IREC

Irrigation Research & Extension Committee

Irrigation Research Update

Presentation Papers 2023

Optimising Irrigated Grains

Cool Soil Initiative

Southern NSW Innovation Hub
Sustainable Agriculture, Landscapes and Communities

Area-wide Weed Management

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Evaluation

HAVE YOUR SAY

Thank you to all those who attended today's event. If you have any feedback, please complete the 2023 IREC Irrigation Update Evaluation (QR Code).

If you have any further questions for speakers, please contact Iva on 0402 069 643 / iva@Irec.org.au or Monica on 0491 380 399 / irec@irec.org.au and we will forward your questions onto the relevant parties.

AGENDA

IREC Irrigation Research Update

Irrigation Research & Extension Committee

THURSDAY 20 JULY, 8.30AM-3.30PM, GEM HOTEL GRIFFITH

TIME	TOPIC	WHO
8.30am	Registrations Introduction	Monica/Virginia (IREC EM and PO) Iva Quarisa (IREC EO)
9.00-9.25am	Cool Soil Initiative	Dr Cassie Schefe (AgriSci)
9.25-9.45am	Managing Soil Variability CDRC Grassroots Grant	James Kanaley (Consulting Agronomist)
9.45-10.05am	Managing the Carbon Footprint of Irrigation Farm Dams	Dr Jackie Webb (Deakin Uni)
10.10-10.30am	Lessons from the 2022/23 Cotton Season and Looking Forward	Kieran O'Keeffe (CottonInfo)
10.30-10.50am	Estimating Soil Moisture Tension in Cotton	Rodrigo Filev Maia (Deakin Uni)
10.50am-10.55am	Farms of the Future Program Update	Sarah Groat (DPI)
10.55-11.20am	Morning Tea Break	All
11.20am-11.40am	NSW DPI Research Update	David Troldahl (DPI)
11.40-12.40pm	Optimising Irrigated Grains Project and Trials • Disease management & inoculation in irrigated chickpeas & other local trials • Plant growth regulator use in barley and durum to improve harvestability and yield • Key Learnings	 Damian Jones (ICC) Hayden Petty (Summit Ag) Sam O'Rafferty (Summit Ag) Ben Morris (FAR)
12.40-1:00pm	Rice Update	Mark Groat (SunRice)
1-1.40pm	Lunch	All
1.40pm-2.05pm	Overview of Area Wide Management of Weeds (AWM) Project Herbicide resistant weed distribution in the Riverina	Dr Rick Llewellyn (CSIRO) –chair AWM sessions (Iva Quarisa)
2.05-2.25pm	Evidence of weed spread across the MIA (AWM)	Dr James Hereward (Uni of QLD)
2.30pm-2.50pm	Growers' attitudes and practices towards area-wide management of weeds in the Riverina (AWM)	Dr Sonia Graham (University of Wollongong Social Scientist)
2.50-3.05pm	Southern NSW Innovation Hub Update	Rob Martin (Chief Knowledge Broker)
3.05-approx. 3.25pm	Close	

CONTENTS

Irrigation Research & Extension Committee

IREC Research Update

Dr Cassandra Schefe, AgriSci

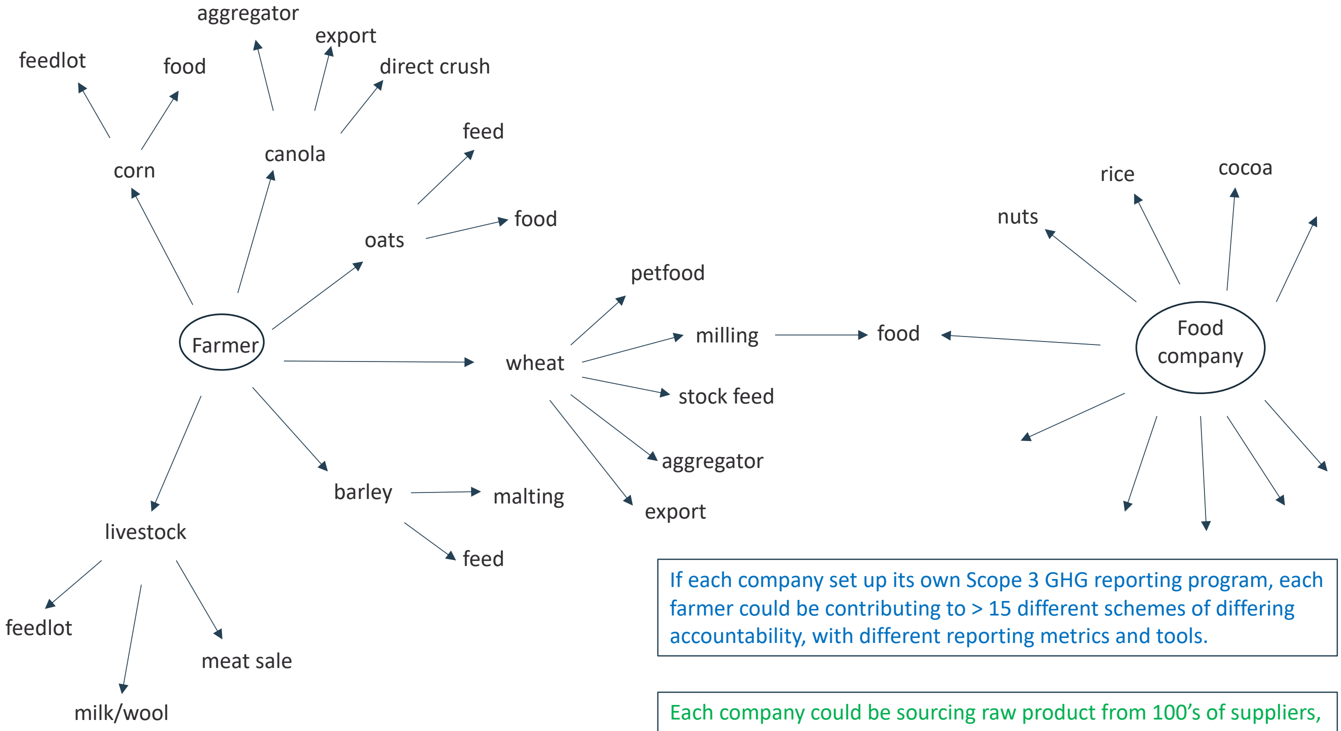
Cool Soil INITIATIVE

Overview – Program Update and relevance:

- What is CSI, and why are companies investing?
- Update of CSI progress and vision
- Cool Farm Alliance update
- Soil test results incl soil carbon
- Emissions
- Future research opportunities

Why are supply chain companies interested in emissions?

- "Scope 3"
- All emissions associated with the production of commodities. For food companies, it is the emissions associated with production of raw ingredients, eg wheat production
- Scope 3 can comprise up to 70-80% of total food footprint.
- This means that even if companies reduce their energy usage in manufacturing facilities, the total emission footprint associated with an end product (eg biscuit) does not drop substantially.
- All publicly listed companies will have increasing requirements for emission / sustainable sourcing reporting. (For a farmer, Scope 3 emissions are the production of fertilisers, pesticides etc)



If each company set up its own Scope 3 GHG reporting program, each farmer could be contributing to > 15 different schemes of differing accountability, with different reporting metrics and tools.

Each company could be sourcing raw product from 100's of suppliers, each potentially with a different GHG footprint accounting system, which they can't align and clearly report against.

Concept of the Cool Soil Initiative (in grains)

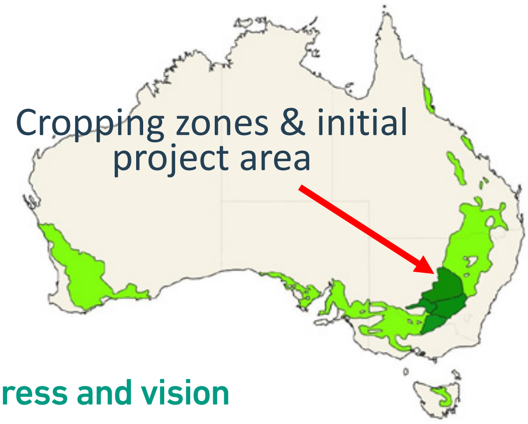
Streamlined farmer data input
&
Engagement & Support for on-farm change
(not a 'tick & flick')

Grain aggregators / millers

Food/beverage processors

End user recognises low on-farm GHG footprint of commodity (consumers/export reporting)
*Global connection

Active engagement & contribution to project success
(Capture *practices*, not just numbers)



Cool Soil Initiative progress and vision

- 2.5 years into the Food Agility CRC investment, ending in September 2023.
- **185** farmers recruited in northern Vic, southern NSW, **4** farmers in Darling Downs with maize.
- Scalable farmer web interface and database being built by external provider, rolled out at present.
- Building alignment in GHG calculation between Cool Farm Tool and Aus national GHG inventory.
- Building visibility of Cool Soil Initiative across Australian grains and related industries (meat, wool, dairy, poultry, pigs).
- Building critical mass in corporate awareness & industry relevance;

"We are all facing the same challenges, we can't solve on our own"

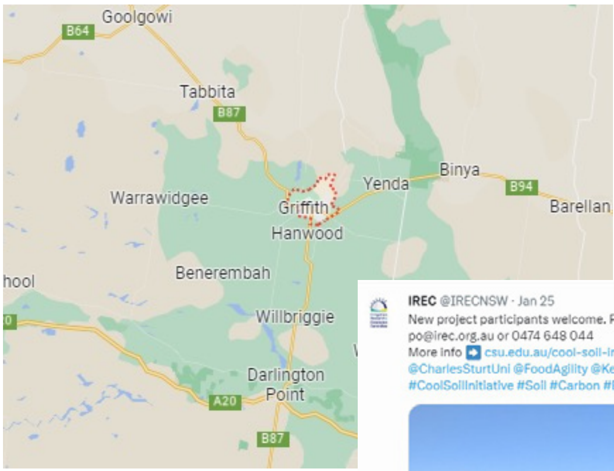
- Cool Soil Initiative 2.0 – Not For Profit entity being developed through CSU to enable continuance and scale (set up by September 2023).

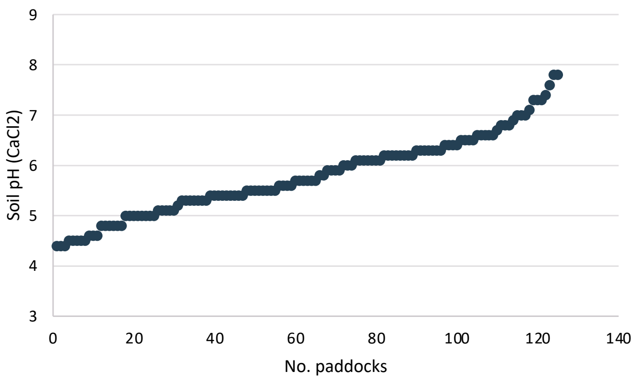
** Unique position as we have 5 years of learnings from doing, not just talking about it! – thanks to the farmers who are working with us.

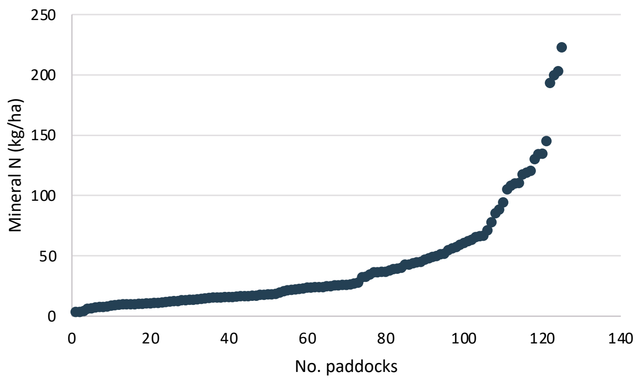
Soft wheat overview and practices

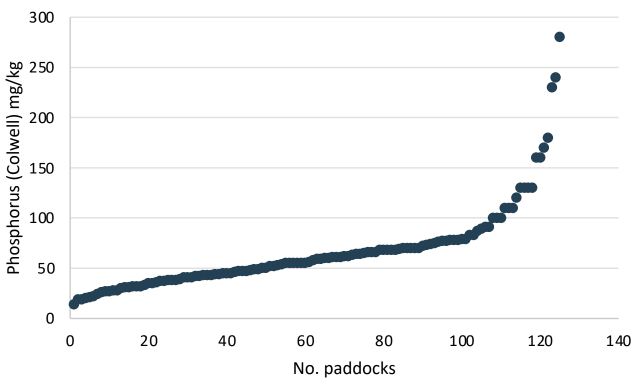
- 10 soft wheat farmers recruited from the MIA, data collected from the 2022 winter season.

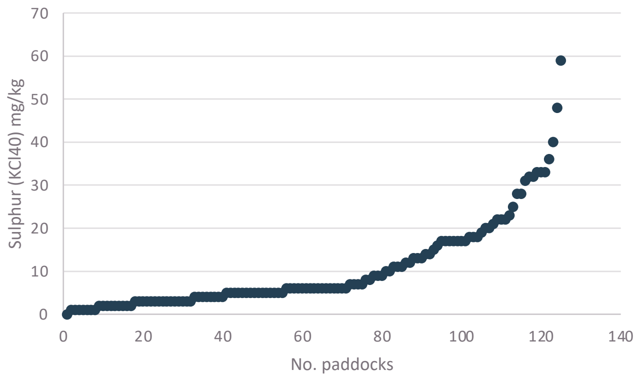
No. paddocks entered:	46
Soft wheat hectares entered:	1,417 ha
Total soft wheat area grown:	2,455 ha
Total farm area represented:	8,766 ha
Soft wheat sold to Allied Pinnacle	4,658 t (59% total tonnes)



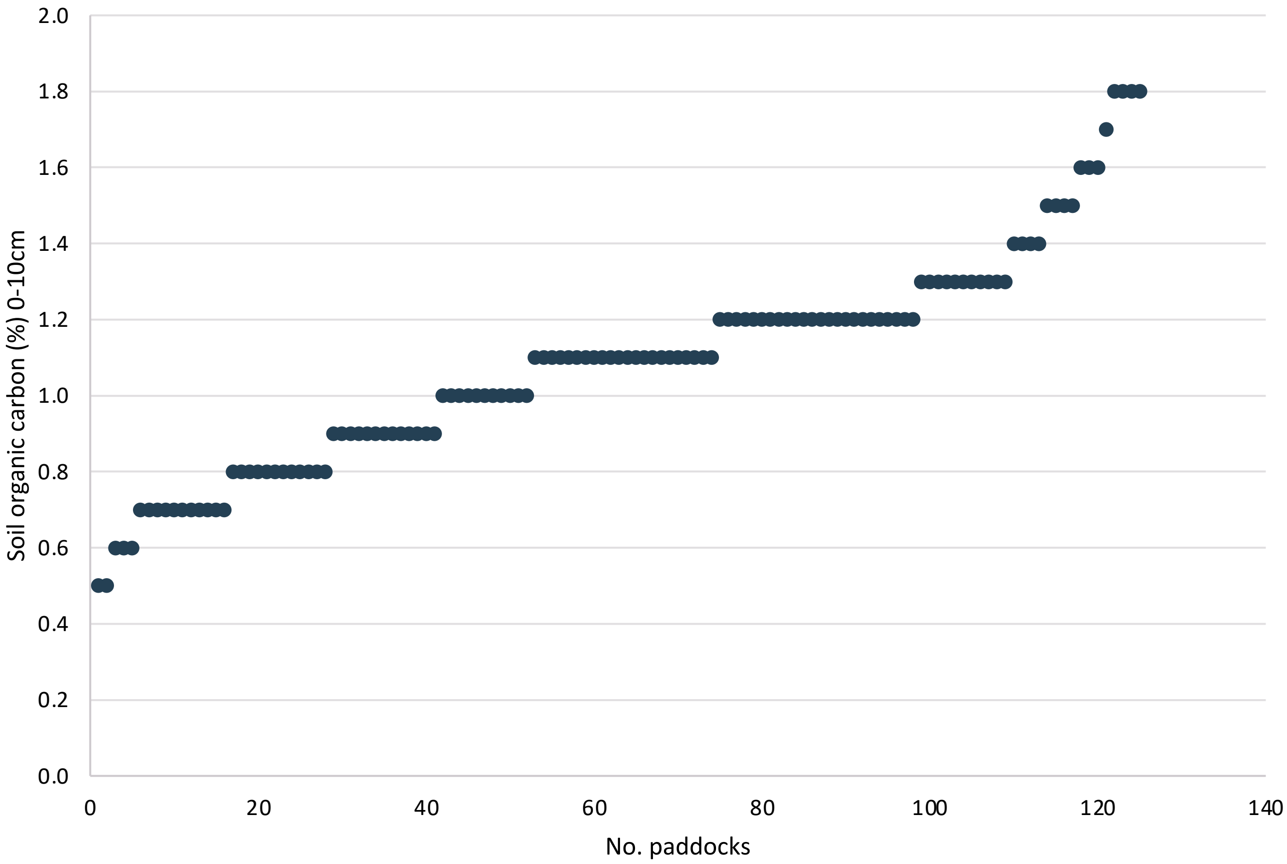








Soil C values



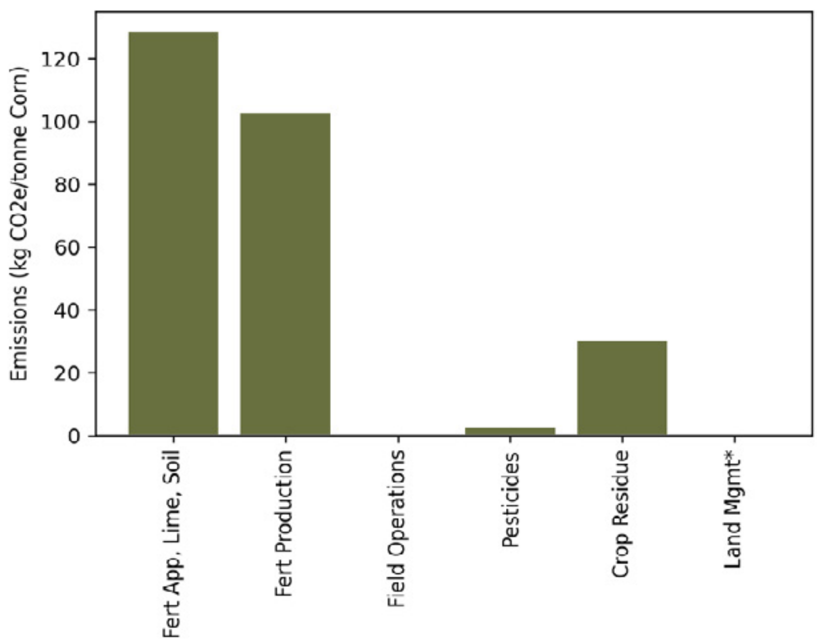
Graphed values at 0-10cm depth

10-20cm depth: Median 0.8%

Range 0.4 – 1.0%

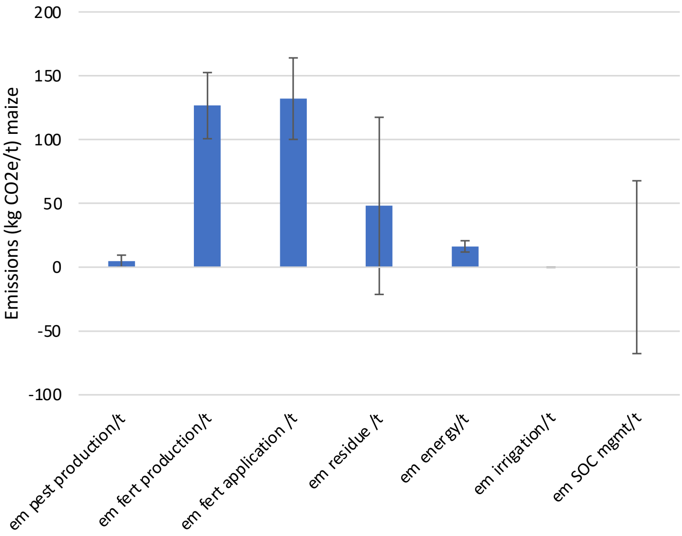
Greater mixing of soil C to 20cm depth in MIA irrigated soils vs dryland min till systems

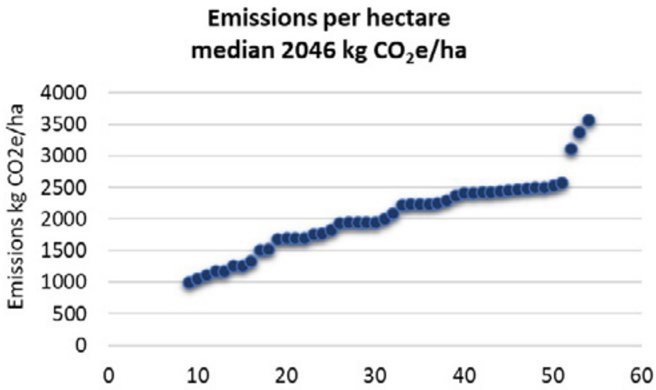
Maize GHG emissions 2021-2022

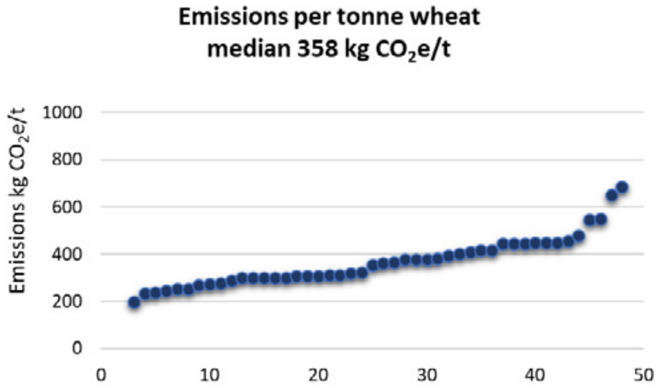


Kg CO_2e/tonne	Kg CO_2e/ha
210	3602

Soft wheat 2022 emissions — IREC







Key farmer comments from 2022:

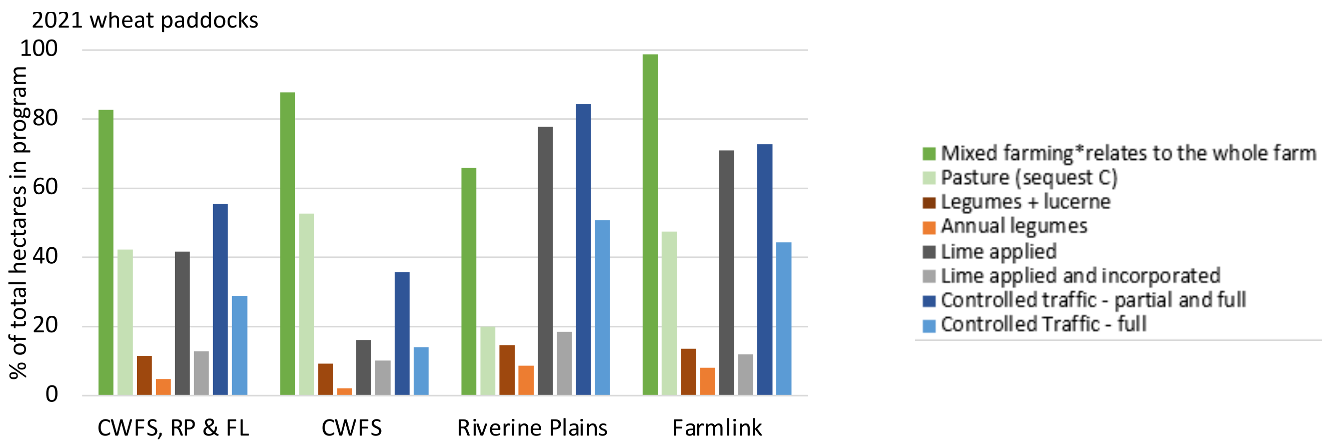
- Very wet, crop affected by waterlogging
- Move to chicken litter
- Need better soil conditioning

Research opportunities

- 'Green' urea (+ nitrification or urease inhibitors) may reduce emission footprint from urea application
    - Likely to have greatest benefit under wet, warm conditions (eg MIA)
    - Building awareness of product, or potential use-case for Green urea in MIA soft wheat
    - In-field research needed to demonstrate release profile of Green urea to provide confidence that N will be released from granule in the window of high plant requirement
- Stubble management – an ongoing issue in high biomass summer crop and rice-growing regions, needs a systems approach.

Learnings from the practice records and support activities

- Data capture provides baseline 'industry' story of current practice, enabling good practice to be recognised (in addition to GHG emissions story)
- Soil pits/paddock walks provide learning opportunities on soils, carbon, emissions, practice, while providing an avenue for farmers to share ideas and novel management.
- 'Innovation paddock program' supports farmers who want to try something new, providing evidence to quantify the value of change (productivity/economics/emissions/carbon)



Summary - What have we learnt over the past 5 years?

- Program started in 2018 – *pre Scope 3* and *ESG*
- While we are working with international standards, further work is needed to make them fit for purpose for Australian conditions.
- International Supply chain – farmer support programs based on ‘pay for practice’, rather than supporting resilient, profitable farming systems
- Farmers are highly motivated to engage. High farmer interest, retention and trust –through providing information, support and data integrity without lock-in contracts.
- Focus on sustainable productivity, with carbon and GHG emissions as the *product* of the system, not a driver - encourages innovation and peer learning
- Recognition of our novel approach:
    - Precompetitive corporate partnerships = integration and alignment of GHG reporting between supply chain players leads to confidence and transparency of GHG accounting
    - Farming groups provide advocacy of farmers, ensuring that project direction is farmer focused.
    - Provides pathway for full connectivity across food and fibre systems
    - Australian relevant, but globally aligned.

Outcome

- Mission: Farmer-focused, scientifically credible, industry relevant
- Vision:
    - Investment across the food and beverage supply chains so that Cool Soil becomes ‘business as usual’ to enable a common language for Scope 3 reporting, while providing the mechanism for farmers to demonstrate best practice
    - Industry-level reporting to export markets, providing evidence of ‘clean & green’ production in Australia
    - Expansion of Cool Soil across sectors and regions

Hear Cassie’s podcast episode here https://pod.co/ontarget/dr-cassandra-schefe

Contact

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Dr Alice Melland – Innovation support & CFT review

Alice.Melland@usq.edu.au

Managing Soil Variability – Coleambally Demo Farm CDRC Grassroots Grant

James Kanaley, Consulting Agronomist

Background

The Murrumbidgee Shire Community Shire Demonstration Farm is run almost entirely by local volunteers. The organisation raises funds for local charities by farming, and then injecting those proceeds back into the community, from upgrading sporting facilities to schools, local health services and community clubs.

Subsequently, the background to this project is to improve the soil on the community farm through attaining funding to do so. Furthermore, we believe these improvements will make a huge difference to the farm's soil health and ensure the community farm can continue to operate in the Coleambally Community in the future.

