oilseed intercropping is a system that is shown to provide production and sustainability benefits in low rainfall cropping systems (Roberts and Day 2021). From seven field trials in four years productivity gains (measured using Land Equivalent Ratio) of up to 40% were achieved, 40-50% of the time where chickpea, lentil and vetch were intercropped with canola compared to growing the crops as monocultures (Roberts, unpublished). Gross margin returns for intercrops with canola were generally similar or more favourable than the sole crops for field pea, chickpea, and lentil. The additional complexity of intercropping systems includes logistical challenges during sowing, harvest, handling, and grain storage. With careful planning considering species mix, variety selection, logistics of seeding, weed control, and harvest, these systems can be successfully adopted to a broadacre scale as demonstrated by grower adoption of intercropping in Australia.

Conclusion

The decision to grow a break crop is generally done with a whole systems approach, as break crops can be utilised to address the issues and constraints that arise from continuously cropping cereals. The choice of break crop is dependent on a number of factors: crop end-use, fit into the sowing program and farming system, financial risk, paddock selection, and soil type.

The ability to control foliar disease in pulse crops needs to be carefully considered prior to growing these crops and an integrated approach is essential. For disease management it is important to follow recommendations on seed and paddock hygiene, select varieties with improved disease resistance where possible, monitor paddocks for disease infection and apply fungicides at first sign of disease prior to rain fronts.

The results from time of sowing trials gives growers more confidence in deciding when to sow each pulse crop, and variety selection to suit their individual seeding program.

Acknowledgements

The research undertaken as part of these projects (DAS00162A and DAV00150) is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

Useful resources

https://grdc.com.au/NVT-south-australian-crop-sowing-guide

https://grdc.com.au/resources-and-publications/grownotes

https://agric.wa.gov.au/n/7658

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SPRAY APPLICATION GROWNOTES™ MANUAL

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

The Spray Application GrowNotes™ Manual is a comprehensive digital publication containing all the information a spray operator needs to know when it comes to using spray application technology.

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CHAIR - JOHN BENNETT

Lawloit, VIC

Based at Lawloit, between Nhill and Kaniva in Victoria's West Wimmera, John and his family run a mixed farming operation across diverse soil types. The farming system is 70 to 80 per cent cropping, with cereals, oilseeds, legumes and hay grown. He wants to see RD&E investments promote resilient and sustainable farming systems that deliver more profit to growers and ultimately make agriculture an exciting career path for young people.

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DEPUTY CHAIR - KATE WILSON

Hopetoun, VIC

Kate is a partner in a large grain producing operation in Victoria's Southern Mallee region and produces wheat, canola, lentils, lupins and field peas. Kate has been an agronomic consultant for more than 20 years servicing the Mallee and northern Wimmera. Kate is passionate about producing high quality grain, whilst enhancing the natural ability of the soil. Kate is passionate about research and the extension of that research to bring about positive practice change to growers.

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ANDREW RUSSELL

Rutherglen, VIC

Andrew is Managing Director and a shareholder of Lilliput AG, and a Director and shareholder of the affiliated Baker Seed Co, a family-owned farming and seed cleaning business. He manages a 2500ha mixed cropping enterprise south of Rutherglen. Lilliput AG produces wheat, canola, lupin, faba bean, triticale, oats and sub clover for seed and hay. Andrew served on the GRDC's medium rainfall zone RCSN (now National Grower Network) and has held many leadership roles. He holds a Diploma of Rural Business Management and an Advanced Diploma of Agriculture.

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JON MIDWOOD

Inverleigh, VIC

Jon has worked in agriculture for the past three decades, both in the UK and in Australia. He has managed Grainsearch, a grower-funded company evaluating European wheat and barley varieties for the high rainfall zone, and his consultancy managed the commercial contract trials for Southern Farming Systems (SFS). Jon was a member of the GRDC's HRZ (RCSN (now National Grower Network) and became a GRDC Southern Panel member in 2015. In 2020 Jon set up an independent consultancy, TechnCrop Services.

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LOU FLOHR

Lameroo, SA

Lou is a farmer based at Lameroo in the Southern Mallee of South Australia. With her parents and partner, she runs a mixed farming enterprise which includes export oaten hay, wheat, barley, a variety of legumes and a self-replacing Merino flock. Prior to returning to the family farm, Lou had a 10-year agronomy career, servicing the Upper South East and Mallee. She is passionate about her industry, particularly in recognising the role that women play in the industry and on the land.

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ANDREW WARE

Port Lincoln, SA

Andrew is a research agronomist, based at Port Lincoln on SA's Eyre Peninsula. He started his career with the South Australian Research and Development Institute (SARDI) at the Minnipa Agriculture Centre, and then spent time at CSIRO in Adelaide. Andrew managed the family farm on Lower Eyre Peninsula for 10 years before returning to SARDI in late 2009. In 2019, Andrew started his own research company EPAG Research, delivering applied research across Eyre Peninsula. Andrew received the GRDC Southern Panel's Emerging Leader award in 2018, and prior to joining the Panel he served on the GRDC's low rainfall zone RCSN (now National Grower Network).

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PRU COOK

Dimboola, VIC

Pru was raised on a mixed farm at Diapur in Victoria's Wimmera region. She has worked at the Victorian Department of Primary Industries and GRDC, where she implemented GRDC's first social media strategy. She then worked at Birchip Cropping Group, managing and supporting extension projects. She has recently started her own business focusing on extension, project development and management.