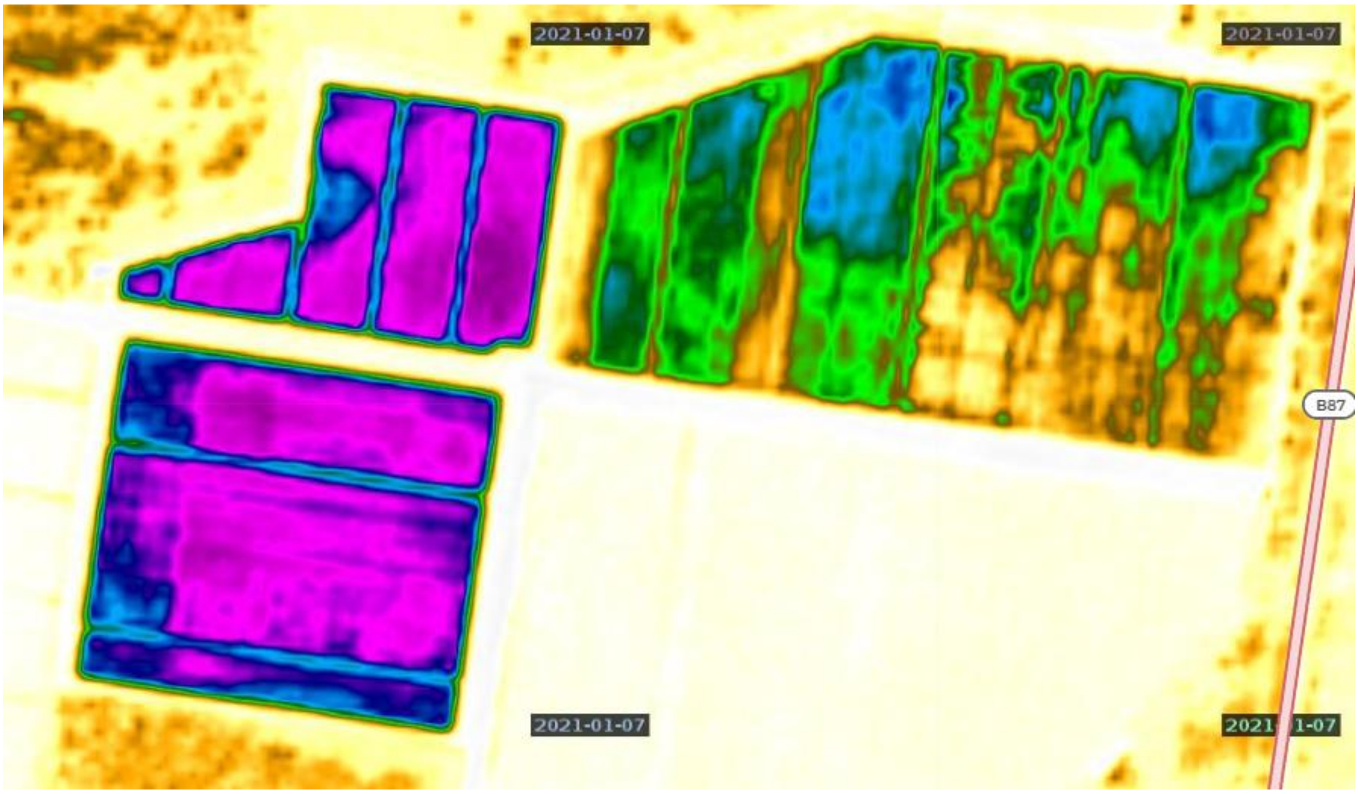

Figure 1 NDVI image showing cotton biomass differences in field and between the 3 fields during the 2020-21 Summer

Objectives

The primary objective of the project is to increase the profitability and longevity of the demonstration farm for the local community. The farm operates with the majority of its work as volunteer labour from community members. Whilst the end goal is financial profitability (to be donated into local charities and groups), the learning experience along the way has an important value to the local farming community as well. Relaying extension to and adoption by growers are a key objective as well.

Cotton is currently planted into 50% of the study area & irrigated bread wheat is planned for the remaining area. We see these objectives taking longer than 12 months of project time to achieve as a typical cotton rotation will cover two years.

Method

The three main fields on the demonstration farm were all fallowed for the 22-23 summer crop season. All three fields were coming out of a cereal rotation which was planted directly behind cotton from the 20-21 summer season. The fields showed significant variability during the cotton rotation, one field in particular was very difficult to establish cotton into, with suspect acidity killing off cotton seedlings.

To assess the soil variability, intensive grid soil sampling was determined as required at a depth of 0-20cm. Precision Agriculture were engaged to provide these services.

The primary soil properties or the "low hanging fruit" targeted with the soil sampling were:

- Exchangeable Sodium Percentage (sodicity)
- pH (acidity)
- Phosphorus (Colwell P)

A number of other soil properties are also sampled but we consider the three above to be key to unlocking soil potential in this area.

EM surveys were also conducted over the three fields to help refine analysing soil variability. They also help to:

- Differentiate soil texture changes (sand/silt/clays)
- Locate and install moisture probe sites
- Define soil testing strategies
- Analyse yield data

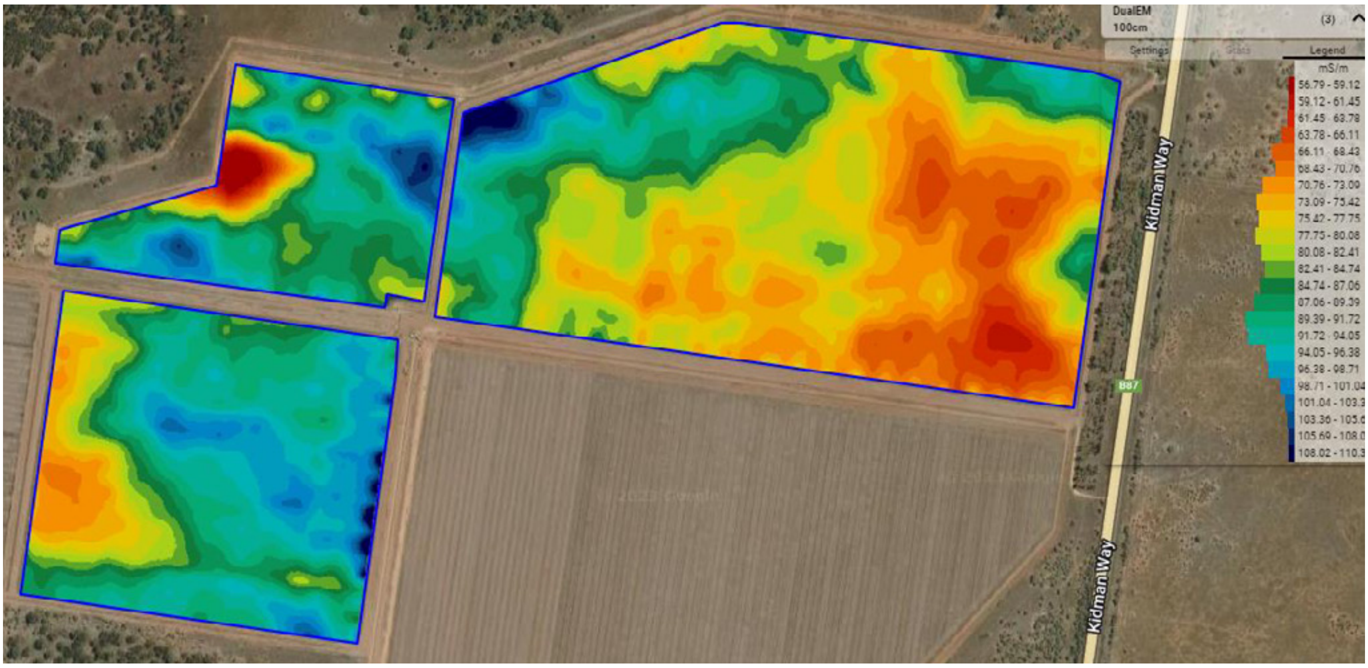

Figure 2 Dual EM Survey - Characterising Soil Variability

Once the grid sample results have been determined, soil amelioration targets can then be done to meet the needs of the crop type, grower budget, severity of the issue. In this instance in the maps below for Field 3, both phosphorus & acidity were found to be our limiting soil constraints.

A Colwell P target of 35 and pH of 5.8 were chosen as our targets, keeping in mind this is over a depth of 20cm where we see our primary tillage depth commonly occurring. Our Variable Rate Application maps are then produced to match the targets required.

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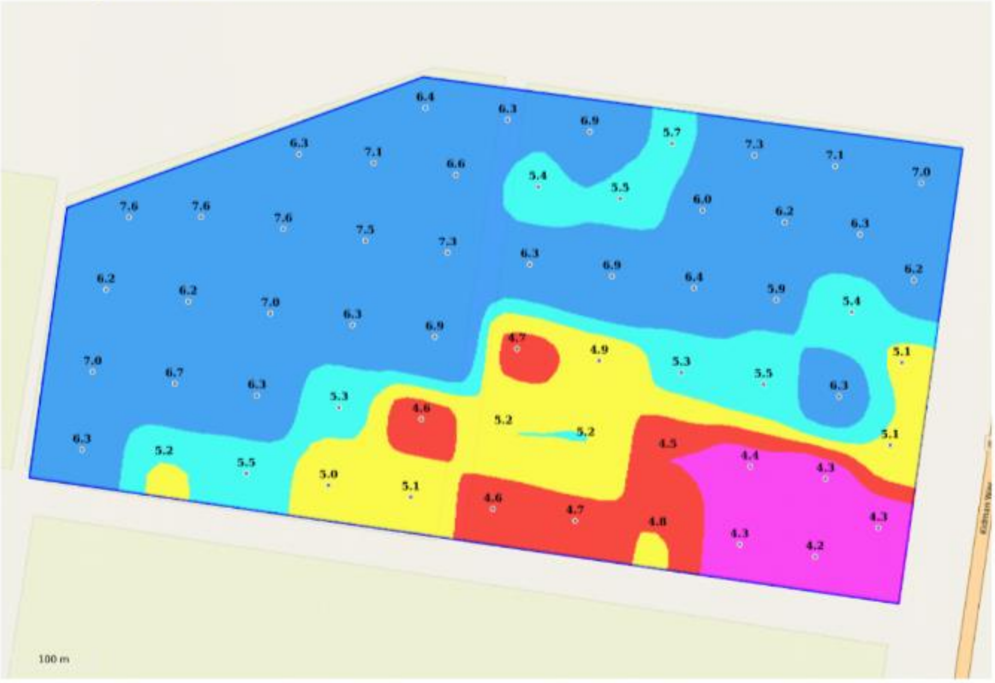
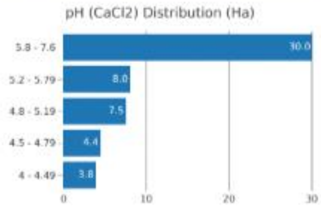
F3: Soil Test

Soil pH (CaCl2)



Client:	Kanaley Ag Consulting
Farm:	Coleambally Demo Farm
Paddock:	F3
Name:	F3
Type:	Soil Test
Date:	25/02/2022
Min:	4.20 pH
Max:	7.60 pH
Avg:	5.89 pH

- Above 5.8 pH
- 5.2 - 5.79 pH
- 4.8 - 5.19 pH
- 4.5 - 4.79 pH
- Below 4.49 pH



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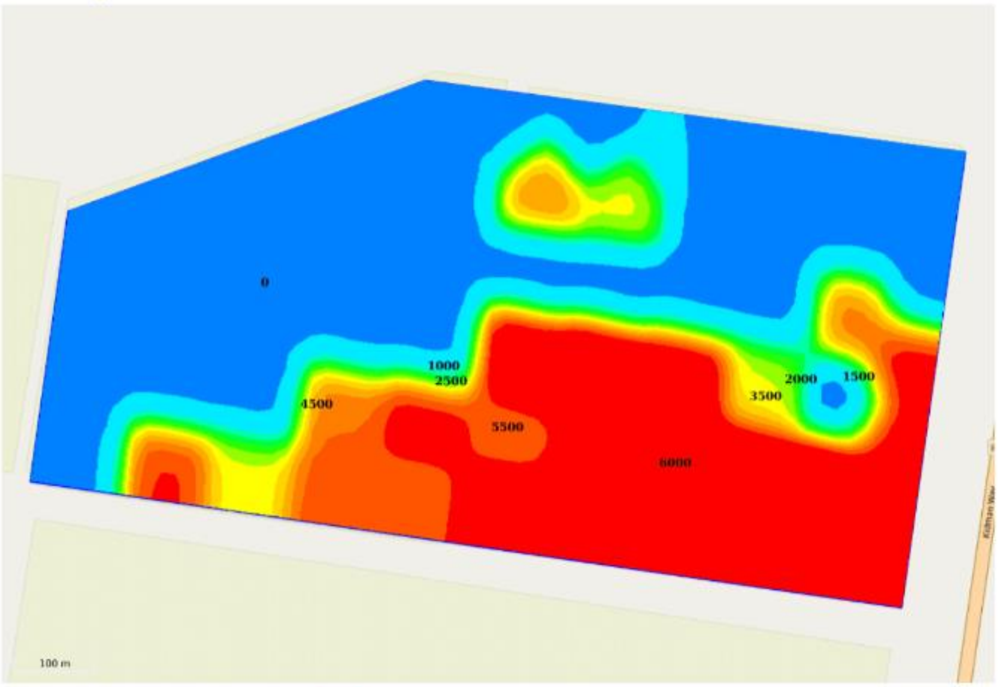
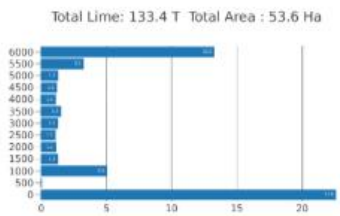
F3: Lime pH Target 5.8

Lime



Client:	Kanaley Ag Consulting
Farm:	Coleambally Demo Farm
Paddock:	F3
Name:	F3
Type:	Lime pH Target 5.8
Date:	25/02/2022
Lime:	133.352 tonnes
Unit Cost:	$0.00/t
Product Cost:	$0.00
Applied Area:	31.023 ha
Minimum Rate Applied:	0.0 kg/ha
Maximum Rate Applied:	6000.000 kg/ha
Average Rate Applied:	2488.839 kg/ha

- 6000 kg/ha
- 5500 kg/ha
- 5000 kg/ha
- 4500 kg/ha
- 4000 kg/ha
- 3500 kg/ha
- 3000 kg/ha
- 2500 kg/ha
- 2000 kg/ha
- 1500 kg/ha
- 1000 kg/ha
- 0 kg/ha



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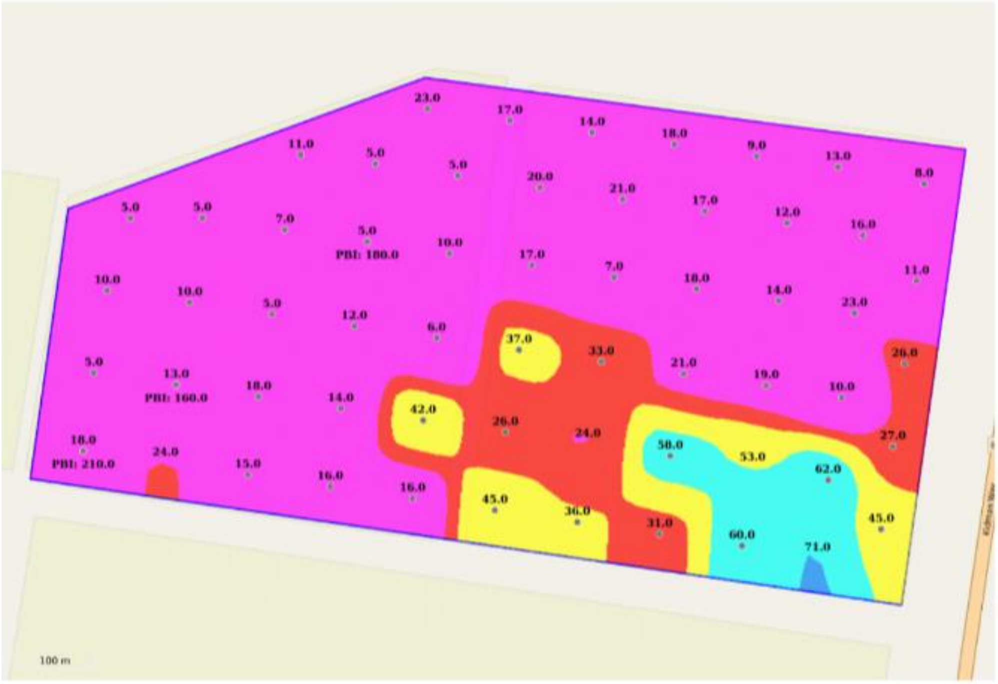
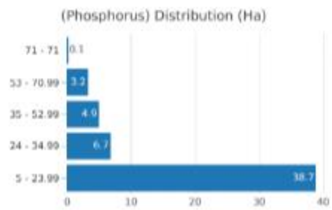
F3: Soil Test
Soil (Phosphorus)



Client:	Kanaley Ag Consulting
Farm:	Coleambally Demo Farm
Paddock:	F3
Name:	F3
Type:	Soil Test
Date:	25/02/2022
Min:	5.00 mg/kg
Max:	71.00 mg/kg
Avg:	21.00 mg/kg

Above 71 mg/kg
53 - 70.9 mg/kg
35 - 52.9 mg/kg
24 - 34.9 mg/kg
Below 23.9 mg/kg



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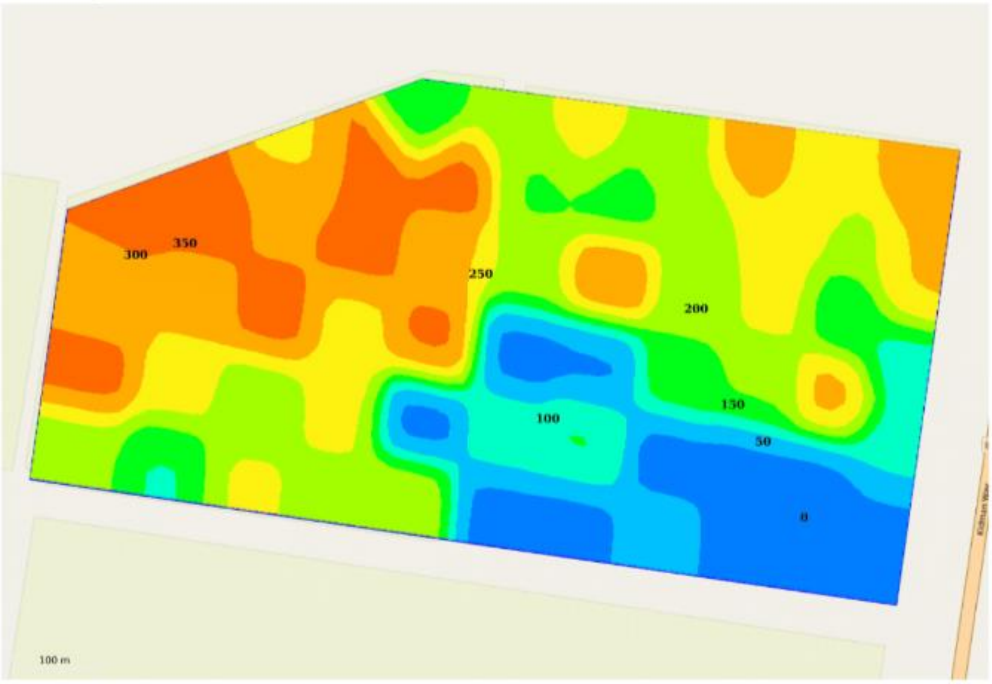
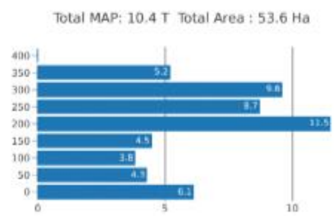
F3: VR MAP - P Target 35
MAP



Client:	Kanaley Ag Consulting
Farm:	Coleambally Demo Farm
Paddock:	F3
Name:	F3
Type:	VR MAP - P Target 35
Date:	25/02/2022
MAP:	10.423 tonnes
Unit Cost:	$0.00/t
Product Cost:	$0.00
Applied Area:	47.474 ha
Minimum Rate Applied:	0.0 kg/ha
Maximum Rate Applied:	400.000 kg/ha
Average Rate Applied:	194.528 kg/ha

400 kg/ha
350 kg/ha
300 kg/ha
250 kg/ha
200 kg/ha
150 kg/ha
100 kg/ha
50 kg/ha
0 kg/ha



Outcomes

The most immediate economic outcomes are the cost savings in applied product. It was calculated across the 3 fields tested that the amount saved over 100ha was:

- Lime – $4300 saved compared to a broadacre 2t/ha
- Gypsum – $6000 saved compared to a broadacre 1t/ha
- MAP – $1200 saved compared to a broadacre 200kg/ha

A total saving of $115/ha in product – for these three fields in particular pays for the testing costs.

The production economic benefits will have to be followed through the picking and winter crop harvest. It is estimated that field average yields will lift due to the "poor performing" areas increasing their output to the benefit of the whole field unit.

Social impacts are endless, as the farm's contribution to the local community, social groups and economy is extensive. Through facilitating the project, local volunteers, farmers and other community stakeholders are increased their understanding and knowledge of soil mapping and nutrition. This will have other benefits to the experience and knowledge in our local farming systems in the community.

The primary environmental benefit is water efficiency, our most valuable resource. "More crop per drop" & maximising the water holding capacity of the soils on farm have flow on benefits such as nitrogen use efficiency. The project has improved the local environment through incorporating sustainable farming measures and placing a strong emphasis on improving our local environment to achieve the best result for the community, environment and beyond.

Key Learnings for participants

Chris Gardiner
APEX member & Local Grower

"The product saved from application in the right areas of the fields through variable rate technology, convinced me that the grid sampling was worthwhile. Prior to this I certainly wasn't sold on the grid soil sampling that's for sure. Now I'm excited to see our results and bring our fields more into line. Unfortunately, we didn't get a cotton crop into the main field (field 5) being too wet as it had the biggest issues from the soil tests."

Joe Briggs
APEX member & Local Grower

"One of the biggest things in Coleambally is redeveloping multiple paddocks with different histories into one bigger block. Rice history has been causing a lot of issues for new cotton growers and new blocks. If we can demonstrate this practice for growers to see the cost saving in fertiliser and correct placement it will potentially make the transition into cotton more profitable in the first season."

James Kanaley
Consulting Agronomist

"The soils we are dealing with in the Murrumbidgee & Murray Valleys are known to be extremely variable. Quantifying that variability and communicating it with growers can be very difficult. But as farmers are very visual, grid sampling & variable rate maps can produce stark and abrupt changes that can be made easily to the system. This isn't new science; this is old soil science but conveyed in new ways."

Conclusion

Soil variability and underlying soil constraints is one of the biggest challenges in irrigated cotton in southern NSW. Standard practices in soil sampling and amelioration have been somewhat effective in the past to combat these issues. However, with increasing costs of production and water input costs & availability becoming more variable, increasing the profitability of the soils we are dealing with is crucial to the long-term sustainability of cotton production in southern NSW.

Growers in Coleambally have already taken on board some of the extension in this project. In the past 6 months, several growers including those involved in the project have adopted strategies used in this project.

This project has also increased the sustainability of community farm. The community farm is such an important pillar in the community, and through conducting this project, we have been able to make improvements and ensure its longevity. More can always be done, but through putting back into the farm, we can ensure the community groups, local charities and communities can continue to benefit into the future.

Figure 3 Sicot 606B3F planted in 22-23

Extension Opportunities

IREC (Irrigation Research & Extension Committee) is a key extension group for irrigators in the Murrumbidgee Valley. IREC runs a research update each season to share findings but also releases quarterly newsletters with farming and agronomy updates.

The Progress report on findings at the demonstration farm & soil amelioration discussion can be shared with growers and other agronomists at local cottoninfo updates.

We would like to thank the following businesses for their assistance and support in this ongoing project. Also, thanks to the Coleambally farmers assisting with implemented changes on the demonstration farm.

precision agriculture pct Kanaley Agricultural Consulting

The carbon footprint of on farm irrigation dams in the Murrumbidgee Valley of Australia

Dr Jackie Webb, Deakin Uni

Where do farm dams sit in agricultural C and emission inventories?

- An **anthropogenic system** that should be included in National emission inventories.
- A **large contribution of CH_4** from farm dams/artificial waterbodies.
- Small in relative farm area
  - **1.76 million** farm dams in Australia
  - **2.56 million** in USA.
- Where water flows carbon goes – potential for C storage

Farm dams ~14% total agricultural **CH_4** emissions, Australia[2]

Farm dams ~1% total agricultural **CH_4** emissions, USA[2]

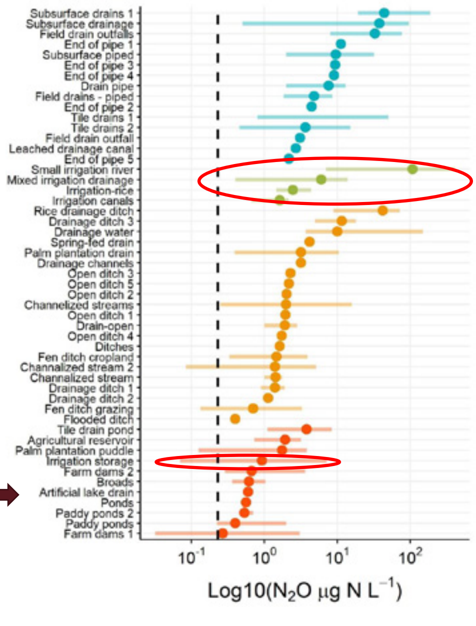
Farm dams 10% QLDs land use change emissions[1]

Artificial waterbodies 60% Mediterranean irrigation emissions[3]

Irrigation dams — major knowledge gap

- Most studies on **livestock dams** or **urban ponds** or farm dams in the **Northern Hemisphere**.
- Irrigation waterbodies represent just **14% of the CH_4 EF dataset** for "*Other Constructed Waterbodies*" (IPCC, 2019).
- Irrigation waterbodies have the most **limited N_2O dataset** for indirect Efs from agricultural surface waters (*Webb et al., 2021*).
- Irrigation industries committing to **net zero emissions**

Summary of dissolved N_2O concentrations from studies compiled in Webb et al. (2021) review of indirect EFs from artificial waters.

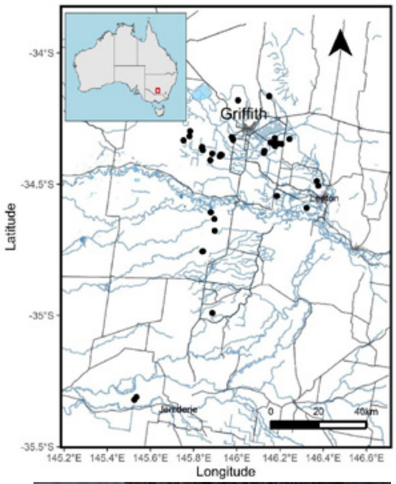


Study objectives

To quantify GHG (CO_2, CH_4, and N_2O) emissions from on-farm irrigation dams covering a broad range of land uses in semi-arid regional NSW, Australia.

Objectives:

1. Collect a preliminary GHG dataset for farm dams across multiple irrigated crop and horticultural land uses
2. Determine the environmental drivers of CO_2, CH_4, and N_2O in irrigation farm dams
3. Identify water quality and dam characteristics that may lead to management opportunities for mitigating emissions.