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MICHAEL TRELOAR

Cummins, SA

Michael is a third-generation grain grower based at Cummins on South Australia's Eyre Peninsula, where he grows wheat, barley, canola, beans, lupins and lentils on a range of soil types. He has been involved in the South Australian Grains Industry Trust, the Lower Eyre Agricultural Development Association and the South Australian No Till Farmers Association. He believes research and development underpins profitability in Australian farming systems and the GRDC is pivotal in delivering research outcomes that support growers.

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MICHELLE WATT

Melbourne, VIC

In February 2020 Professor Michelle Watt was appointed the Adrienne Clarke Chair of Botany at the University of Melbourne. From 2015 to 2019, she was Director of the Plant Sciences Institute at the Helmholtz Centre and Professor of Crop Root Physiology at the University of Bonn in Germany. Prior to 2015 Michelle was at CSIRO. She has been in multi-partner projects with Australia, the USA, India, the Philippines, UK and Germany in the under-studied but critical area of plant roots. She is President of the International Society of Root Research and Co-Chair of the Root Phenotyping.

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DR NICOLE JENSEN

Canberra, ACT

Nicole is general manager of GRDC's Genetic and Enabling Technologies business group. She brings a wealth of experience in digital agriculture, plant breeding and genetics from roles she has held in Australia and internationally in the seed industry.

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SOUTHERN/WESTERN REGION*

PREDICTA® B

KNOW BEFORE YOU SOW

*CENTRAL NSW, SOUTHERN NSW, VICTORIA, TASMANIA, SOUTH AUSTRALIA, WESTERN AUSTRALIA

Cereal root diseases cost grain growers in excess of $200 million annually in lost production. Much of this loss can be prevented.

Using PREDICTA® B soil tests and advice from your local accredited agronomist, these diseases can be detected and managed before losses occur. PREDICTA® B is a DNA-based soil-testing service to assist growers in identifying soil borne diseases that pose a significant risk, before sowing the crop.

Enquire with your local agronomist or visit http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

Potential high-risk paddocks:

- Bare patches, uneven growth, white heads in previous crop
- Paddocks with unexplained poor yield from the previous year
- High frequency of root lesion nematode-susceptible crops, such as chickpeas
- Intolerant cereal varieties grown on stored moisture
- Newly purchased or leased land
- Cereals on cereals
- Cereal following grassy pastures
- Durum crops (crown rot)

There are PREDICTA® B tests for most of the soil-borne diseases of cereals and some pulse crops:

- Crown rot (cereals)
- Rhizoctonia root rot
- Take-all (including oat strain)
- Root lesion nematodes
- Cereal cyst nematode
- Stem nematode
- Blackspot (field peas)
- Yellow leaf spot
- Common root rot
- Pythium clade f
- Charcoal rot
- Ascochyta blight of chickpea
- White grain disorder
- Sclerotinia stem rot

Government of South Australia
Primary Industries and Regions SA

SARDI
South Australian Research and Development Institute

GRDC
Grains Research & Development Corporation

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Acknowledgements

We would like to thank those who have contributed to the successful staging of the Wudinna GRDC Grains Research Update:

- The local GRDC Grains Research Update planning committee that includes growers, advisers and GRDC representatives.
- Partnering Organisation: AIR EP

Prefer to provide your feedback electronically or 'as you go'? The electronic evaluation form can be accessed by typing the URL address below into your internet browsers:

www.surveymonkey.com/r/WudinnaGRU

To make the process as easy as possible, please follow these points:

- Complete the survey on one device
- One person per device
- You can start and stop the survey whenever you choose, **just click 'Next' to save responses before exiting the survey**. For example, after a session you can complete the relevant questions and then re-access the survey following other sessions.

2021 Wudinna GRDC Grains Research Update Evaluation

1. Name [ ]

ORM and/or GRDC has permission to follow me up in regards to post event outcomes

2. How would you describe your main role? *(choose one only)*

- ❑ Grower
- ❑ Agronomic adviser
- ❑ Farm business adviser
- ❑ Financial adviser
- ❑ Communications/extension
- ❑ Grain marketing
- ❑ Farm input/service provider
- ❑ Banking
- ❑ Accountant
- ❑ Researcher
- ❑ Student
- ❑ Other* (please specify)

Your feedback on the presentations

For each presentation you attended, please rate the content relevance and presentation quality on a scale of 0 to 10 by placing a number in the box (**10 = totally satisfactory, 0 = totally unsatisfactory**).

3. Harvest weed seed control - getting the best results: *Chris Davey*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

4. New pre-emergent herbicides - opportunities and challenges: *Chris Preston*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

5. Russian wheat aphid thresholds - insect density, yield impact and control decision making: *Maarten van Helden*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

6. Phosphorus application recommendations based on soil characterised zones – Does it pay? *Sean Mason*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

7. Low rainfall production - one pulse does not fit all: *Sarah Day*

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

☐

Your next steps

8. Please describe at least one new strategy you will undertake as a result of attending this Update event

☐

9. What are the first steps you will take?

e.g. seek further information from a presenter, consider a new resource, talk to my network, start a trial in my business

☐

Your feedback on the Update

10. This Update has increased my awareness and knowledge of the latest in grains research

Strongly agree	Agree	Neither agree nor Disagree	Disagree	Strongly disagree
❑	❑	❑	❑	❑

12. Do you have any comments or suggestions to improve the GRDC Update events?

☐

13. Are there any subjects you would like covered in the next Update?

☐

Thank you for your feedback.