Field campaign

- Murrumbidgee and Coleambally Irrigation areas – 38 farm dams, 19 farms.
- 3rd largest irrigation area in Australia
- Cotton, rice, wine grapes, citrus, mixed broadacre, almonds, grains
- Spring and summer spatial surveys
- Dissolved GHG samples, water quality
- Sediment cores. Surrounding soil characteristics

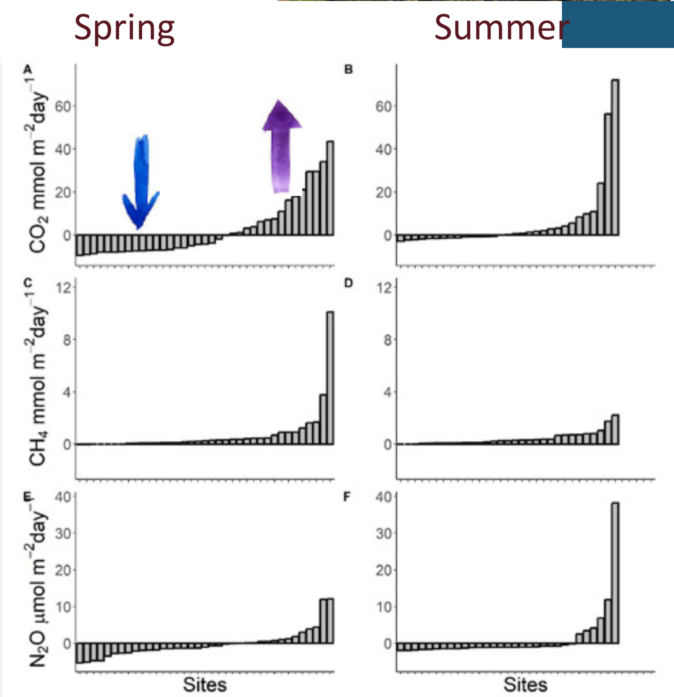
Floating chamber measurements to characterise farm dam gas transfer velocity

Four different types of farm dams

- **Horticultural**
- **Storage**
- **Recycle**
- **Large "turkey nests"**

Results: GHG fluxes

- 48% emitters of CO_2
- 88% emitters of CH_4
- Only 30% emitters of N_2O

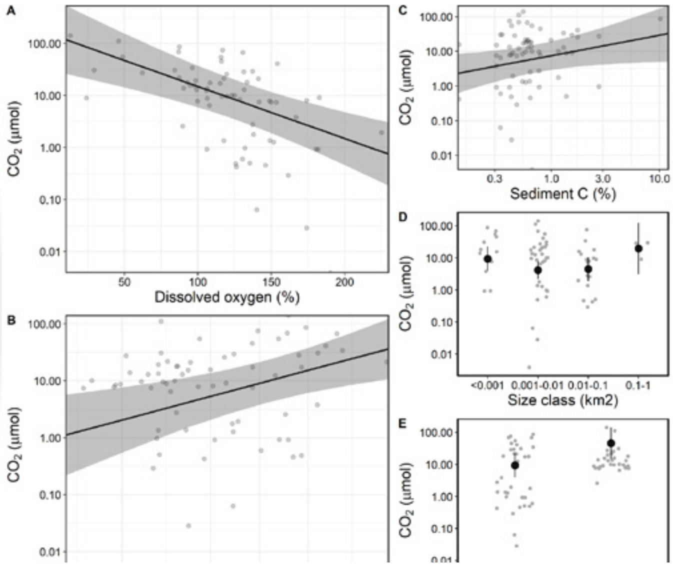


Semi-arid irrigation dams are small sources of GHGs

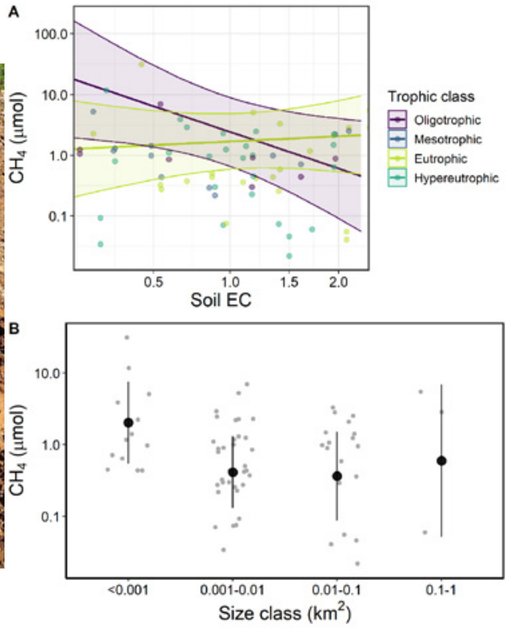
- **25%** were net GHG sinks
- Carbon emissions **3-18 times lower** than other Australian farm dams.
- Study average CH_4 EF = **34-38 kg/ha/yr**
  - IPCC CH_4 EF = **183 kg/ha/yr**
- Indirect N2O-N:NO3-N EF **0.06%**
  - **0.26%** from IPCC (rivers and lakes).

Results: Carbon dioxide drivers

- Most strongly driven by **biological metabolism**.
- Strongest relationship with **DO** and **NH_4**,
- Weak relationship with sediment carbon.
- Weak seasonal effect
- No difference in sizes
- LMEM explained 54% of variability



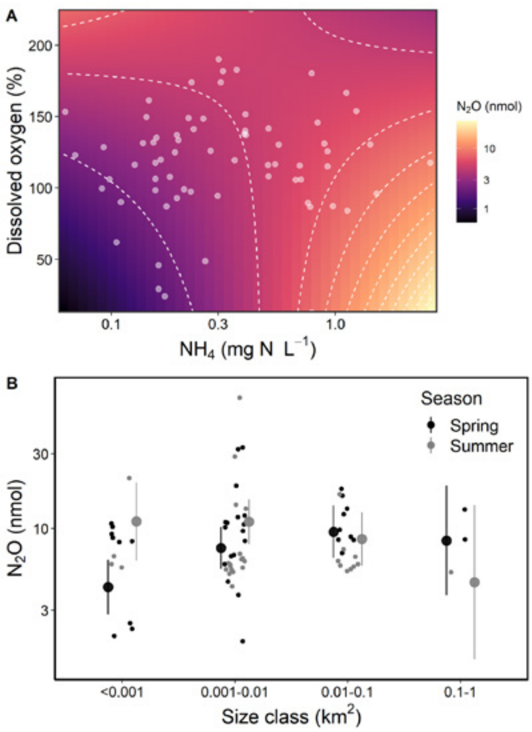
Results: Methane drivers



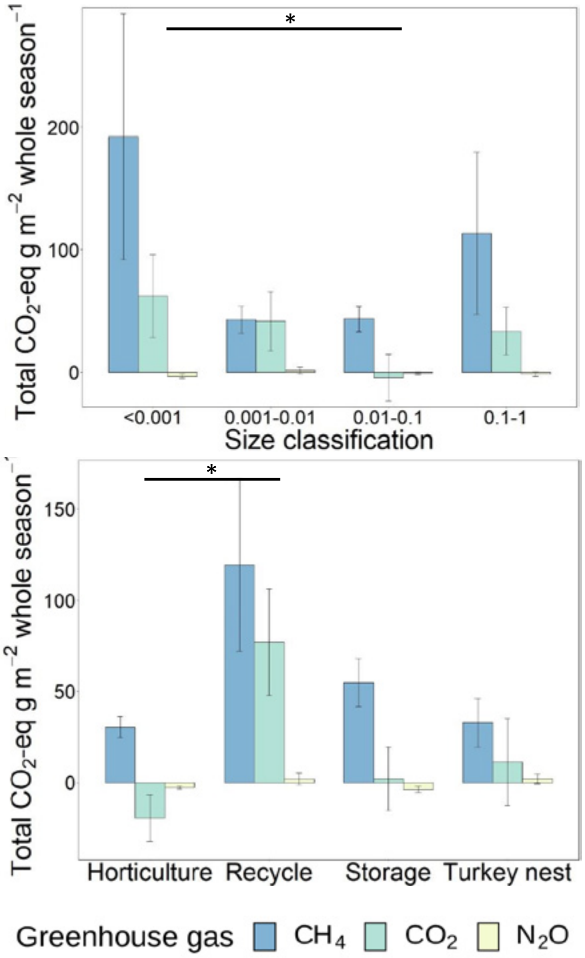
- CH_4 decreased in dams surrounded by **soil with higher EC**
- **Eutrophic dams** masked this effect
- Dams **<0.001 km²** were significantly higher in CH_4.
- No seasonal effect.
- LMEM explained 78% of variability

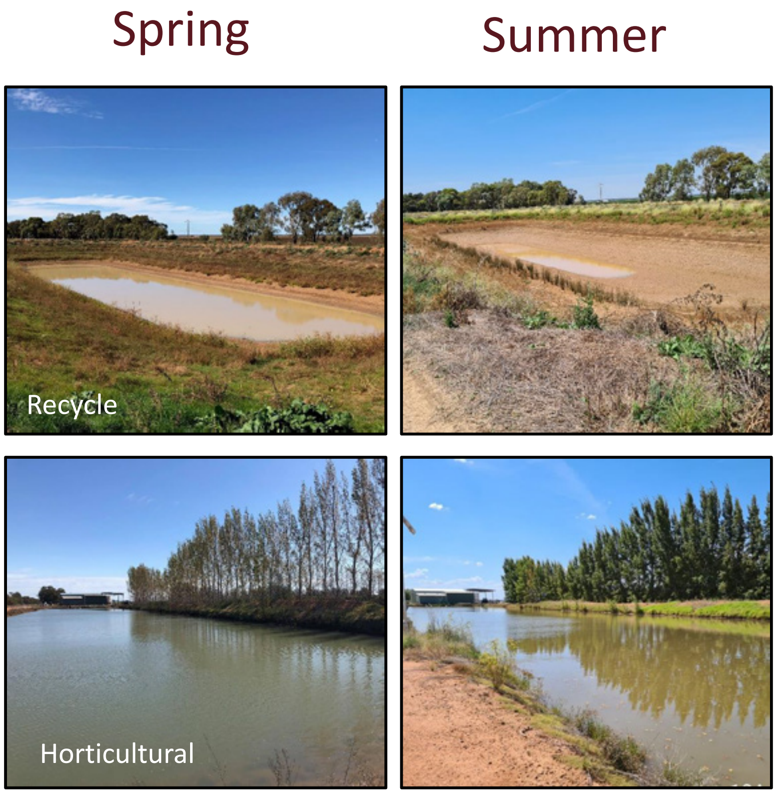
Results: Nitrous oxide drivers

- N_2O relationship with NH_4 is governed by dissolved oxygen.
- Widespread N_2O undersaturation = complete denitrification, *but at high oxygen levels?*
- Primary productivity driving N_2O consumption...?
- Smallest dams had lower N_2O in spring.
- LMEM explained 44% of variability

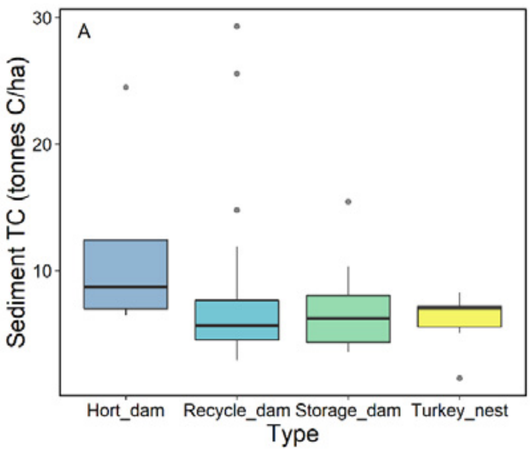


CO_2-equivalent emissions from irrigation dams





Carbon storage



- Surrounding vegetation carbon stock estimates were 14.7 t/ha to 38.0 t/ha.
- Carbon density in the top 10 cm surface sediments of dams ranged from 1.49 to 29.28 t C ha^{-1} and averaged 8.40 t C ha^{-1}
- Large range in ages (1-90 years)

Managing irrigation dams

"Creating sustainable irrigation networks in Australia can have wide-ranging benefits for both agriculture and the environment. Irrigation dams present opportunities for both emissions reduction and carbon storage."

Managing irrigation dams for carbon benefits

Emissions from constructed freshwater ponds such as farm dams used for irrigation have now been included the National Greenhouse Gas Emissions Inventory. If managed appropriately, irrigation farm dams can be a part of net zero emissions goals with several opportunities for emission reduction and carbon storage.

Introduction

Irrigation farm dams help support $8.6 billion worth of irrigated production in the Murray-Darling Basin (Australian Bureau of Statistics, 2019). These vital water assets on farms can have wetland-like characteristics that may support carbon storage and potentially offset greenhouse gas (GHG) emissions. Collectively, these artificial waters represent more than 60 km^2 in the irrigation regions of the Riverina, a substantial inland aquatic area that would otherwise not exist. While farm dams are included in national emissions reporting, the carbon footprint of irrigation farm dams remains unknown. With many of Australia's irrigation farming industries committing to net zero emissions, there exists an opportunity to include farm dams in sustainability frameworks.

To better understand the potential of irrigation farm dams as a carbon asset, this study carried out on-ground research investigating the carbon footprint of such dams typically found in large-scale surface irrigation enterprises in the Riverina region of NSW. This fact sheet summarises key preliminary findings from the scoping study and provides suggestions on how to improve the overall carbon footprint of irrigation dams through reducing GHG emissions and boosting natural carbon storage.

Lower emissions than other agricultural waters

When compared with global averages for artificial waterbodies, most Riverina irrigation dams emit far less methane. Depending on the season, the average emission factor (EF) for diffusive methane fluxes from a mix of 38 horticulture and broadacre irrigation dams in the region was found to be four to eight times lower than the global EF (183 kg CH_4/ha/year) for constructed freshwater ponds, as reported by the Intergovernmental Panel on Climate Change (Lovelock *et al.*, 2019). Given Australia recently joined the Global Methane Pledge to reduce methane emissions by 30%, this is promising for irrigators to know that their farm dams are generally minor emitters of methane. It is unclear whether lower emissions could be due to the soil type, regional landscape effects, irrigation management scheduling, rainfall or differences in organic matter input (e.g. animal manure vs plants). It is clear, however, that irrigation dams in the Riverina should not be assumed to emit the same high levels of methane as other artificial fresh waterbodies.

Further, it is well-known that farm waterbodies can be indirect sources of nitrous oxide through fertiliser runoff from fields. This study revealed that although dissolved nitrogen levels were often elevated in irrigation farm dams, this did not result in high nitrous oxide emissions. In fact, at the time of sampling, 73% of the surveyed dams were sinks, playing a role in actively removing this strong greenhouse gas from the atmosphere. Like for methane, this study demonstrates that irrigation dams in the irrigation farming enterprises of the southern Murray-Darling Basin have lower nitrous oxide emissions than those quantified for other agricultural freshwater bodies.

A new area for on-farm emission reduction

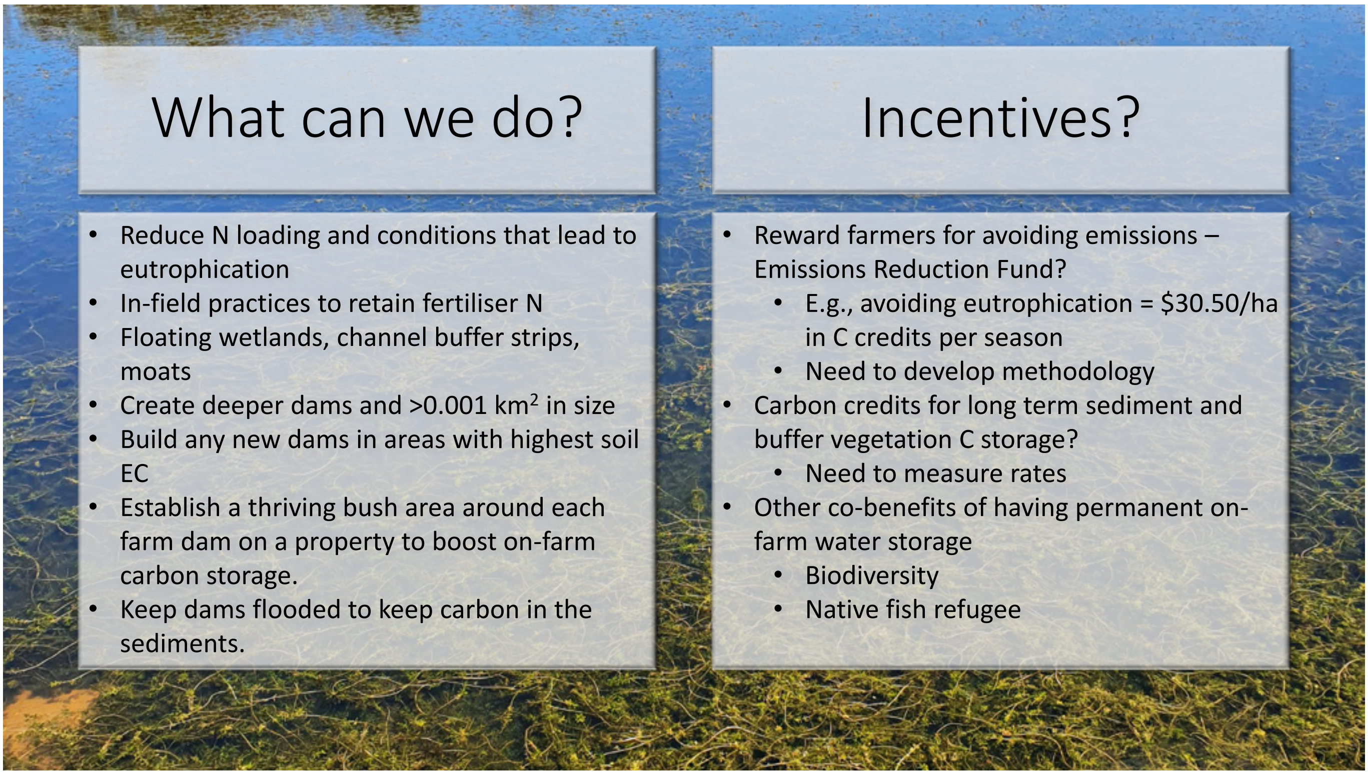
Effective farm dam management can be used as a tool to avoid emissions and even support longer-term storage of carbon on farm. This study provides new data that suggests certain irrigation farm dam characteristics can reduce emissions. Although specific management practices are yet to be tested, this observational study provides clues as to management changes that can improve a farm's carbon footprint. Two findings stood out:

1. Waters that were eutrophic had 2-4 times greater CO_2-equivalent emissions than those that were non-eutrophic.
2. Recycle dams had CO_2-equivalent emissions an order of magnitude higher than other dam types (storage, horticultural and turkey nests).

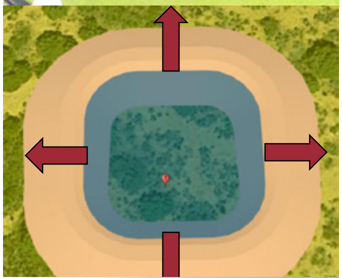
Learn more
www.agrifutures.com.au

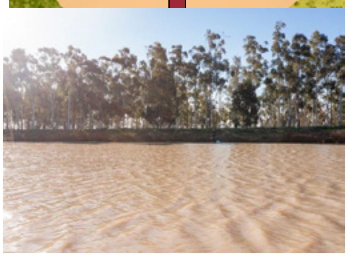
AgriFutures Australia | CERRF Centre for Regional and Rural Futures | Deakin University

https://agrifutures.com.au/product/fact-sheet-managing-irrigation dams-for-carbon-benefits/



Potential emission savings across the region





- Avoiding eutrophication could save up to 1.03 t CO_2 ha^{-1} emissions over the summer irrigation season. Across the MIA = **1,382 t CO_2-eq** or amounts to **$42k** collectively in C credits.

- Even greater emission savings of up to 2.13 t CO_2-eq ha^{-1} could be achieved if dams were constructed to be greater than 0.1 ha in size. Across the MIA = **2,140 t CO_2-eq** emissions avoided = **$65k** C credits

- If all dams in the regional analysis supported just 1 ha of buffer vegetation, this could amount to **253-655k t CO_2** in stored in biomass.

Conclusions

- Artificial waterbodies are not always large CH_4 emitters.
- **70%** of irrigation dams were N_2O sinks
- **IPCC overpredicts** CH_4 and N_2O in semi-arid irrigation farm dams.
- EF models do not account for the possibility of **N_2O uptake**.
- Horticultural dams had the lowest carbon footprint
- Regional effects – are all irrigation waterbodies low GHG emitters?
- High priority: assign **EFs that are more realistic** agricultural waterbody types.
- Investigate management effects on carbon storage

References: 1. A. Grinham, S. Albert, N. Deering, et al., Hydrol . Earth Syst. Sci., 2018, 22, 5281 5298. 2. M. E. Malerba, T. de Kluyver, N. Wright, et al., Communications Earth & Environment, 2022, 3, 306. 3. E. Aguilera, J. Vila Traver , B. R. Deemer , et al., *Environmental Science & Technology* , 2019, 53, 5091 5101.

Dynamics of C burial and GHG cycling in irrigation dams

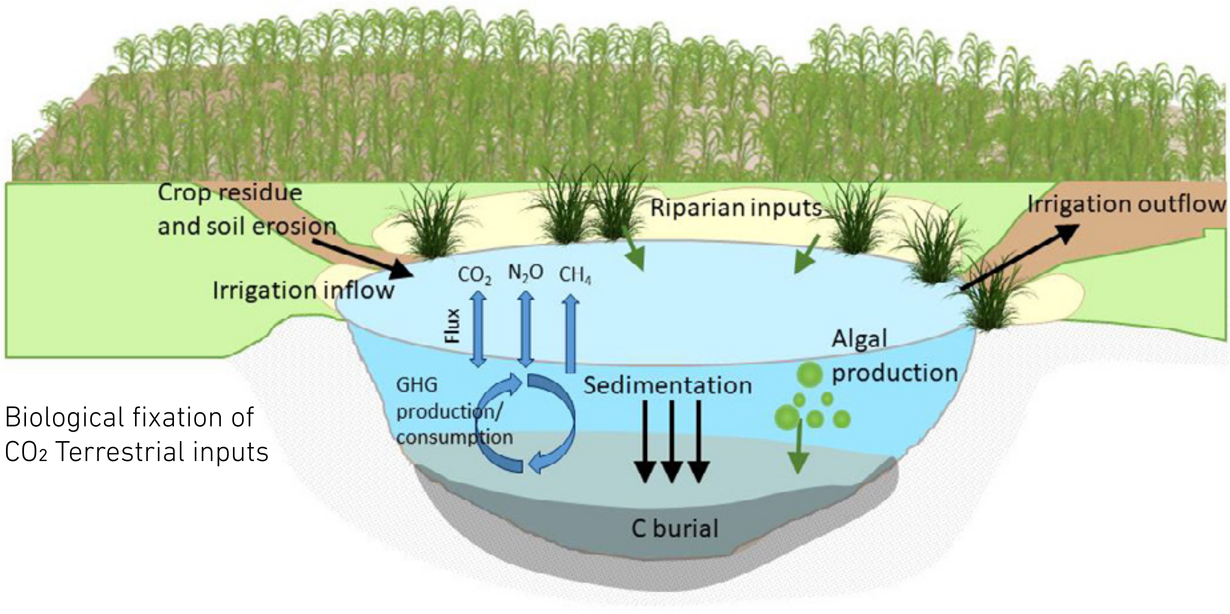


Table 3: Summary of irrigation farm dam types and their physical, sediment, and soil properties. Presented as mean with range in parathesis.

Characteristic	Horticultural (n = 5)	Recycle, (n = 19)	Storage, (n = 8)	Turkey nest, (n = 6)	p-value[2]
Soil EC, mS cm^{-1}	0.59 (0.18 – 1.17)	0.99 (0.23 - 2.35)	1.10 (0.31 - 1.97)	1.66 (0.89 - 2.11)	<0.001
Soil pH	7.52 (6.70 - 8.12)	6.62 (5.86 – 7.47)	6.48 (5.79 - 7.13)	6.72 (6.02 - 7.50)	<0.001
Area, ha	1.19 (0.53 – 2.33)	1.42 (0.02 - 13.70)	0.23 (0.05 - 0.63)	6.51 (0.16 - 14.50)	<0.001
Perimeter, m	665 (399 - 1,560)	397 (62 - 1,390)	293 (86 - 1,340)	1,006 (359 - 1,340)	<0.001
Sediment C, %	1.33 (0.58 - 2.76)	1.20 (0.31 - 10.20)	0.68 (0.31 - 1.75)	0.47 (0.14 - 0.63)	0.007
Sediment N, %	0.047 (0.020 – 0.095)	0.101 (0.020 - 0.870)	0.047 (0.020 - 0.080)	0.037 (0.010 - 0.050)	0.314
Sediment $d^{13}C$, ‰	-11 (-23.4 - 13.5)	-21.7 (-27.8 - -4.6)	-20.3 (-24.9 - -13.5)	-21.5 (-23.1 - -19.0)	0.014
Sediment $d^{15}N$, ‰	16 (8 – 21)	13 (5 – 28)	27 (9 – 125)	19 (11 – 42)	0.038
Sediment C/N ratio	35 (11 – 68)	13 (9 – 39)	15 (8 – 29)	13 (12 – 15)	0.002

Table 4: Summary of water quality variables, greenhouse gas concentrations, and trophic status across 38 farm dams during spring and summer. Presented as mean ± standard deviation (SD) for continuous variables and count (percentage) for group variables.

Characteristic	Units	Spring, N = 37	Summer, N = 31	p-value[2]
Surface temperature	°C	15.49 (1.58)	25.58 (3.00)	<0.001
Dissolved oxygen	%	134.91 (29.88)	103.46 (40.66)	0.002
Electrical conductivity	µS cm^{-1}	326.35 (225.15)	419.43 (514.49)	0.845
pH		8.55 (0.73)	8.93 (0.75)	0.004
Phosphate	mg P L^{-1}	0.05 (0.04)	0.09 (0.11)	0.714
<0.025		18	8	
Ammonium	mg N L^{-1}	0.65 (0.50)	0.23 (0.17)	<0.001
Nitrate	mg N L^{-1}	0.72 (0.64)	1.10 (1.31)	0.662
CO_2	µM	18.70 (24.50)	21.50 (29.57)	0.107
CH_4	µM	2.30 (5.31)	1.37 (1.55)	0.893
N_2O	nM	10.37 (6.57)	9.96 (11.90)	0.011
Trophic class				0.245
Oligotrophic		2 (5.4%)	6 (19.4%)	
Mesotrophic		6 (16.2%)	7 (22.6%)	
Eutrophic		14 (37.8%)	8 (25.8 %)	
Hypereutrophic		15 (40.5%)	10 (32.2 %)	

[2]Wilcoxon rank sum test; Wilcoxon rank sum exact test; Fisher's exact test

Lessons from the 2022/23 Cotton Season and Looking Forward

Kieran O'Keeffe, CottonInfo

XtendFlex cotton is the first cotton trait developed to be tolerant to over-the-top applications of glyphosate, dicamba and glufosinate-ammonium herbicides, providing flexibility to manage a wider-spectrum of difficult-to-control and resistant weeds in-crop. There will be a good opportunity to have a look at the XtendFlex varieties coming through the system next season with a permit for 50,000 ha to be grown.

A full program of variety trials and ambassador fields are planned for next season.

Variety descriptions and CSIRO trial data is provided here by Dr Warwick Stiller, CSIRO Research group Leader, Cotton breeding.

CSX1049B3XF

New germplasm, normal leaf, Normal density, often relatively compact determinate growth (though not always), has performed consistently well in dryland and sometimes in Southern irrigated. May also have fit in Northern Australia (Note: lower disease rank than other lines)

CSX4133B3XF

Full season, normal leaf, low density, broad adaptation, overall performance similar to Sicot 748B3F.

CSX5438B3XF

Full season, normal leaf, low density, has performed best from the Macquarie north. Need to be aware of the lower micronaire.

CSX3141B3XF

New germplasm, normal leaf, low density, resistant to CBT, has shown broad adaption, appears to have increased resistance to verticillium wilt (but need more data).

CSX4389B3XF

New germplasm, okra leaf, low density, resistant to CBT, broad adaptation but has performed best in high yielding full season sites, appears to have increase verticillium resistance (but need more data), need to be aware of lower micronaire.

LINE	TRAITS	YIELD (rel. to Sicot 746B3F)		LP	LEN	STR	MIC	VRR	FRR
		Irrigated	Dryland						
CSX1049B3XF		99	106	41.5	1.24	31.6	4.3	92	103
CSX4133B3XF		101	101	44.1	1.23	29.9	4.2	110	125
CSX5439B3XF		99	102	42.5	1.29	30.1	3.9	102	122
CSX3141B3XF	CBT	103	102	43.5	1.26	31.5	4.2	118	139
CSX4389B3XF	OT, CBT	104	103	44.1	1.24	31.0	3.8	121	116

Note: The above trial data is from previous seasons across all sites. More trial data will become available from this season on the CSD website.

CSIRO MIA XtendFlex Trials mean 2019/20, 2020/21, 2021/22.

LINE	TRAITS	Yield b/ha	LP	LEN	STR	MIC
CSX1049B3XF		11.97	40.3	1.25	31	3.6
CSX4133B3XF		11.4	42.9	1.24	29.3	3.5
CSX5439B3XF		11.2	41.4	1.28	29.2	3.1
CSX3141B3XF	CBT	12.6	42.7	1.27	30.1	3.5
CSX4389B3XF	Okra, CBT	12.61	44.3	1.22	29.7	3.2

Upcoming XtendFlex Cotton Spray Applicator Training Sessions

As part of Bayer's commitment to whole of system stewardship, the spray applicator training will be a requirement for:

- Technology User Agreement (TUA) signers;
- All on-farm staff responsible for spray applications (including mixing/handling); and
- Any spray contractor that applies XtendFlex Cotton System products over-the-top (OTT) of XtendFlex cotton varieties, once approved by the APVMA.

Upcoming training sessions are listed in the table below.

Monday 28 August, 2023	**Condobolin**	8.45 am – 2.30 pm
Tuesday 29 August, 2023	**Hillston**	8.45 am – 2.30 pm
Wednesday 30 August, 2023	**Hay**	8.45 am – 2.30 pm
Thursday 31 August, 2023	**Coleambally**	8.45 am – 2.30 pm
Friday 1 September, 2023	**Griffith**	8.45 am – 2.30 pm
Monday 4 September, 2023	**Darlington Point**	8.45 am – 2.30 pm
Tuesday 5 September, 2023	**Deniliquin**	8.45 am – 2.30 pm

Register for workshops online at XtendFlex cotton.

Investigating machine learning algorithms to forecast soil matric potential in cotton crops

Rodrigo F. Maia, Carlos B. Lurbe, Brenno T. Faria, John Hornbuckle, Deakin University

This project is supported by funding from the Australian Government Department of Agriculture Fisheries and Forestry as part of its Rural R&D for Profit program.

Research done within the

Smarter Irrigation for Profit 2

Objective: Support growers to monitor and control irrigation remotely based on Internet of Things and Remote Sensing

Challenge: How to automate the paddocks providing water efficiency, reducing labour and contributing with grower decision-making process?

Research done within the

Smarter Irrigation for Profit 2

New technologies integrated and automated smart sensing for cotton for

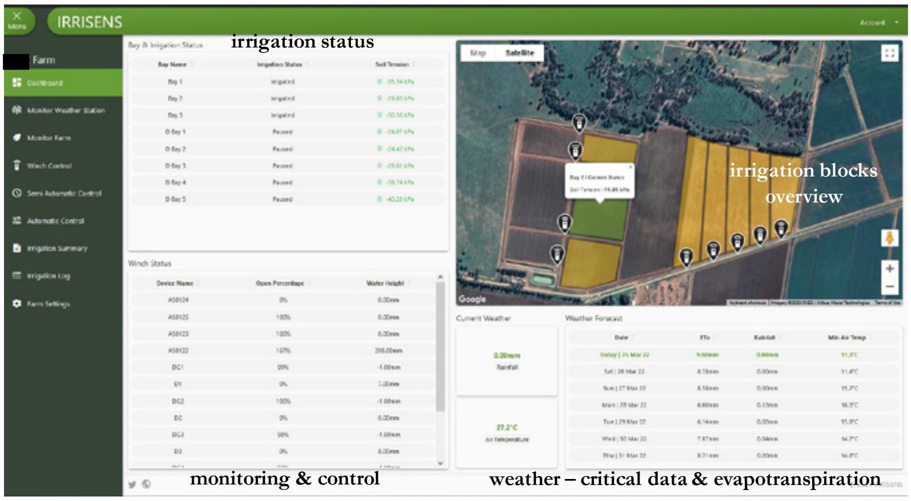
Forecast mechanism – save water in irrigation

Smart Irrigation Platform – IRRISENS

Wifield Logger / Automatic winches

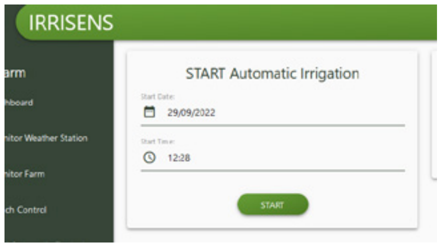
Wi-Fi communication (range around 700m)

Project outcomes – IRRISENS platform

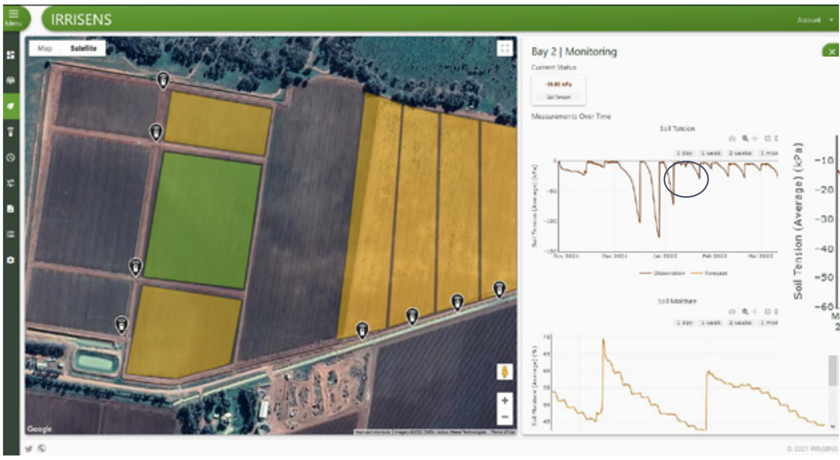


Features

- Show monitoring bays, weather
- Forecast soil tension
- Automatic control – system control all gates openings and closings without manual operation



Monitor bay & machinery (field)



Internet of Things (IoT) drives innovation in AgTech

Electronics and equipment cheaper and reliable ✓

Communication spread through paddocks (robust Wi-Fi, LoRa, etc) ✓

Loggers / probes cover small areas FACT

Labour to install and maintain the equipment in larger fields may be a challenge

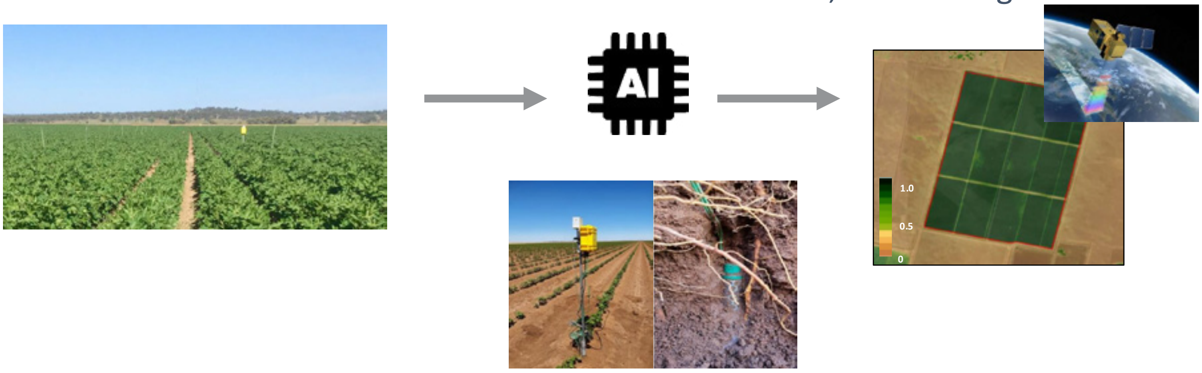
Is it possible to create a mechanism to estimate soil matric potential in larger areas reducing labour and maintenance?

Inspiration: IrriSAT + Remote Sensing

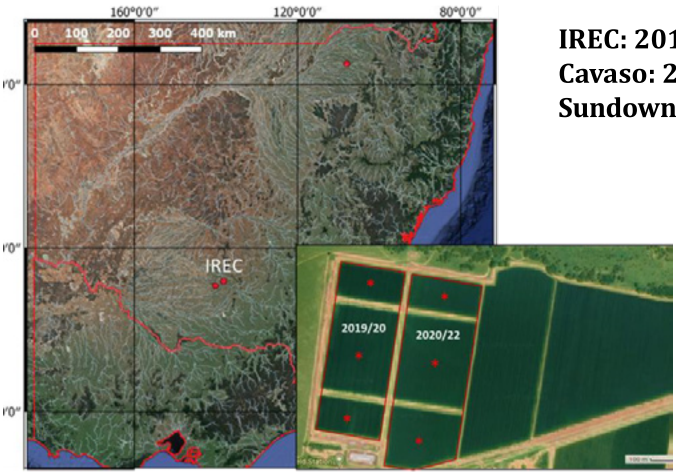
IrriSAT provides Cummulative Evapotranspiration for growers in larger areas

Limitation: Remote Sensing does not provide soil tension deeper in soil – root zone (20cm)

Challenge: Elaborate a machine learning model to combine sensors + remote sensing data to estimate soil tension in areas without sensors installed, considering climate events

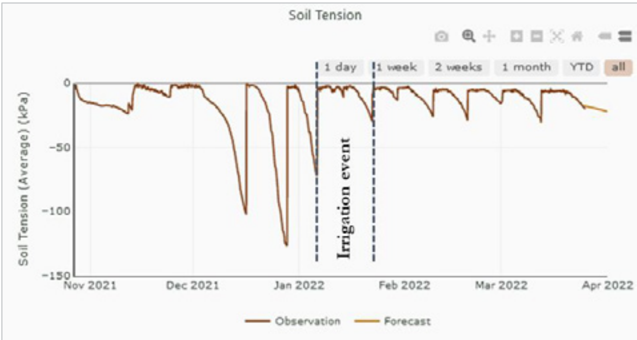


First Step Machine Learning – Data harvest and model training



Data haversted through Wifield Loggers – 3 seasons

IREC: 2019 – 2022
Cavaso: 2019/2020
Sundown Pastoral: 2020/2022



Dataset features – Algorithm Performance evaluation

Evaluation data

- Mixed data from all farms and all seasons
- Split data into training and testing
- window size 20 days (shuffled)
- 600 ≤ GDD ≤ 1700

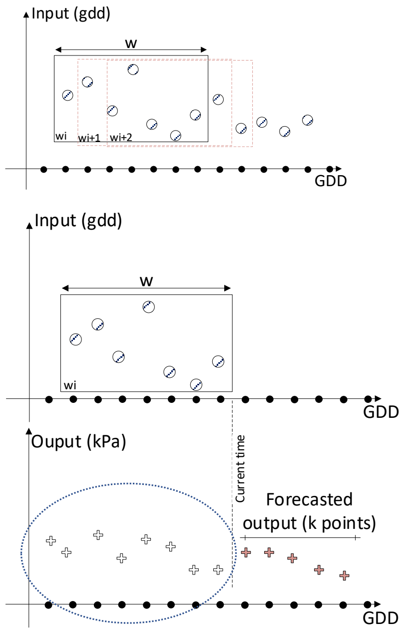
Testing

- Data from bays not trained
- window size 20 days (shuffled)
- 600 ≤ GDD ≤ 1700

Weather data:

2019/20 – hotter and dryer – highest temp recorded (47.1C)

2020/21 – colder and wet – lowest temp recorded (19.7C)

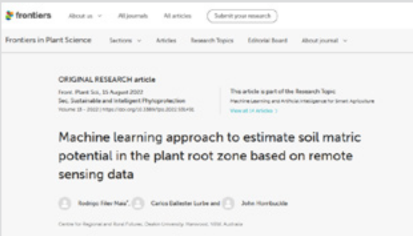


First Tentative

Use data only from IREC

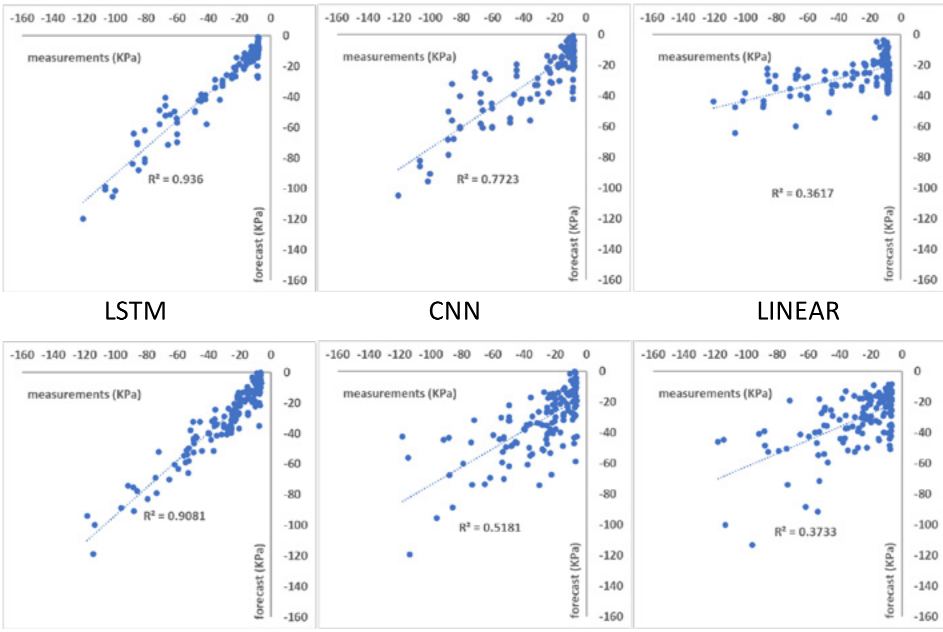
"Machine learning model LSTM could estimate soil tension from non monitored bays successfully with one and two season data"

Results with data from all 3 farms


ORIGINAL RESEARCH article

Machine learning approach to estimate soil matric potential in the plant root zone based on remote sensing data

https://doi.org/10.3389/fpls.2022.931491



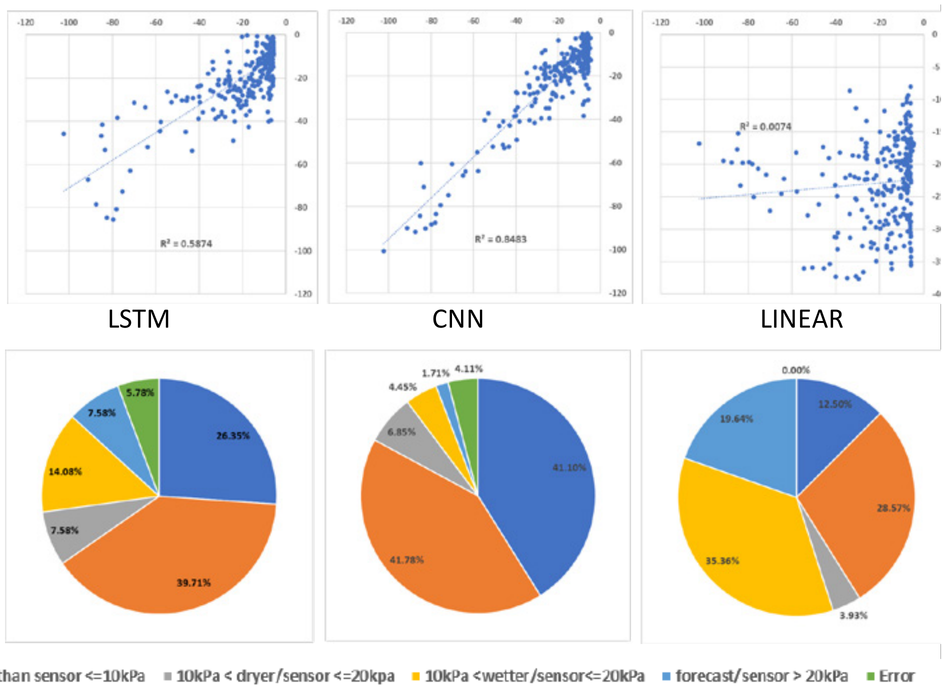
IREC: Model Effectiveness – Two Seasons 7 days forecast

Second Tentative

Use data from all farms and all seasons trying to forecast 14 days in advance

"Machine learning model CNN could estimate soil tension from non monitored bays successfully considering all farms"

In CNN approx 83% of estimated soil tension present similar sensor measurement error



Concluding remarks

Machine learning models are able to estimate soil tension in no-monitored bays, since the model has as input data from one monitored bay

Convolutional Neural Network (CNN) hits 83% of satisfactory soil tension results in non monitored bays

Models need at least 20 days of monitored data to estimate soil tension properly

Attention needed for wrong estimation provided by both LSTM (5%) and CNN (4%)

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DEAKIN UNIVERSITY

NSW DPI current research in MIA

David Troldahl, DPI

Summer Cropping

Cotton Agronomy

Project Title: Supporting Southern Cotton Production Systems: Southern agronomy and fibre quality

Project Team: Beth Petty and Rachel Diversi

Funding: NSW DPI and CRDC

Summary: This project is looking at specific practices that may influence micronaire levels in cotton.

On-Site Experiments

- Applied Nitrogen Experiment
- Hormone Experiment
- Cut Out Date Experiment
- Defoliation Priming Experiment

Off-Site Experiments

- Day Degree Crop Monitoring
- Black Root Rot Novel Products

Cotton Weeds

Project Title: Regional demonstration of integrated weed tactics across farming systems

Project Team: Eric Koetz, Graham Charles and Adam Shephard

Funding: NSW DPI, GRDC and CRDC

Summary: This project aims to:

- Reduce the reliance on Glyphosate in the face of increasing resistance
- Demonstration of different weed control tactics across farming systems
- Integrate residual herbicides and emerging weed control tactics
- Evaluate plant back and crop safety from high rates of optical sprayers
- Herbicide resistance surveys and testing
- Develop a weed control threshold model for on-farm application

Rice Agronomy

Project Title: Agronomy and remote sensing to maximise rice water productivity

Project Team: Brian Dunn, Tina Dunn, Alex Schultz and Josh Hart

Funding: NSW DPI and Agrifutures

Summary:

- Provide science based agronomic management packages for all rice varieties grown across all water management practices.
- Determine phenology of varieties to provide sowing dates, PI date prediction model develop a maturity date prediction model.
- Continue developing remote sensing PI N uptake predictions
- Maintain NIR calibrations and PI Tissue Test nitrogen topdressing recommendations.
- Collaborate with Rice Extension etc to ensure relevant research outputs are delivered to growers.

Winter cereals

These experiments are nodes of projects at Yanco led by researchers from NSW DPI, CSIRO and University of Western Australia.

Project Title: Integrating long coleoptile wheat into Australian farming systems through an integrated understanding of genetics, management and environment.

Funding: NSW DPI and GRDC

Summary: Validating benefits of long coleoptile durum wheat genetics to allow deeper sowing into soil moisture earlier in the sowing window and disease interactions within the northern grain's region.

Project Title: Improving canola heat tolerance.

Funding: NSW DPI and GRDC

Summary: This project looks specifically at the genetics of heat tolerance in canola trials across the canola growing regions of Australia.

Project Title: Optimising pulse profitability linking physiology to tactical agronomy: a crop ecophysiology approach.

Funding: NSW DPI and GRDC

Summary: Testing Faba bean varieties to best suit the irrigation areas.

Project Title: Accelerating the development of tools using satellite imagery and environmental data to identify optimum canola windrow timing.

Funding: NSW DPI and GRDC

Summary: In conjunction with the University of New England, we have created models with very strong prediction of maturity however testing whether this is repeatable from season to season is the current goal.

Project Title: Pulse NVT seed bulk up

Funding: NSW DPI and GRDC

Summary: Increase seed of various pulses to provide to NVT sites for evaluation

Horticulture

Entomology Research

Project Title: Integrated pest management of citrus gall wasp and Fuller's rose weevil

Project Team: Dr Jianhua Mo (lead), Scott Munro, Andrew Creek, Steven Falivene

Project Collaborators: University of Queensland, University of Southern Queensland, Cesar, Riverina IPM

Funding: NSW DPI and Horticulture Innovation Australia

Summary: Citrus gall wasp (CGW) and Fuller's rose weevil (FRW) are two of the most important insect pests of citrus in Australia. CGW causes yield loss and reduced fruit size. FRW is a market-access pest of citrus. The project aims to improve management of CGW and FRW in Australia through better understanding of the biology and ecology of the pests, development of reliable and effective monitoring tools, and exploration of new and more sustainable management options.

Project Title: Preparedness and management of huánglóngbìng (Citrus greening disease) to safeguard the future of citrus industry in Australia, China and Indonesia

Project Team: Dr Jianhua Mo (lead), Dr Mark Stevens, Tahir Khurshid, Steven Falivene, Scott Munro

Project Collaborators: Universitas Gadjah Mada (Indonesia), Citrus Australia, Citrus Research Institute of China

Funding: NSW DPI, ACIAR with Horticulture Innovation Australia

Summary: Huanglongbing (HLB) is a destructive disease of citrus. Infected trees gradually lose productivity and eventually die, and currently there is no cure.

Citrus research

Griffith NSW DPI site of Riverina Citrus Centre of Excellence. Set up to look at:
Automation, Irrigation, Varieties and Climate

Projects:

Citrus IPDM Extension program

Citrus tree intensification – growing smaller trees – HLB project

Citrus rootstock evaluation – dwarfing rootstock trial

Citrus black core rot

Project Team: Dr Tahir Khurshid, Dr Dave Monks, Robert Hoogers, Joe Valenzisi and Steven Barbon

Funding: NSW DPI, Horticulture Innovation and Griffith & District Citrus Growers Inc.

Viticulture research

Project Title: Resting Vineyard trials

Project Team: Dr Katie Dunne, Robert Hoogers, Jade Cooper, Dr Bruno Holzapfel

Project Collaborators: SARDI team: Dr Paul Petrie, Dr Marcos Bonada and Gaston Sepulveda

Funding: NSW DPI and Wine Australia

Summary: This project Investigates the options for growers to 'rest' vineyards where fruit is uncontracted.

Project Title: CSIRO Gen 1

Project Team: :Dr Katie Dunne, Jade Cooper

Funding: NSW DPI and Wine Australia Regional program

Summary: This project has a selection of varieties planted at the Griffith Station for reds and whites. Looking at low inputs (some resistance to powdery mildew and downy mildew)

Project Title: CSIRO Generation 2 project

Project Team: Dr Bruno Holzapfel and Dr Katie Dunne

Project Collaborators: CSIRO Dr Ian Dry

Funding: NSW DPI and Wine Australia

Summary: This project has vines with Double gene resistance to Powdery Mildew and Downy Mildew. There are multiple sites with the Griffith Research Station being the main field site

Plant Biosecurity Research & Diagnostics

Project Title: Potential native vectors of bacterium *Xylella fastidiosa (Xf)*

Project Team: Dr Mark Stevens, Dr Jessica Hoskins, Glenn Warren, Leanne Johnston and Minna Russell

Project Collaborators: Agriculture Victoria

Funding: NSW DPI, PBRI (Plant Biosecurity Research Initiative), DAFF, Wine Australia and Horticulture Innovation Australia

Summary: *Xf* is the greatest single threat to Australian plant biosecurity, and is transmitted between plants by xylem-feeding leafhoppers and spittlebugs. *Xf* causes Pierce's Disease in grapes, Olive Quick Decline Syndrome, Leaf Scorch in cherries and almonds, and Variegated Chlorosis in citrus.

Native insects are often effective vectors when an *Xf* incursion occurs.

Project Title: Development of an Integrated Pest Management Program for the NSW rice industry

Project Team: Dr Mark Stevens, Dr Jessica Hoskins, Glenn Warren, Leanne Johnston and Minna Russell

Funding: NSW DPI and Agrifutures

Summary: This project focuses on understanding the impact of Russian wheat aphid on drill-sown rice, developing improved management techniques and economic thresholds for armyworms, and improving the performance of niclosamide for snail control using spray additives.

Optimising Irrigated Grains Project: Chickpea Agronomy – Disease Management

Damian Jones, Irrigated Cropping Council

Protocol Objective:

To evaluate the economics of disease management strategies of different costs in irrigated chickpea production by:

Evaluating the influence of cultivar resistance on the cost effectiveness of disease management strategies for irrigated chickpea production.

Evaluating the disease control, yield response and quality effects of cheap (based on older fungicide chemistry) and expensive disease management strategies (based on new chemistries).

Location: Whitton, NSW
Sown: 29 May 2020 PBA Monarch and Genesis 090
Harvested: 22 December 2020
Rotation position: Cotton 2019/20
Soil Type: Neutral red clay loam, 150 cm beds

Key Messages:

- Yield and was not influenced by the trial treatments, neither fungicide strategy nor variety selection.
- Variety selection did result in a larger grain size.
- Although the growing season was above average, much of this rainfall was prior to sowing. The winter period tended to be drier than average, resulting in conditions that did not favour disease. Coupled with the relatively few local crops, disease pressure was low and very little disease was evident in the trial.
- Neither the older Genesis 090 nor the new release PBA Monarch showed any differences in disease expression given there was minimal disease pressure.
- Overall yields were possibly suppressed by the co-operators decision to not irrigate in early spring.

The treatments were untreated, 'cheap' based on using chlorothlonil and 'expensive' using Veritas (a strobulurin/triazole mix) and Aviator (a SDHI and triazole mix) fungicides applied to two varieties Genesis090, rated as MS for Ascochyta and and PBA Monarch, rated as S for ascochyta.

Table 1: Trial treatment summary

TRT	Variety	Management Strategy	4-5 weeks post emergence	Pre-Flower	Late Flower
1	Genesis 090	Untreated*	Chlorothalonil 720 1 l/ha	-	-
2	Genesis 090	Cheap	Chlorothalonil 720 1 l/ha	Chlorothalonil 720 1 l/ha	Chlorothalonil 720 1 l/ha
3	Genesis 090	Expensive	Veritas 1l/ha	Aviator Xpro 600ml/ha	Veritas 1l/ha
4	PBA Monarch	Untreated*	Chlorothalonil 720 1 l/ha	-	-
5	PBA Monarch	Cheap	Chlorothalonil 720 1 l/ha	Chlorothalonil 720 1 l/ha	Chlorothalonil 720 1 l/ha
6	PBA Monarch	Expensive	Veritas 1l/ha	Aviator Xpro 600ml/ha	Veritas 1l/ha

** Untreated received a fungicide application as part of a herbicide application on July 15 by the co-operator*

The plant canopy was assessed for disease prior to each fungicide application. No foliar disease was recorded at any stage of the trial.

Table 2. Chickpea yield (t/ha) and grain size (g/100 seeds)

	Grain Yield		Grain Size	
Treatment	PBA Monarch	Genesis 090	PBA Monarch	Genesis 090
Untreated (Control)	1.82	1.90	40.5 a	32.7 b
'Cheap'	1.96	1.96	40.8 a	33.2 b
Expensive	2.11	1.84	40.5 a	32.5 b
Yield: p_{var} = 0.427, p_{fung} = 0.458 p_{vxf} = 0.207, lsd_{vxf} = NS, cv% = 10.1				
Grain size: p_{var} = <0.001, p_{fung} = 0.784, p_{vxf} = 0.570, lsd_{vxf} = 2.45, cv% = 10.1				

Trial mean yield was 1.9 t/ha.

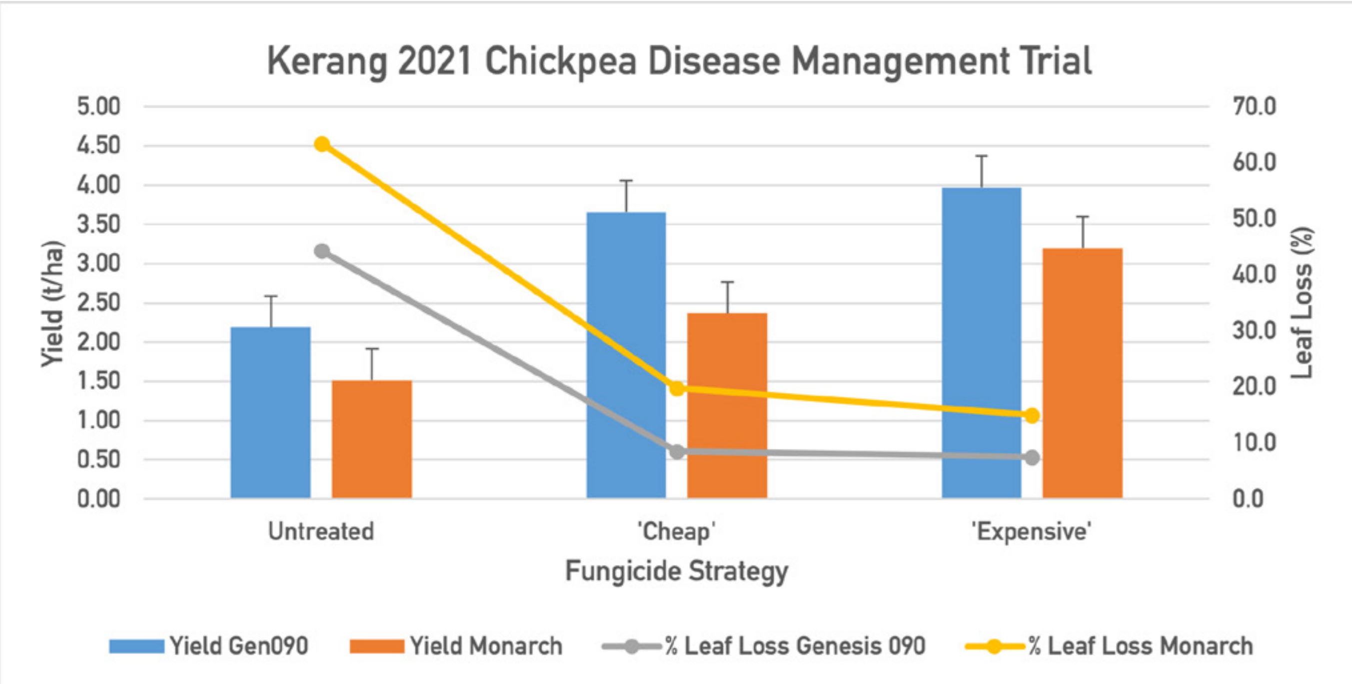
Results from Kerang 2020-2022.

The ICC Kerang site ran similar trials to the Whitton site. The major difference was in the irrigation management; the Kerang site was pre-irrigated prior to sowing and then received one spring irrigation prior to flowering (but not required in 2022).

The trial results from Kerang in 2020 were similar to that at Whitton: Disease pressure was low and fungicide strategy did not affect yield. However, variety selection did, with Genesis090 having greater yield (4.5 t/ha vs 3.5 t/ha) and smaller grain size.

2021 saw a wetter season, and increased disease pressure.

Figure 2: Leaf loss (%) and grain yield (t/ha) in the 2021 chickpea fungicide strategy trial

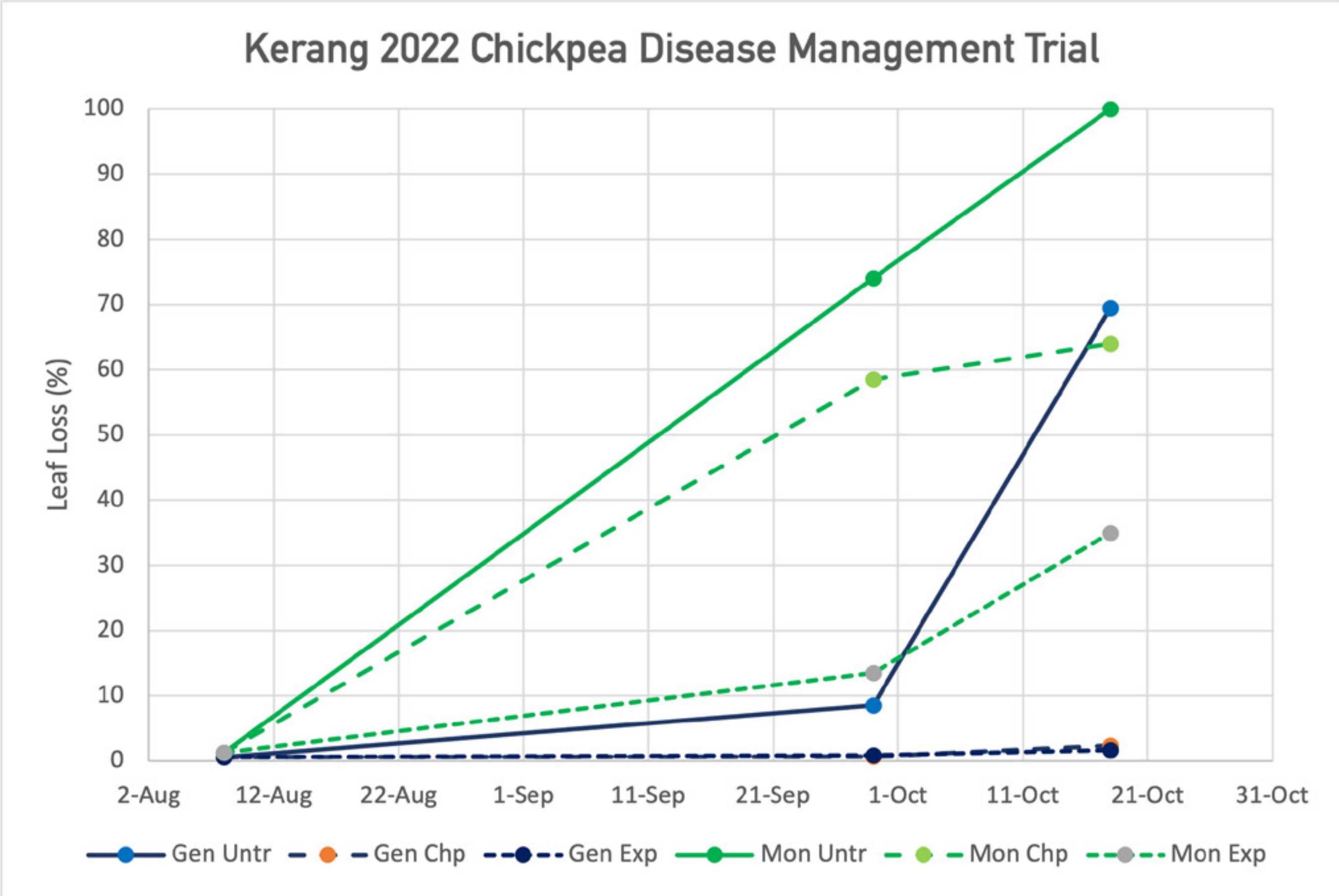


PBA Monarch demonstrated poorer disease resistance (Ascochyta) than the older Genesis090, as reflected in the % leaf loss data. The 'cheap' strategy was sufficient to protect Genesis090's yield but the 'expensive' strategy was required to maintain PBA Monarch's yield potential.

2022 proved to be an even higher disease pressure season, with Ascochyta detected in early August. The fungicide applications started in late August and were close to three-week cycle until 18 October.

PBA Monarch again proved to have less resistance, with the untreated plots quickly succumbing to disease. Untreated Genesis090 resisted significant leaf loss until late September, whereas PBA Monarch saw over 50% leaf loss at this stage in both the untreated and 'cheap' strategies and death of most plants in the untreated plots by 21 October. The 'cheap' strategy in Genesis090 saw similar leaf loss to the 'expensive' strategy.

Figure3: Leaf loss (%) in the 2022 chickpea fungicide strategy trial



Unfortunately flooding of the ICC trial site on October 31st saw the trial abandoned and not harvested. However, inspection through October revealed very little podding despite quite large and healthy (where disease was controlled) plants.

Conclusion:

Check the latest disease ratings for your intended variety – newer doesn't necessarily mean better. A more susceptible variety would require a more robust disease management strategy.

2020 and 2022 were vastly different growing seasons and this was borne out by the leaf loss results. Apart from my enthusiasm for irrigated chickpeas dented by the poor podding in the Kerang 2022 trial, the two seasons demonstrated a responsive approach should be taken when managing chickpea leaf disease.
– take into consideration the variety's current disease rating and plan you spray program in response to the season
– a dry season would see a 'cheap' strategy be quite adequate, whereas a wet season needs regular application of a more robust fungicide to keep disease at bay.

In a high disease pressure year, a spring strategy would need start in early August and be re-applied on a three-week cycle.

Optimising Irrigated Grains Durum Nitrogen Use Efficiency Trial - Nitrogen Timing trial

Damian Jones, Irrigated Cropping Council

Project Objective:

To assess the impact of nitrogen (N) timing with three levels of N on durum wheat grown with surface irrigation (hills).

Location: Darlington Point, NSW

Sown: May 2022

Cultivar: DBA Vittaroi

Harvested: 7th Dec 2022 (hand harvest)

Rotation position: Cotton (2021-22)

GSR: April-October 489mm.

Summary

N applications were applied to a durum crop (in addition to the co-operators N strategy) at either 50 and 100 kg N/ha and either GS30 (beginning of stem elongation), GS32 (2nd node), GS43 (early booting) or 50 kg/ha as UAN at GS69 (end of flowering).

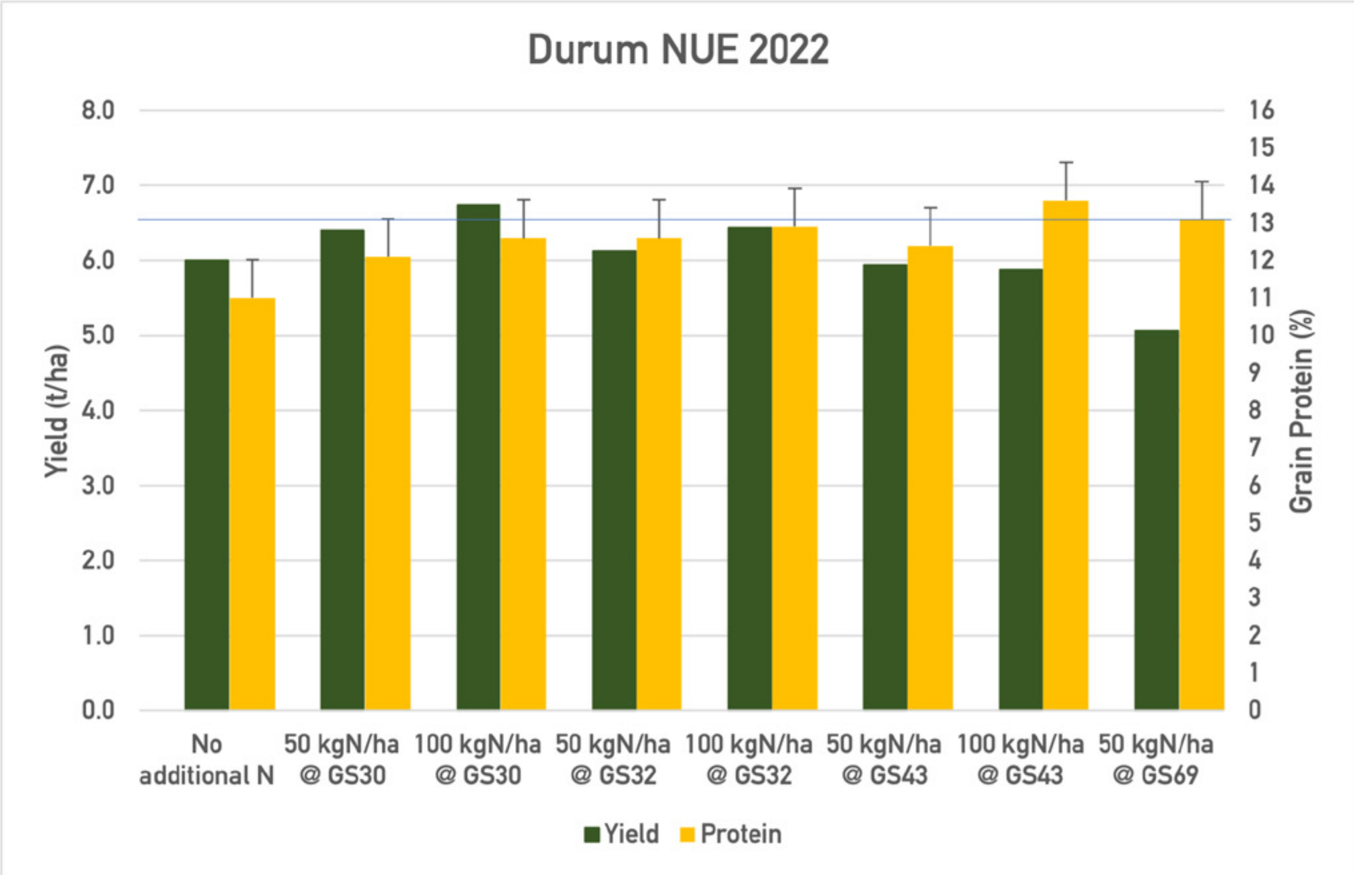
- The co-operators N strategy saw a yield of 6.0 t/ha at 11.0% protein (DR2).
- Yield was not influenced by N rate or timing when the N fertiliser was topdressed.
- Grain protein did increase as N rate increased and applied at a later stage than the co-operators strategy.
- 100 kg N/ha applied at GS43 or 50 kg N/ha after flowering saw the DR1 13% protein requirement met.
- However, the cost of attaining DR1 exceeded the price premium over DR2.
- Late application of 50 kg N/ha as a foliar spray resulted in yield loss.

Table 1: Treatment Summary – N application rates (kg N/ha) and timing (Growth Stage) in addition to the co-operator N application of 95 kg N/ha (9 July), 55 kg N/ha (21 July) and 45 kg N/ha (15 Sept)

Treatments	Nitrogen rate (kg N/ha)				
Intended N timing	GS30	GS32	GS43	GS69	
Date	28 July	18 August	20 September	12 October	**Total N applied**
Treatment 1	0	0			**195**
Treatment 2	50	0			**245**
Treatment 3	100				**295**
Treatment 4		50			**245**
Treatment 5		100			**295**
Treatment 6			50		**245**
Treatment 7			100		**295**
Treatment 8				50	**245**

GS69 treatment applied as UAN. All other treatments were as urea.

Figure1. Influence of N rate on grain yield and grain quality



Grain yield was generally consistent across all topdressed treatments, with only the late application of 50 kg N/ha as a foliar spray resulting in a reduced yield. The late application was followed by rainfall that may have seen the UAN flushed into the heads and subsequently damaging the developing grain.

The trend in grain protein was as the N rate increased and at a later timing, protein levels rose.

As DR1 wheat is about meeting the minimum specification of 13% protein, this was achieved in this trial by applying a 100 kg N/ha at GS43 or 50 kg N/ha at GS69 in addition to 195 kg N/ha applied during the season. While the late application was more 'efficient', it also resulted in a yield penalty.

Looking at the economics of the trial, the co-operator achieved 6 t/ha of DR2 at $570/t or $3420/ha income. The cost of the extra urea required to attain DR1 was approximately $260/ha (pricing urea at $1200/t) and the premium for DR1 in 2022 was $30/t over DR2, or $180/ha in this trial. Therefore, the extra cost of the urea did not exceed the extra income ($260 - $180 = $80 loss) and so the co-operator's strategy was the most profitable. The late application of UAN was even less profitable, losing $550/ha.

What is missing in this trial is the starting soil N. The durum trials at Kerang, part of the OIG project, have all been sown after faba beans, where the soil N contribution has been around 140 kg N/ha. A trial at Finley that was sown after a fabas then fallow rotation saw soil N at sowing of 232 kg N/ha which was sufficient to produce 7.4 t/ha of DR1 durum without additional fertiliser.

Conclusion

The trials have shown that we can grow irrigated durum wheat successfully and achieve DR1 if required.

High yield does require high N inputs to achieve the high protein levels required.

A considerable portion of the N required can be sourced from the appropriate rotation.

At the end of the day, the most profitable strategy will be determined by the price differentials between the durum grades and the cost of the nitrogen inputs.

Optimising Irrigated Grains Project: Chickpea Agronomy – Inoculation

Damian Jones, Irrigated Cropping Council

Trial Objective:

To evaluate the influence of different rhizobium treatments on chickpea nodulation, dry matter, grain yield and profitability under irrigation by:

Comparing the nodulation of direct drilled chickpeas sown into cotton stubble with different inoculant treatments

Assessing whether rhizobium treatments improve dry matter, yield and grain size under irrigation.

Location: Whitton, NSW

Sown: 29 May 2020 PBA Royal

Harvested: 22 December 2020

Rotation position: Cotton 2019/20

Soil Type: Neutral red clay loam, 150 cm beds

Key Messages:

- Starting soil N levels were 85 kg N/ha (0-60 cm) at sowing.
- Chickpeas had been grown in the trial location 5 years prior, and all treatments did have nodules when assessed 10 weeks after sowing.
- The higher inoculum rates of 20 and 30 kg/ha did result in higher nodulation scores than that of the untreated control.
- Yield and grain size were not influenced by the trial treatments.

The inoculation trial used the Alosca granules at three different rates 10, 20 and 30 kg/ha and compared them to no inoculation as well as topdressing 40 kg N/ha at either sowing or early podding. As the site had previously grown chickpeas about 5 years previously, we did get some nodulation of the uninoculated treatments, but inoculation did improve nodulation but the rate of inoculum didn't. However, the nodulation differences were not reflected in yields, and all treatments yielded approximately 2 t/ha.

The trial was planned to be irrigated but well-above average April rainfall (106mm) on the back of a summer crop and predictions of a wetter season discouraged the co-operator from pre-irrigation. He decided the spring rainfall was sufficient, therefore unnecessary for any spring irrigation.

Table 1. Nodulation Scores 10 weeks post sowing

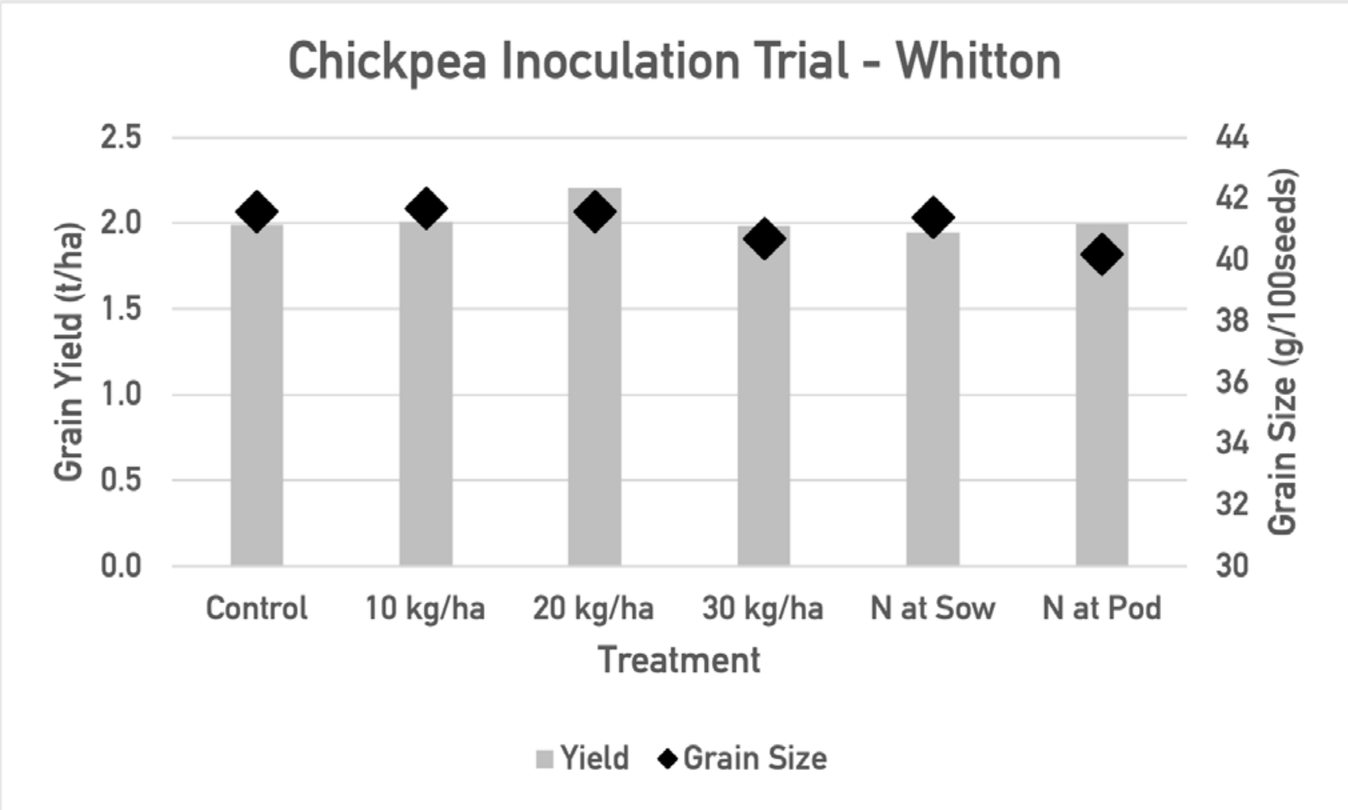
Treatment	Nodulation Score	
Nil (Control)	2.15	b
ALOSCA granules 10 kg/ha	2.65	ab
ALOSCA granules 20 kg/ha	2.80	a
ALOSCA granules 30 kg/ha80	3.00	a
N applied at Sowing 40 kg N/ha	1.85	b
N applied at Podding 40 kg N/ha	1.93	b
p = 0.004, lsd = 0.61, cv% = 16.9		

Nodulation scoring is based on the number of nodules present and their placement on the roots.
Nodulation figures followed by different letters are considered to be statistically different (p=0.05)

There was an improvement in nodulation as the rate of granule was increased.

However, the higher rate of nodulation did not result in either higher grain yield or seed size.

Figure 1. Grain yield (t/ha) and grain size (g/100 seeds)



Grain Yield: p = 0.795, lsd = NS, cv% = 13.3, trial mean = 2.02 t/ha

Grain size: p = 0.770, lsd = NS, cv% = 4.1, trial mean = 41.2 g/100 seeds

Kerang Results

The Kerang site had not grown chickpeas and so the level of nodulation was greatly improved by inoculating the seed, with the first year seeing an improvement as the rate of inoculum increased. This difference was reduced in years two and three, to the point that

However, like the Whitton site, improved nodulation did not result in a yield gain.
Yields were in the 3.5 to 4.1 t/ha range. Soil N at sowing (0-60cm) ranged from 110 to 125 kg N/ha.

Conclusion

Despite the lack of response, I would still recommend inoculating chickpeas if there are being sown into paddocks that have not grown chickpeas before, or it has been several years between crops on acidic soils. This ensures that the right inoculum in the right numbers is present to maximise the chances of having successful inoculation.

Chickpea inoculum seems to survive reasonably well in neutral clay soils.

High soil N at sowing probably negated the need for the chickpea plant to fix its own nitrogen.

IREC Irrigated Durum Trial Winter 2022

Hayden Petty and Sam O'Rafferty, Summit Ag

Aim

The purpose of this experiment was to apply Plant Growth Regulators (PGRs) to a high input durum wheat crop to understand the impact of PGRs on standability and grain protein. The trial also included a variety split within a field to understand the interaction between durum wheat varieties.

Background & Methodology

Durum wheat was sown into an ex-cotton field on 23 May 2022. Seasonal conditions and timely sowing put this crop in a high potential situation for the grower to achieve high yields. Initial N budgets were in the realm of 500 kg/ha urea applied and as such was identified as an ideal crop to test PGRs.

Once the crop reached Z31 (first node detectable), 0.2L Moddus Evo and 1L Errex were applied by aerial application in the replicated configuration shown in Figure 1.

	DBA Mataroi						DBA Vittaroi					
	-PGR	+PGR	+PGR	-PGR	-PGR	+PGR	+PGR	-PGR	-PGR	+PGR	+PGR	-PGR
Swath Width (m)	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**
Replicate	**1**	**1**	**2**	**2**	**3**	**3**	**1**	**1**	**2**	**2**	**3**	**3**
Plot Number	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**

Figure 1: Trial design.

To quantify the influence of the PGR application the crop was assessed at harvest for:

- Plant height
- Tiller number
- Harvest Index
- Yield (both hand harvest and yield map)
- Grain Quality (Protein, Test Weight, 1000 Grain Weight)

Results

Mataroi saw a 2% increase in harvest index with the application of PGR at Z31, whereas Vittaroi saw a slight reduction in harvest index with the application of PGR. Due to the poor grain fill period last season the harvest index was very low indicating that the crop struggled to convert biomass into grain. Plant height was not influenced by PGR application, however, Mataroi was 16cm taller on average than Vittaroi, a varietal trait that in another season has the potential to lodge. There was no influence on tiller number as a result of PGR application.

Yield data from harvest index cuts and header yield maps showed no yield response between variety or PGR application. Similar to yield there was no significant difference between treatments for protein %. The best treatment was Vittaroi with the PGR application achieving 11.35%, which almost met the 11.5% cut off for DR2, the other treatments fell short. Vittaroi achieved a higher 1000 grain weight than Mataroi but there was no influence from the PGR treatments.

Table 2. Average tiller counts, plant heights and calculated harvest index for each treatment

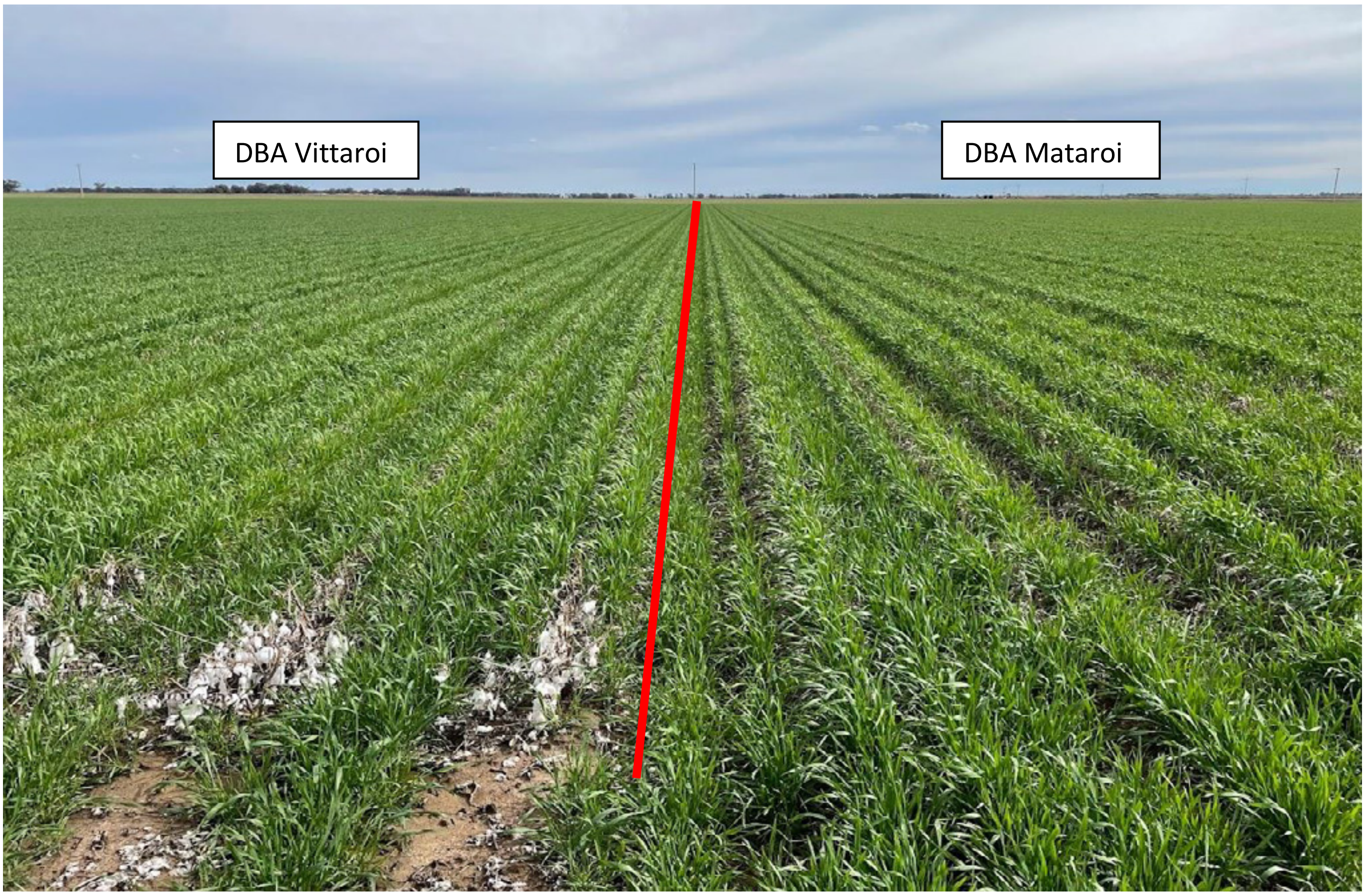
Trt	Treatment	Harvest Index	Tiller Count	Plant Height	
No.	Name	%	per m2	cm	
1	Mataroi +PGR	32.77	362.93	93.83	a
2	Mataroi -PGR	30.73	414.93	94.5	a
3	Vittaroi +PGR	28.77	402.67	77.27	b
4	Vittaroi -PGR	30.4	382.13	78.37	b
LSD P=.05		2.702	105.924	4.996	
Treatment Prob(F)		0.0577	0.6606	0.0002	

Table 3. Average grain yield (from HI cuts and yield maps), protein, test weight and 1000 grain weight for each treatment

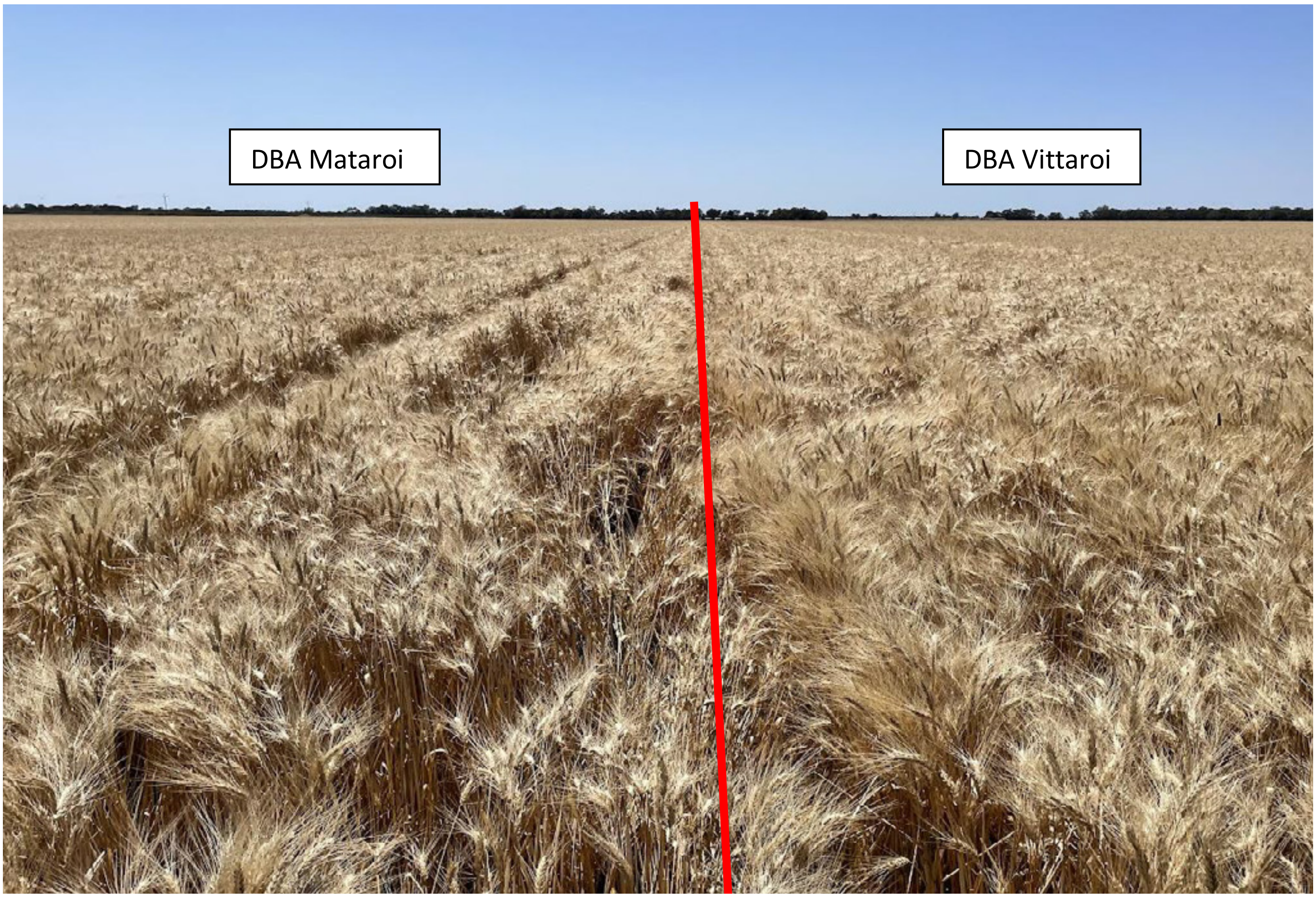
Trt	Treatment	Grain Yield (HI Cut)	Grain Yield (Header)	Grain Protein	Test Weight	1000 Grain Weight
No.	Name	t/ha	t/ha	%	kg/hl	g
1	Mataroi +PGR	6.263	6.19	10.203	74.33	46.897
2	Mataroi -PGR	6.59	6.46	11.123	74.5	47.577
3	Vittaroi +PGR	6.723	6.46	11.35	76.63	49.583
4	Vittaroi -PGR	6.883	6.26	10.49	74.63	49.923
LSD P=.05		3.0597	0.585	1.4271	9.822	2.5896
Treatment Prob(F)		0.9636	0.614	0.2686	0.9295	0.0721

Conclusion

Overall the durum trial showed no significant yield or protein changes from the application of PGRs at Z31. It showed the difference in variety height suggesting that Mataroi is a good candidate for PGR application to reduce lodging in a situation where soil constraints are not limiting. PGR applied to Vittaroi showed a 'slight' increase in protein and test weight almost pushing it into DR2 grade.



DBA Vittaroi (left) and DBA Mataroi (right) at Z31 just prior to PGR application.



Both varieties at harvest. DBA Mataroi standing on average 16cm taller than DBA Vittaroi

GRDC Irrigation Project

Ben Morris, FAR Australia

Agronomy & Soil Amelioration Research

GRDC Project: FAR 1906 – 003RTX

Winter Crops Results – Good Management Guide

IREC

Irrigation Research Update

20th July 2023

Irrigation Research & Extension Committee

PTQ Yield Potential of Wheat

Location	Estimated Optimum flowering date	Calculated PTQ (MJ/m2/d/oC>0)			Potential Yield based on PTQ (t/ha)		
		2020	2021	2022	2020	2021	2022
Finley, NSW	**18-Oct**	1.23	1.33	1.16	11.1	11.9	10.4
Kerang, VIC	**13-Oct**	1.13	1.28	1.16	10.1	11.5	10.4
Frances, SA	**27-Oct**	1.32	1.51	1.28	11.8	13.5	11.4
Hagley, TAS	**9-Nov**	1.46	1.44	1.23	13.1	12.9	11.1

Irrigated 8

- Cultivar
- Phenology to match sowing date
- Wider and later flowering window
- Bigger biomass and higher harvest index
- More nutrient efficient
- More N required but rarely responds to more than 200-250 kg N/ha
- PGRs important for irrigated crops
- Disease management critical

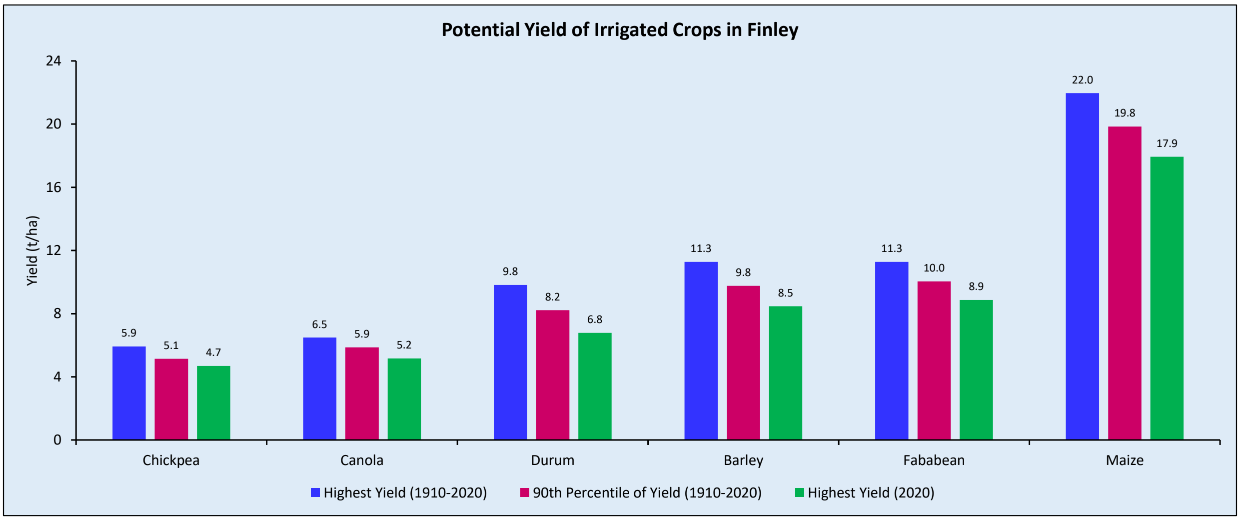
Finley Highest Yields

Crop	Highest Yield (t/ha)	Year achieved	Input costs ($/ha)	Gross Margin ($/ha)
Grain Maize	19.36	2019-20	2099	5645
Canola	5.20	2021	930	2710
Durum	8.77	2020	1059	2449
Faba beans	7.88	2021	695	2220
Chickpeas	3.66	2020	555	1641
Barley	10.10	2021	939	2394

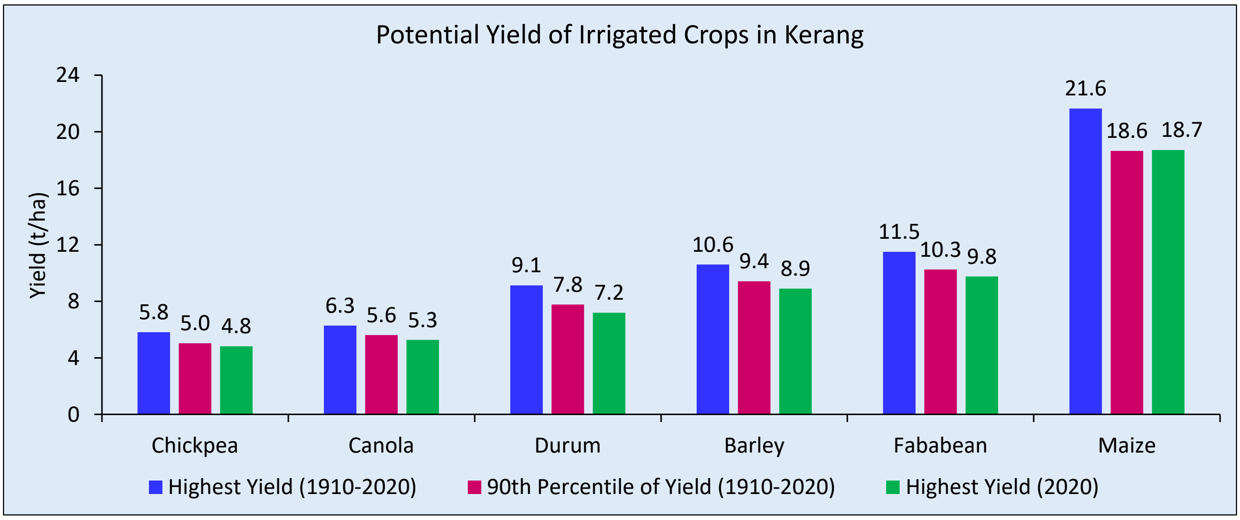
Kerang Highest Yields

Crop	Highest Yield (t/ha)	Year achieved	Input costs ($/ha)	Gross Margin ($/ha)
Grain Maize	19.40	2019-20	1348	6411
Canola	4.49	2021	930	2213
Durum	10.55	2020	1059	3161
Faba beans	7.88	2020	695	2220
Chickpeas	4.88	2020	555	2373
Barley	8.27	2021	939	1790

Apsim Yield Potential — Finley



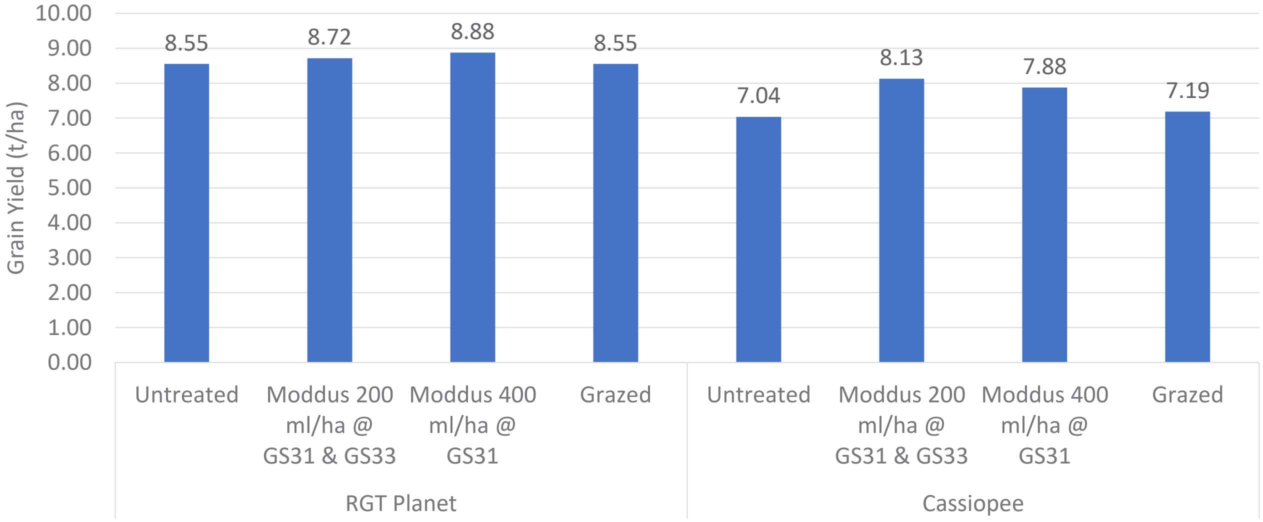
Apsim Yield Potential — Kerang



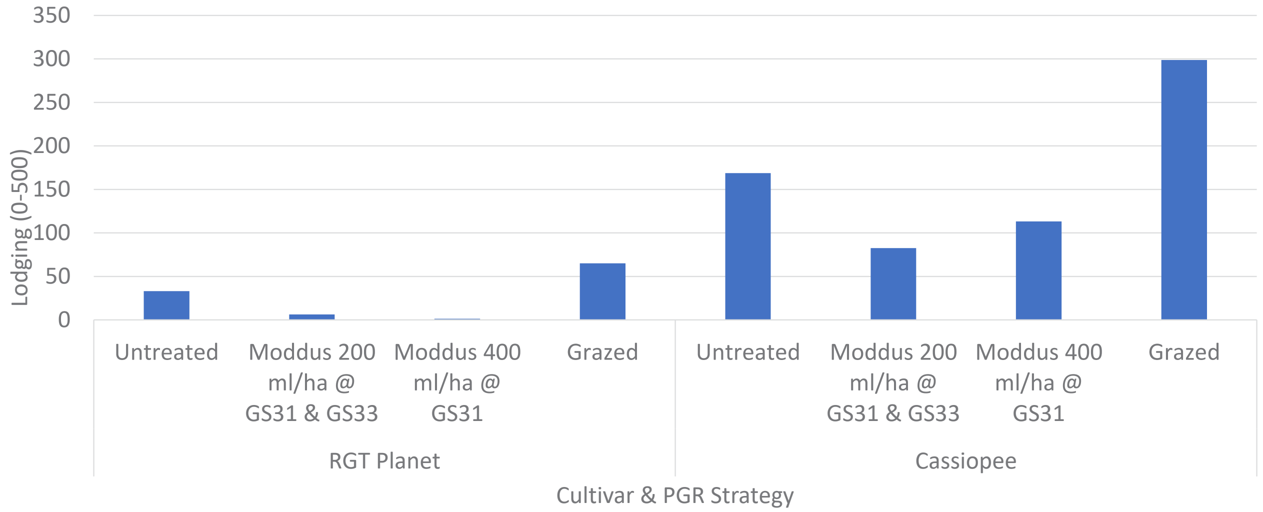
Maize Kerang 2021-22

Treatment				Grain Yield, Dry Matter Yield and Quality				
				Yield			DM	
	Pre-drill	Post drill	Total kg N/ha	t/ha			t/ha	
1.	0	0	**0**	10.34	d		22.64	d
2.	40	40	**80**	11.98	c		29.33	c
3.	80	80	**160**	15.05	bc		33.94	bc
4.	120	120	**240**	17.13	a		31.42	ab
5.	160	160	**320**	16.66	ab		32.53	ab
6.	200	200	**400**	17.76	a		35.56	ab
7.	200	200	**480**	17.04	a		33.66	a
8.	280	280	**560**	17.03	a		34.28	a
LSD Yield (p=0.05)			1.659	**P Val**			<0.001	
LSD DM (p=0.05)			3.398	**P Val**			<0.001	
LSD Test Wt (p=0.05)			ns	**P Val**			0.094	
LSD HI (p=0.05)			ns	**P Val**			0.059	

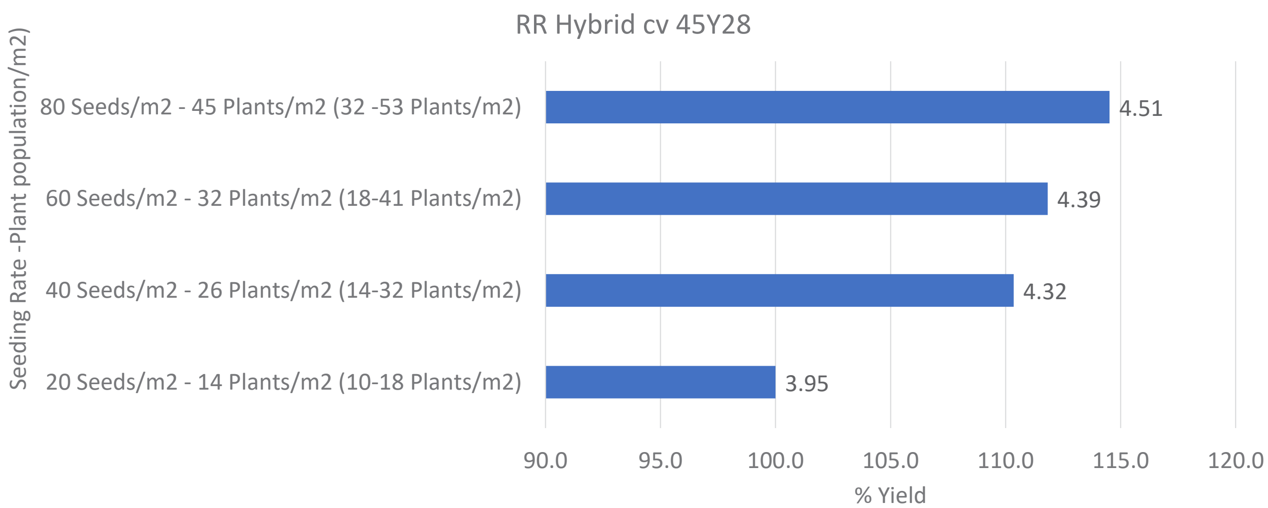
Barley Finley 2020-21



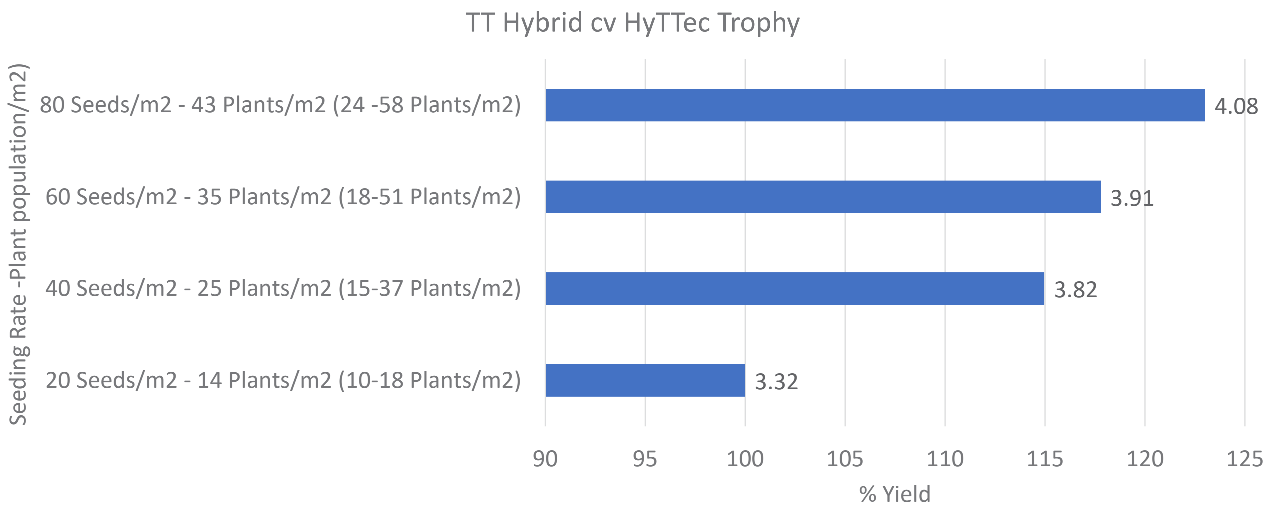
Barley Finley 2020-21



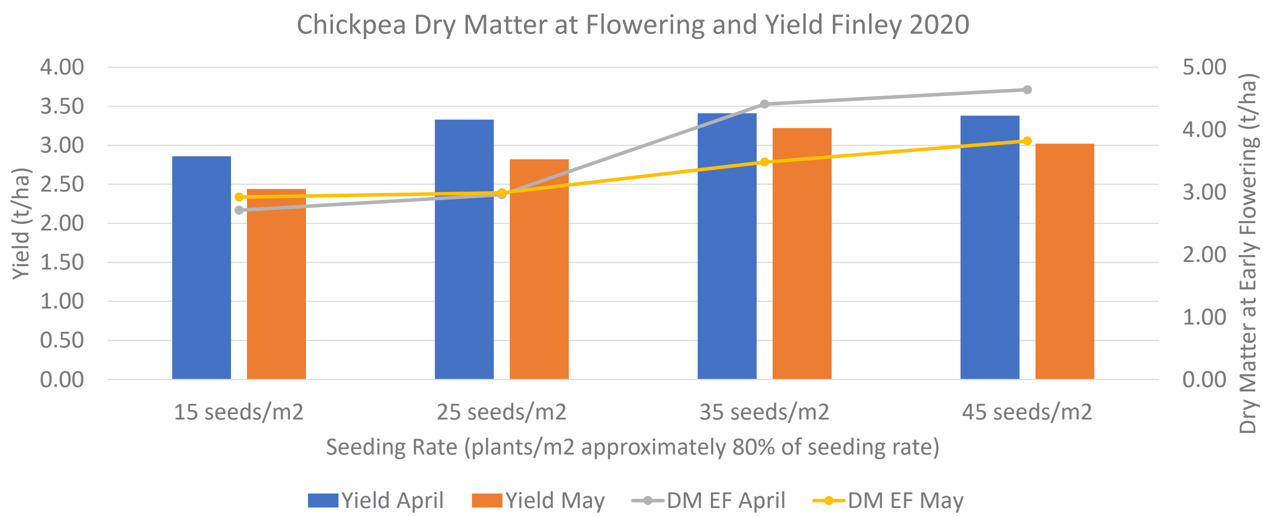
Canola Finley and Kerang 2020-21



Canola Finley and Kerang 2020-21



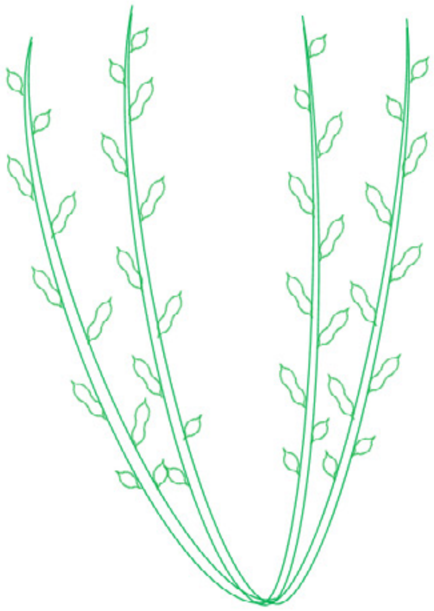
Chickpeas Finley 2020



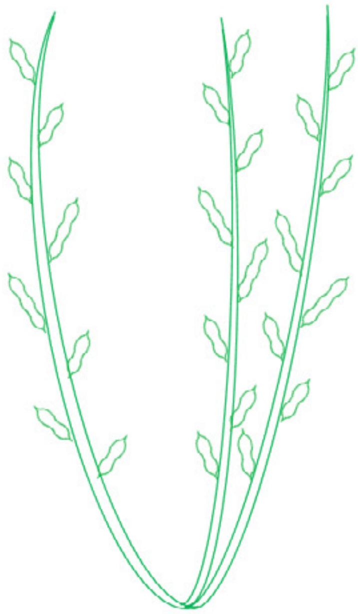
Durum N Timing

	0kg/ha N		100kg/ha N		200kg/ha N		300kg/ha N		Mean	
Nitrogen Timing	**Protein %**		**Protein %**		**Protein %**		**Protein%**		**Protein%**	
PSPE & GS30	10.9	-	12.4	-	13.8	-	15.0	-	**13.0**	**b**
GS30 & GS32	10.6	-	12.5	-	13.7	-	15.0	-	**13.0**	**b**
GS32 & GS37	10.9	-	13.4	-	15.3	-	16.4	-	**14.0**	**a**
Mean	**10.8**	**d**	**12.8**	**c**	**14.3**	**b**	**15.5**	**a**		
N Timing		LSD	0.4		P val		<0.001			
N Rate		LSD	0.5		P val		<0.001			
N Tim x N Rate		LSD	ns		P val		0.235			

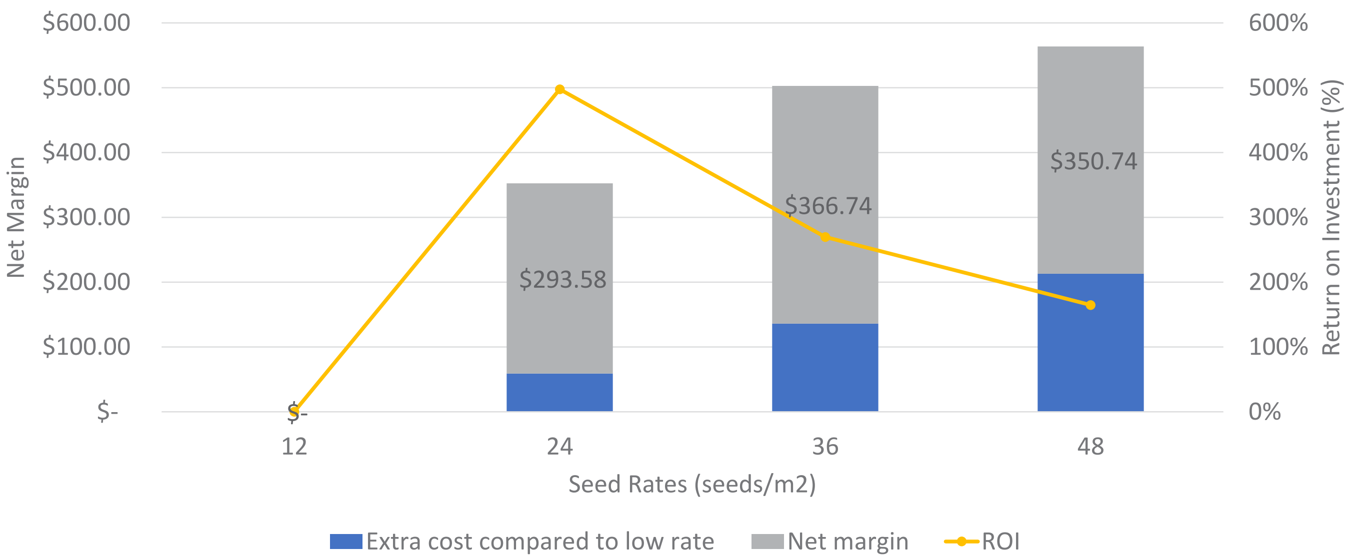
Yield Components of a 7 tonne Faba Bean Crop



Thin		Yield Component	Thick	
4.3	-	Stems/plant	2.7	-
9.5	-	Pods/stem	7.9	-
492	-	Pods/m^2	471	-
1.7	-	Seeds/pod	2.3	-
687	-	Tsw (g)	694	-
52	**b**	**Stems/m^2**	**60**	**a**
840	**b**	**Seeds/m^2**	**1088**	**a**



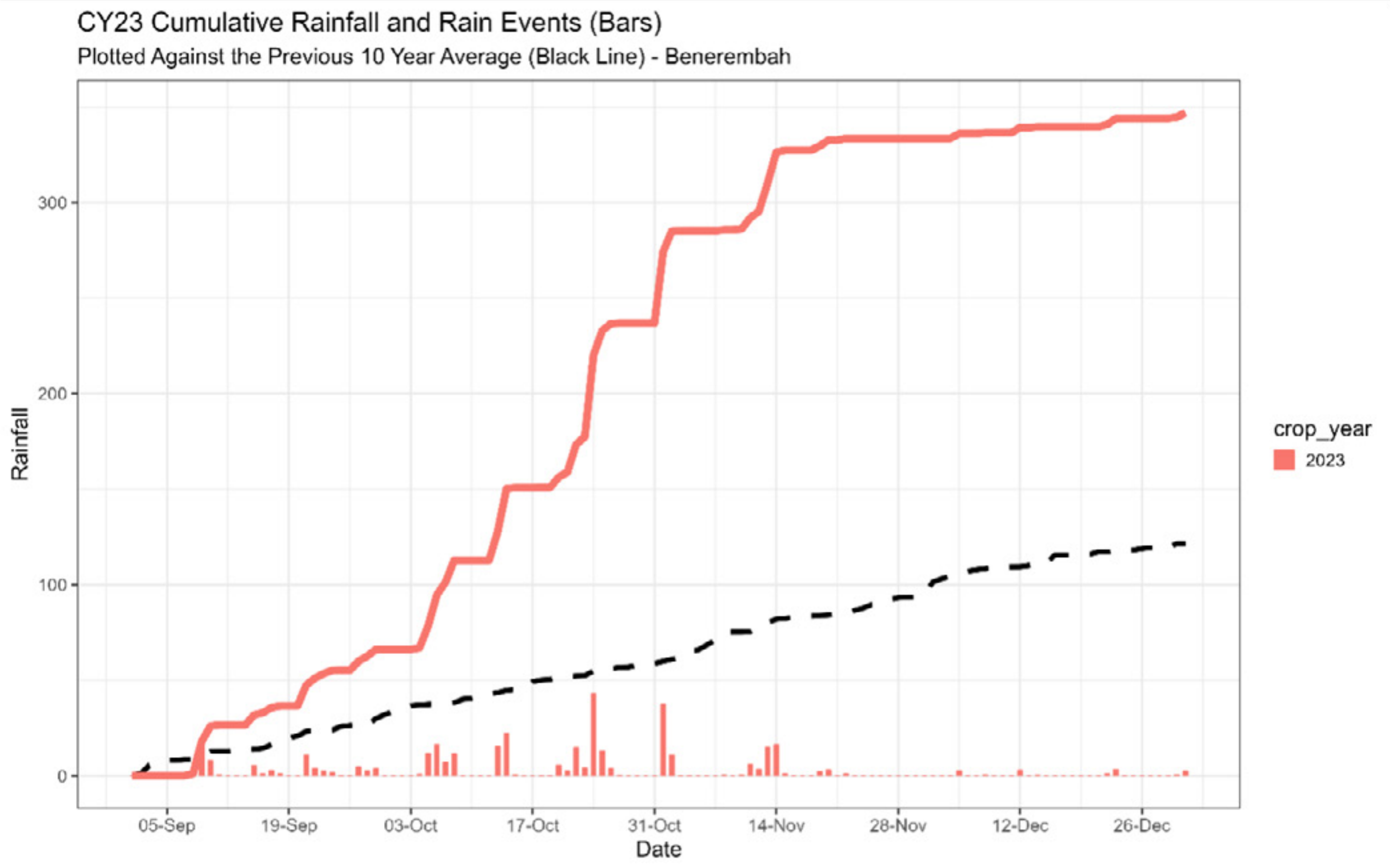
Economics of Higher Seed Rates



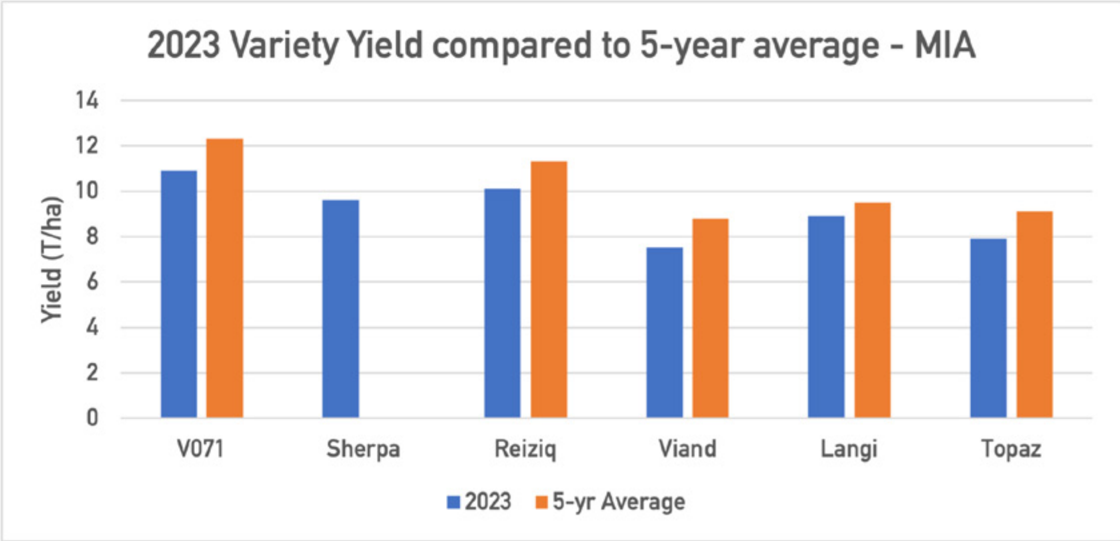
Rice 2022/23 – What have we learnt?

Mark Groat, SunRice

2023 will be remembered as many rice growers, and indeed any summer crop growers, as a very challenging season. The below cumulative rainfall chart says it all, with an exceptionally wet spring following a wet winter making preparation almost impossible for many paddocks. This meant less than 20% of crops within the MIA were planted within their ideal window.



To add to the challenges, the season was significantly cooler than long term average, particularly during the early vegetative phase and then again at the critical (and cold sensitive) reproductive phase. This all added up to a late harvest with, still to date, the final few deliveries are being made. The (almost) final harvest figure had an overall average of 10.2T/ha, or 8% below the previous 5-year average of 11.1T/ha (average of all varieties). Interestingly all varieties performed to a similar standard. Topaz, the least cold tolerant variety, performed as well as V071, the dominant and most cold tolerant variety (as a percentage compared to the 5-year average).



Also, as with every season, there was the standouts. The top paddock yield was 15.1T/ha, with 22% of farms achieving above 12T/ha. The average of the top 20% of V071 yields, which was 65% of the crop area, yielded an average of 13.1T/ha. This was 2.2T above the average of 10.9T/ha for V071. This is a similar trend every year, for every variety within every region where the Top 20% yields around 2T/ha better than the average for the same region.

So, what did these Top yields have in common? Given how difficult the season was, how were these yields achieved?

1. Timing was everything – getting the crop in the ground in a timely manner trumped ideal preparation or even having fertiliser already in the ground for the water seeded crops. Generally speaking, yield dropped by 0.6T/ha/week for every week planted after November 1st for V071 to early December.

2. Preparation was key – ground prepare the previous autumn allowed planting to take place on time in good conditions.

3. Flexibility of management – much of the 2023 crop was planted into rice stubble and burning the stubble in spring and getting on the ground proved very difficult. For many, Plan A was not an option and having the flexibility to decisively change direction paid dividends. This included changing sowing methods, fertiliser application, variety choice and weed control.

4. Weed control – while getting seed in the ground was paramount, a knock down spray to clean up seedbeds was extremely important. A mild, wet winter meant plenty of established dirty dora and barnyard grass that was both difficult and expensive to control in crop.

5. Nutrition – high yields can only be achieved with adequate nutrition. For many, nitrogen applications particularly could not be ideally achieved. To compensate crops were fertilised with less efficient and more expensive application methods, such as flying urea into water. Compensating for this with higher rates and multiple applications however still yielded excellent results.

6. Water Management – many crops experienced cold temperatures during the critical reproductive and cold sensitive microspore phase. Deep water alleviated a lot of potential damage but getting the timing right was critical

7. Limit expectations – for those crops that were planted late, the management of nitrogen application and rates was a function of plant population, how late the crop was and variety. High rates on late and thick crops usually resulted in a bulky crop with low yields.

In all, given the preparation and establishment conditions for the 2023 rice crop, to get individual high yields and even to get a final result that is only 8% below the 5-year average is a real credit to the adaptability of the crop and the skills of the producers.

Herbicide resistance status and spatial distribution of key mobile weeds in the Riverina (MIA): implications for area wide management strategies

Dr Rick Llewellyn (CSIRO), **Christopher Preston** (University of Adelaide), **Christina Ratcliff**, and **IREC**.

Summary findings

- Resistance to glyphosate was identified in fleabane samples from the Riverina. The frequency of resistance varied with year.
- Glyphosate-resistant samples were distributed across the sampled region.
- None of the fleabane samples tested was resistant to paraquat + diquat.
- Resistance to glyphosate was found in most of the annual ryegrass samples from Riverina in both years.
- Glyphosate-resistant annual ryegrass was distributed relatively evenly across the sampled region.
- One sample of silverleaf nightshade from Riverina (from 11) survived glyphosate on testing. A dose response experiment showed this sample had increased tolerance to glyphosate compared to a sample of silverleaf nightshade that was controlled by glyphosate.
- There was no major spatial pattern to the distribution of glyphosate resistance in any of the weeds, with no obvious major clusters of resistance on localised areas.
- The presence of susceptible weeds on paddocks (and roadsides) nearby resistant populations but no strong evidence of districts or land uses with particularly high levels of resistance suggests a 'neighbourly' approach to resistance spread will be important.

Background

In the multi-region area-wide weed management project supported by GRDC, CRDC and DAWE, major effort was made to map and spatially analyse resistance to the priority mobile weeds of cropping in each region. The aim was to identify levels and patterns of resistance to inform future resistance management strategies.

The project involved over 400 geo-referenced weed samples fleabane, feathertop Rhodes grass, annual ryegrass, common sowthistle and silverleaf nightshade were tested for resistance to glyphosate. Fleabane was also tested for resistance to paraquat + diquat and common sowthistle to 2,4-D (sampling area from IREC collections in the Riverina are shown in maps below). Only results from the Riverina are presented here.

Resistance results

Three weed species were collected in Riverina and tested for resistance to glyphosate (Table). In 2020 64 samples of fleabane were tested with a further 57 samples tested in 2021. In 2020, 64% of the tested samples were resistant to glyphosate and in 2021 37% of the samples tested were resistant. There was no resistance identified in either year to paraquat + diquat. The amount of resistance to glyphosate detected in 2021 was lower than 2020.

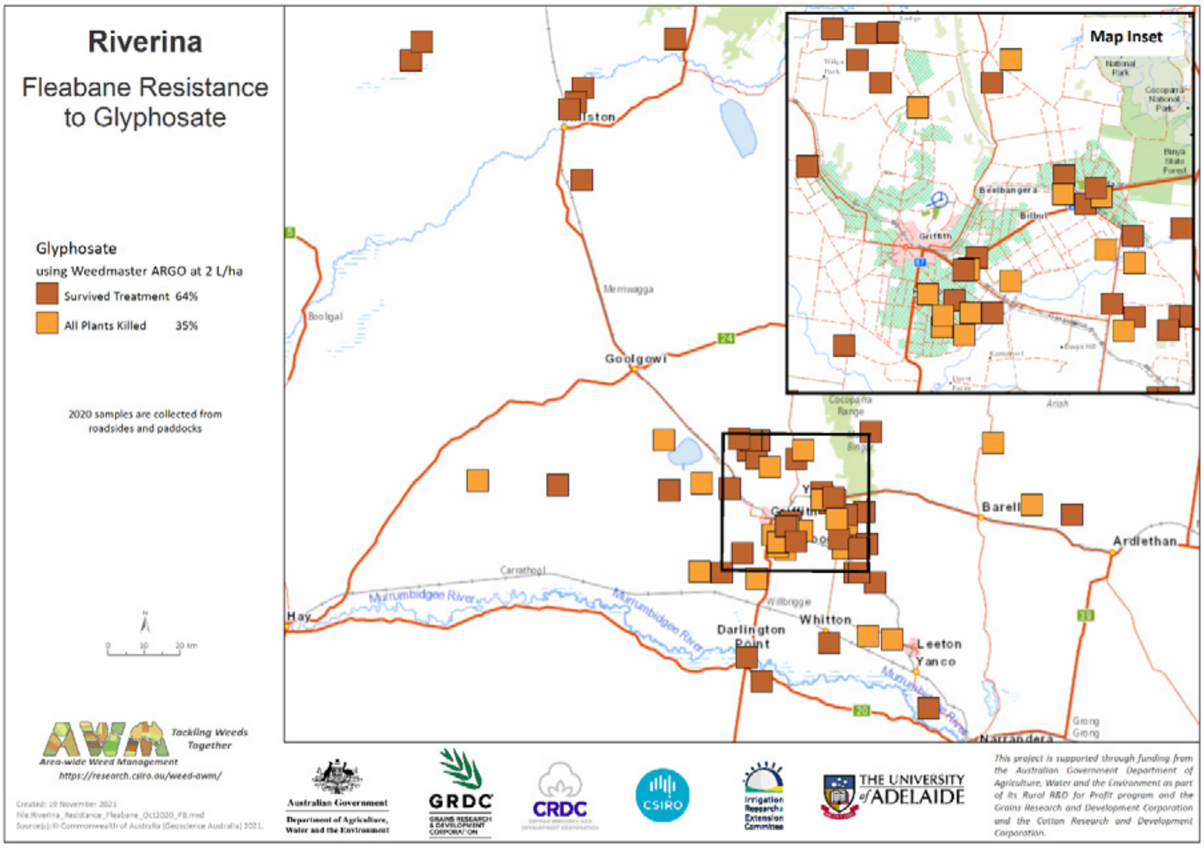
Identified by regional stakeholders as being potentially high cost, a total of 11 samples of silverleaf nightshade were also tested in 2021. A single sample had survivors to glyphosate (Table). It was tested a second time and also had survivors. There is no label rate for glyphosate for controlling silverleaf nightshade, so a dose response experiment was conducted to confirm resistance in 2022.

Table. Results of resistance testing for fleabane, annual ryegrass and silverleaf nightshade from the Riverina to glyphosate and fleabane to paraquat + diquat in 2020 and 2021.

Weed species	Year	Samples tested	Resistant to glyphosate	Resistant to paraquat + diquat
Fleabane	2020	64	41	0
	2021	57	21	0
Annual ryegrass	2020	20	13	-
	2021	16	13	-
Vineyard samples				
Fleabane	2021	22	9	0
Silverleaf nightshade	2021	11	1	-

- not tested

This dose response experiment was conducted using plants grown from short root pieces, which tend to be more tolerant that plants grown from seedlings. Silverleaf nightshade is a deep-rooted perennial weed that is poorly controlled by glyphosate due to its ability to re-shoot from its extensive root system. Increased tolerance to glyphosate in silverleaf nightshade would be a major challenge to grape growers in the region, as they can have no other effective tactics to control this weed species.



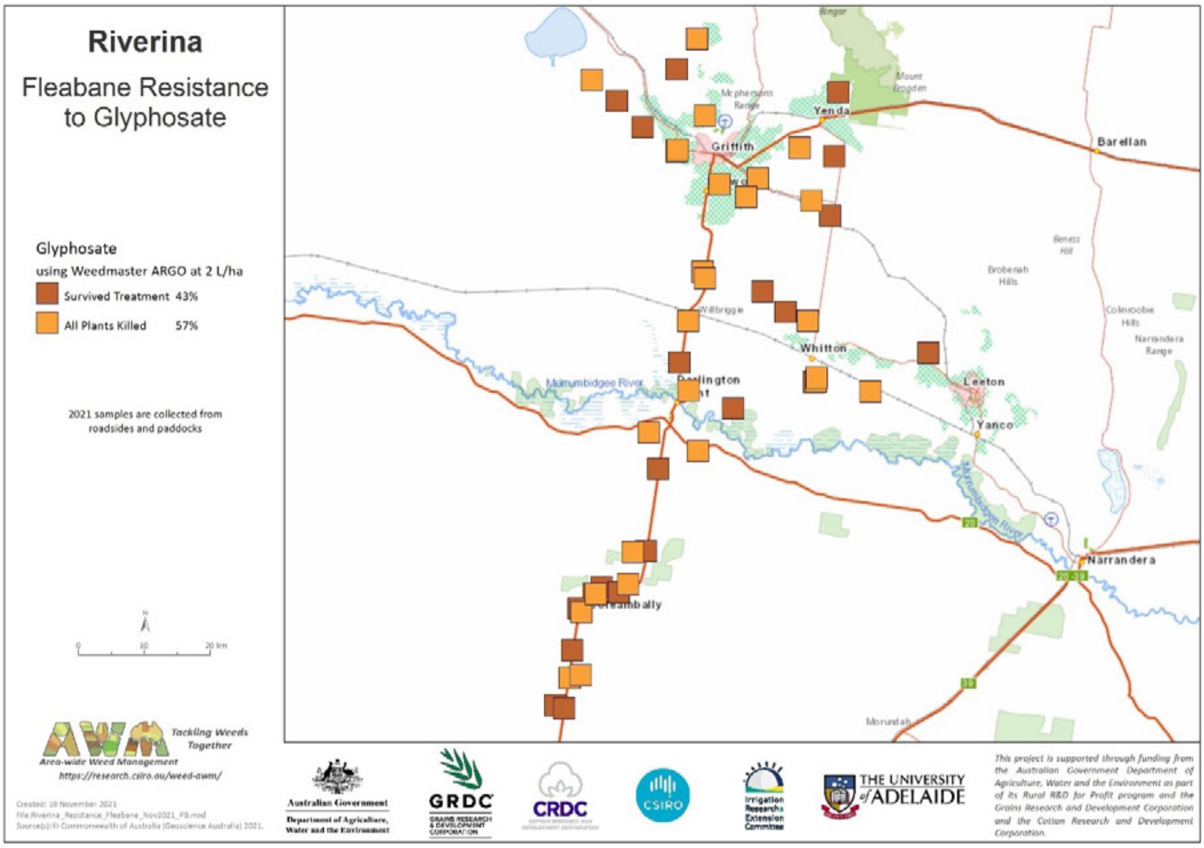


Figure. Distribution of glyphosate-resistant (dark symbols) and glyphosate-susceptible (light symbols) of fleabane in the Riverina in 2020 (top) and 2021 (bottom).

In both 2020 and 2021, fleabane was distributed across the region (Figure). In 2020, there were more samples collected north of Griffith than in 2021. The area around Hillston only had glyphosate-resistant fleabane in 2020; however, elsewhere, resistant and susceptible samples were located in close proximity to each other. The Hillston area was not sampled in 2021. The area sampled in 2021 contained a mix of resistant and susceptible samples with resistant samples located close to susceptible samples.

There were 20 samples of annual ryegrass tested in 2020 and 16 samples tested in 2021. In 2020, 65% of annual ryegrass samples tested resistant to glyphosate and more in 2021. These results show that glyphosate resistance in annual ryegrass is widespread in the Riverina region but substantial susceptibility still remains.

The distribution of glyphosate-resistant annual ryegrass occurred across the region sampled in 2020 (Figure below). Samples resistant and susceptible to glyphosate occurred in all parts of the region sampled.

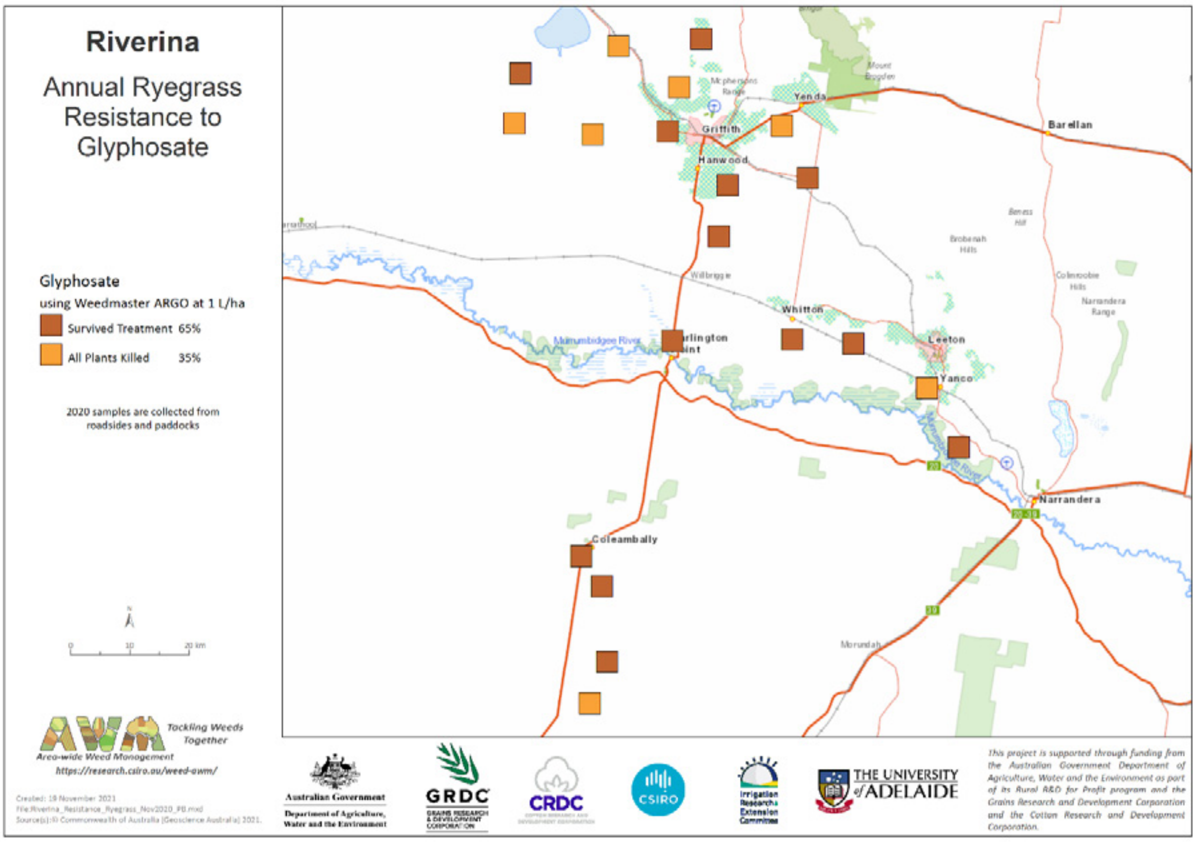


Figure. Distribution of glyphosate-resistant (dark symbols) and glyphosate-susceptible (light symbols) of annual ryegrass collected from the Riverina in 2021.

A set of samples of fleabane and silverleaf nightshade were separately collected from vineyards in the Riverina in 2021. Of the 22 fleabane samples, 9 were resistant to glyphosate and none were resistant to paraquat + diquat (Table above). The frequency of glyphosate resistance in fleabane samples from vineyards (41%) was similar to that observed in the structured collection across the Riverina.

Conclusion

The results show that resistance to glyphosate was common in fleabane and annual ryegrass. However, there was no resistance to paraquat + diquat in fleabane in the Riverina districts sampled (or Sunraysia). Glyphosate resistance in the weeds tested was spread across each of the sampled regions. The frequency of glyphosate resistance varied between years, in part because of different locations being sampled. However, for fleabane there was also likely to be some local extinction of populations between years, affected by the short seedbank life.

There was no significant pattern to the distribution of glyphosate resistance in any of the weeds. For example, there is no clear evidence that high levels of resistance in one sub-district could be restricted from spreading to a sub-district with low frequency of resistance. This suggests a combination of multiple resistance evolution events and relatively random spread contributed to the distribution of each weed. The presence of susceptible populations close to resistant populations suggests potential for 'neighbourly' approaches to management of resistance risk and its spread.

Evidence of weed spread across the MIA (AWM)

James Hereward, UQ

Area-wide Weed Management

Social science

Genetics

Herbicide resistance testing

Regional trials

Economics

More mobile weeds are generally better candidates for AWM

sustainability

MDPI

Article

Opportunities to Manage Herbicide Resistance through Area-Wide Management: Lessons from Australian Cropping Regions

Kaitlyn Height *, Sonia Graham, Rebecca Campbell, Gina Hawkes, Silja Schrader, Louise Blessington and Scott McKinnon

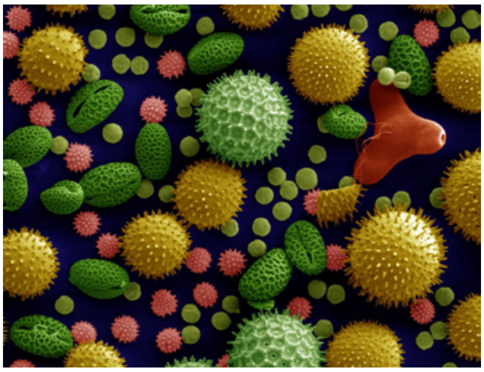
School of Geography and Sustainable Communities, University of Wollongong, Wollongong, NSW 2522, Australia; sgraham@uow.edu.au (S.G.); crebecca@uow.edu.au (R.C.); ghawkes@uow.edu.au (G.H.); silja@uow.edu.au (S.S.); louise.blessington@anu.edu.au (L.B.); scottmck@uow.edu.au (S.M.)

* Correspondence: kheight@uow.edu.au

Spread of resistance is a major concern and potential driver of AWM

Growers worried about resistance spreading to neighbours property

At what scale do weed individuals and herbicide resistance genes move?



pollen

seeds

Feathertop Rhodes Grass

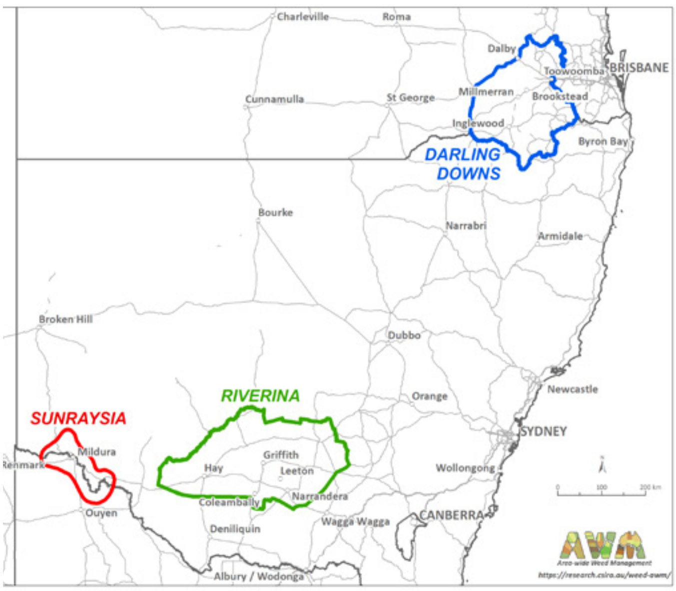
Chloris virgata

Fleabane

Conyza bonariensis

Annual Ryegrass

Lolium rigidum



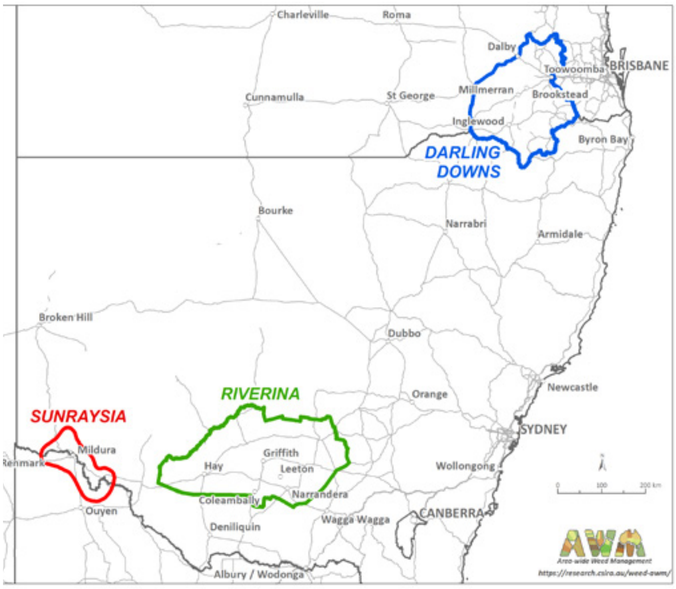
2020 sampling

Darling Downs

Sunraysia

Riverina

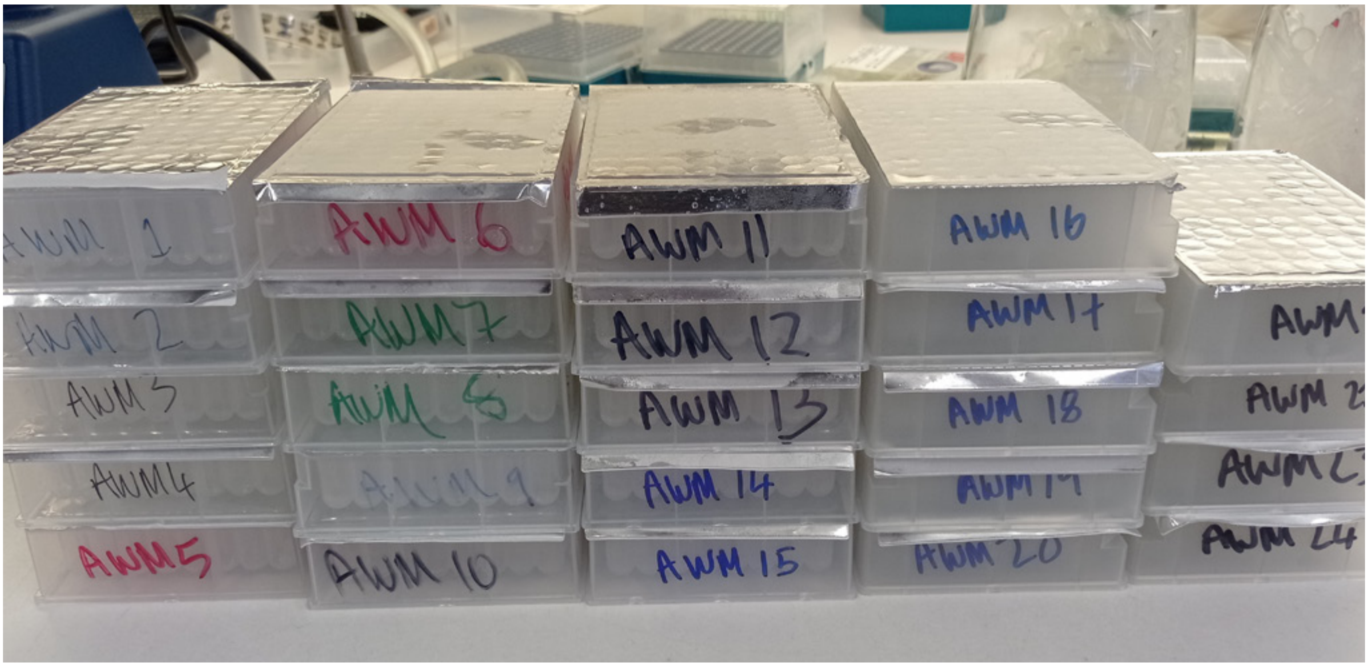
2021 sampling



Darling Downs

Sunraysia

Riverina



$F_{ST} = 0.0059$ $F_{IS} = 0.1314$ outcrossing

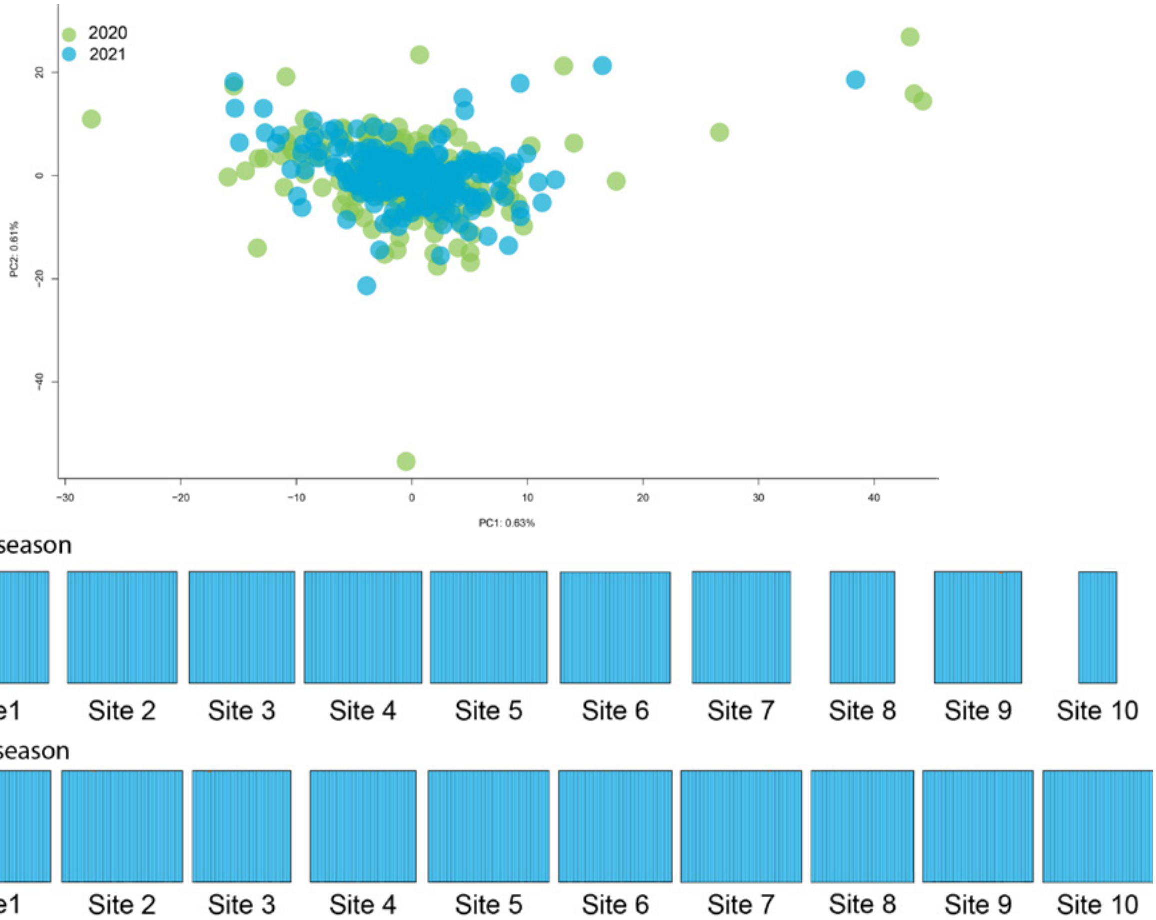
$F_{ST} = 0.0075$ $F_{IS} = 0.0024$ outcrossing

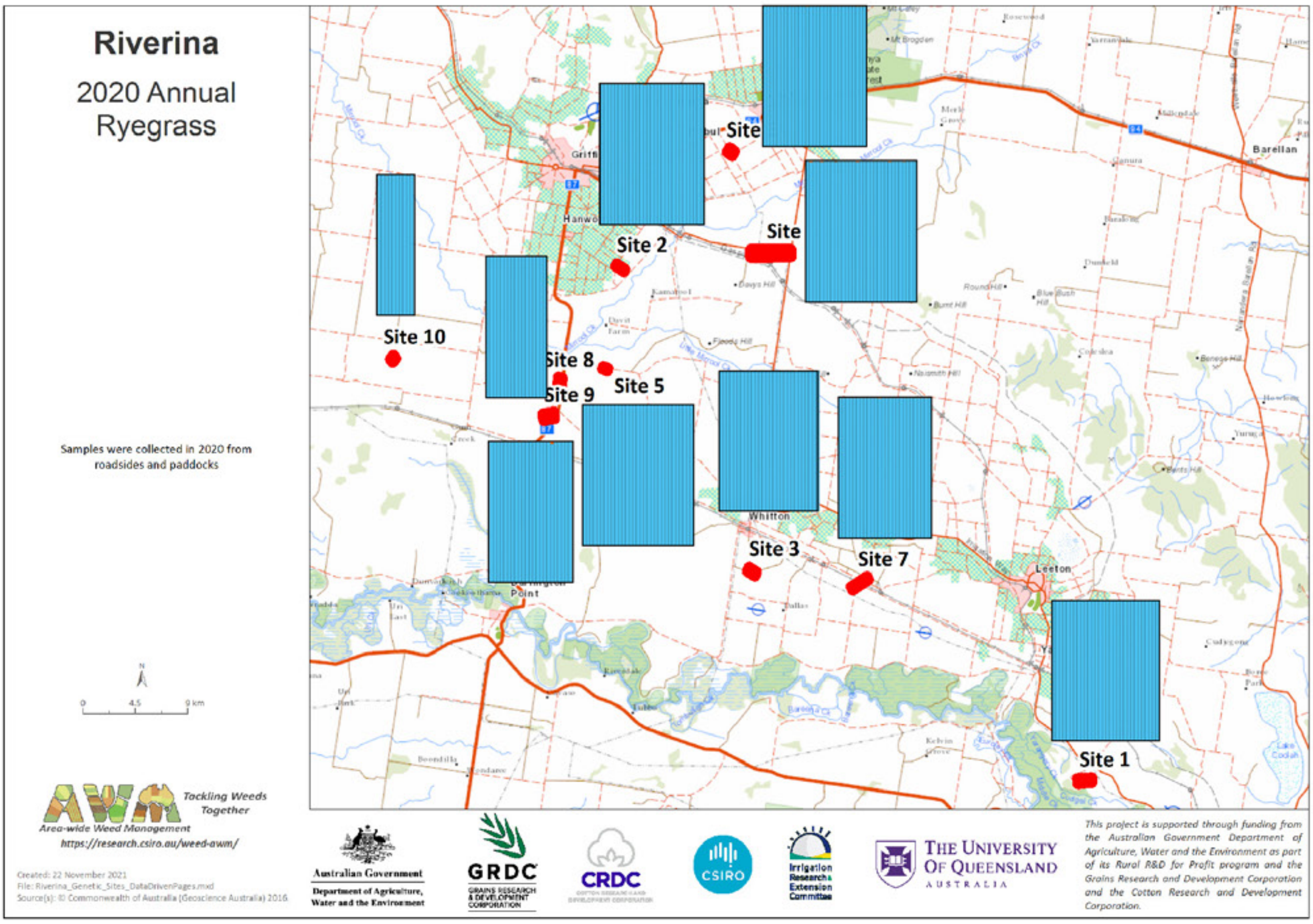
$F_{ST} = 0.2670$ $F_{IS} = 0.7289$ selfing

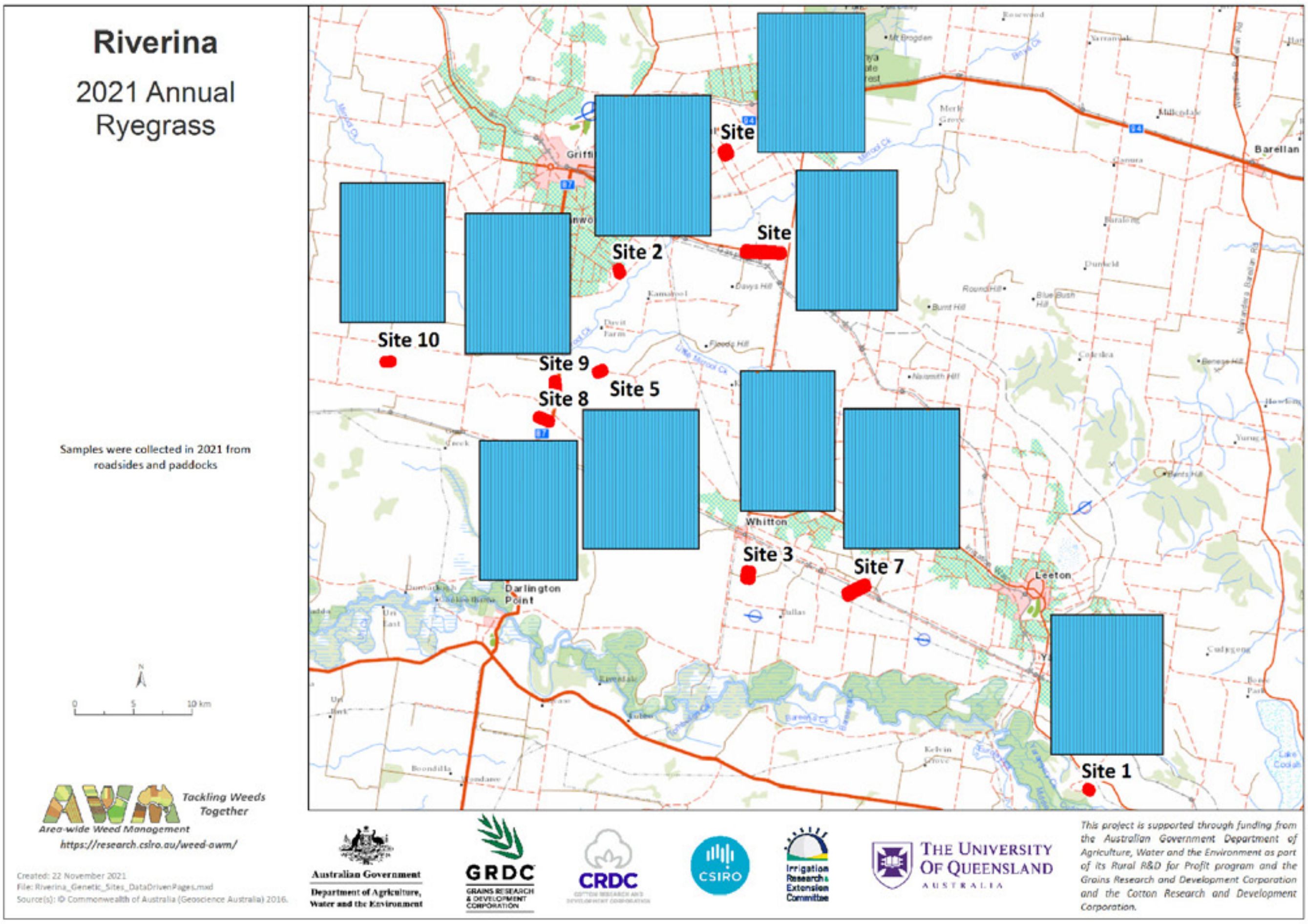
FTR and Ryegrass can move resistance genes by pollen as well as seed

Outcrossing also enables weeds to stack resistance to different modes of action more effectively

Ryegrass
Riverina
2020 and 2021




Riverina
2020 Annual Ryegrass
Samples were collected in 2020 from roadsides and paddocks
Site
Site 2
Site
Site 10
Site 8
Site 9
Site 5
Site 3
Site 7
Site 1
Griffith
Hanwood
Whitton
Leeton
Darlington Point
Barellan
Tackling Weeds Together
Area-wide Weed Management
https://research.csiro.au/weed-awm/
Created: 22 November 2021
File: Riverina_Genetic_Sites_DataDrivenPages.mxd
Source(s): © Commonwealth of Australia (Geoscience Australia) 2016.
Australian Government
Department of Agriculture, Water and the Environment
GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION
CRDC
CSIRO
Irrigation Research & Extension Committee
THE UNIVERSITY OF QUEENSLAND AUSTRALIA
This project is supported through funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program and the Grains Research and Development Corporation and the Cotton Research and Development Corporation.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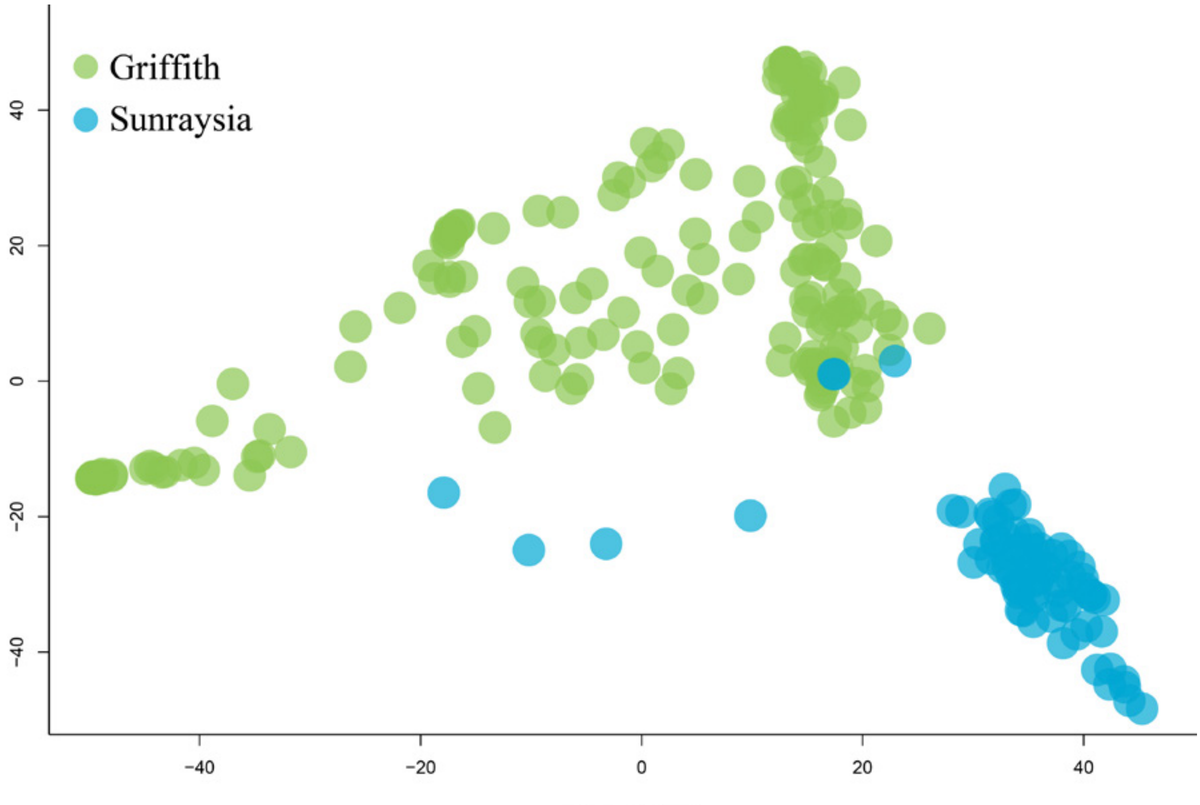
High gene flow across the Riverina region

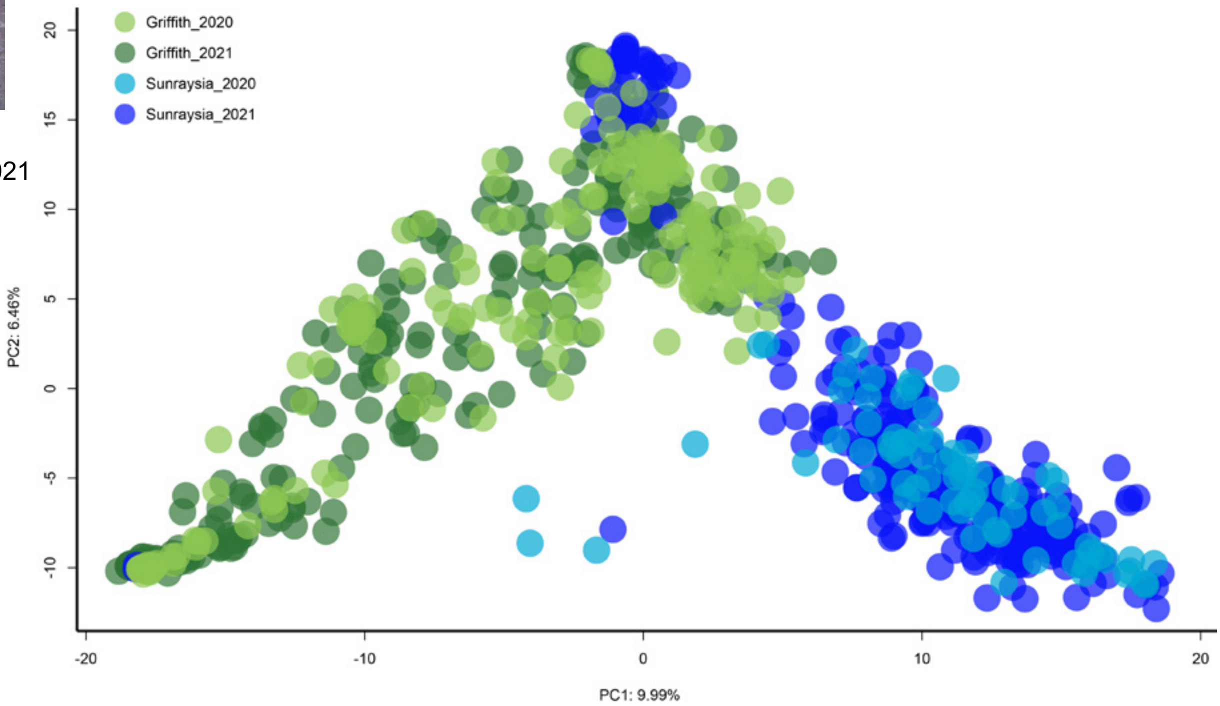
Geneflow spreads resistance across region

~35% susceptible in 2020

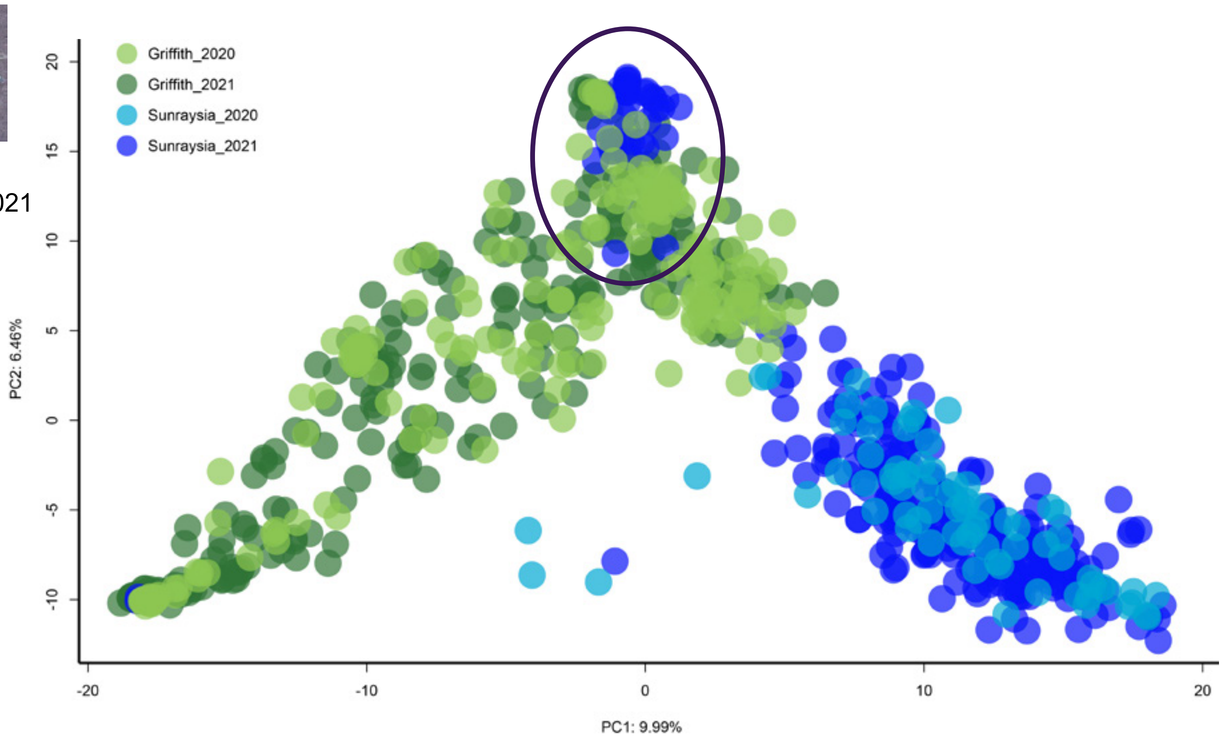
Fleabane
2020

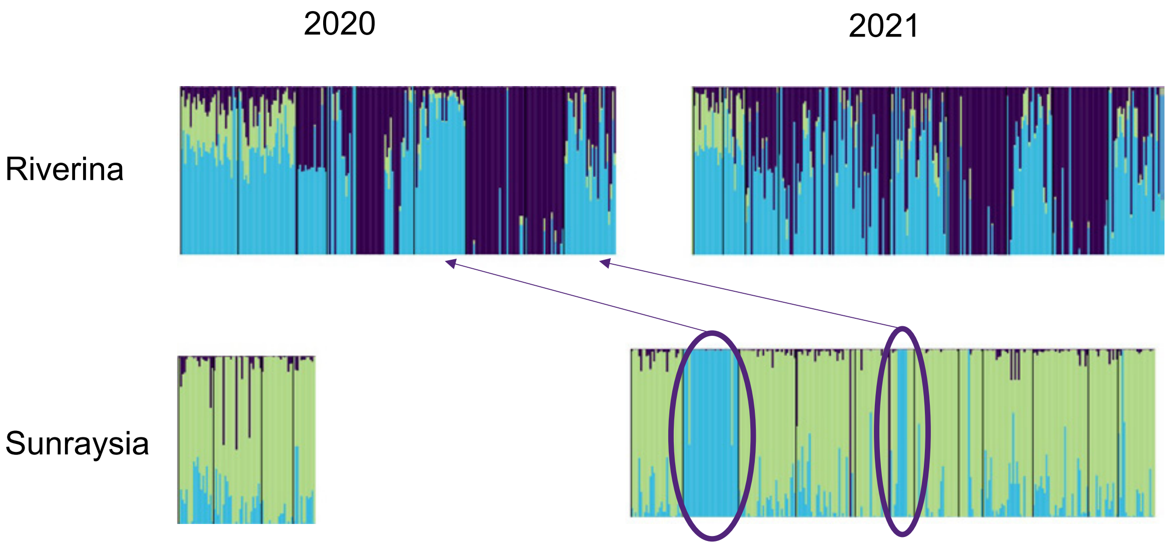


Fleabane
2020 and 2021



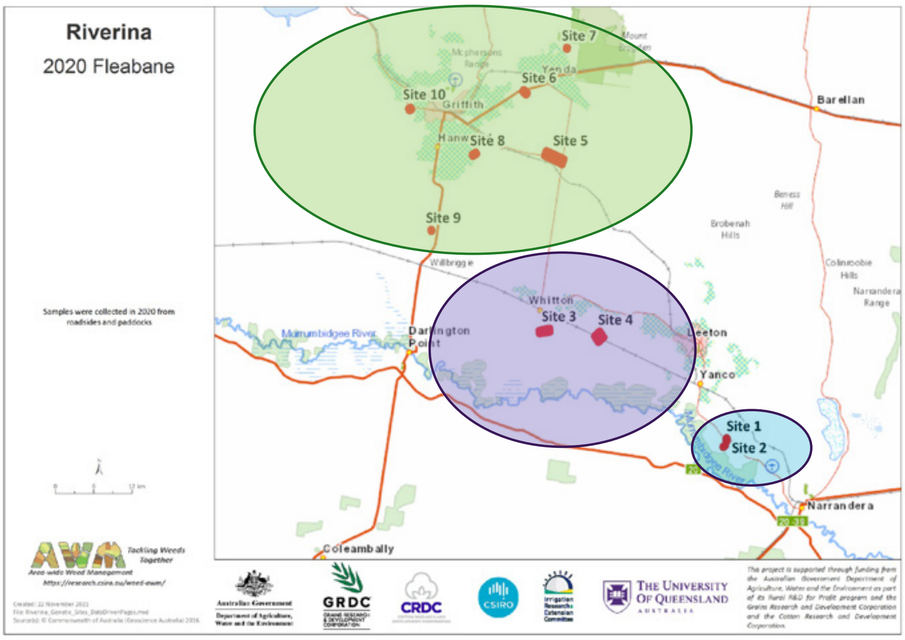
Fleabane
2020 and 2021

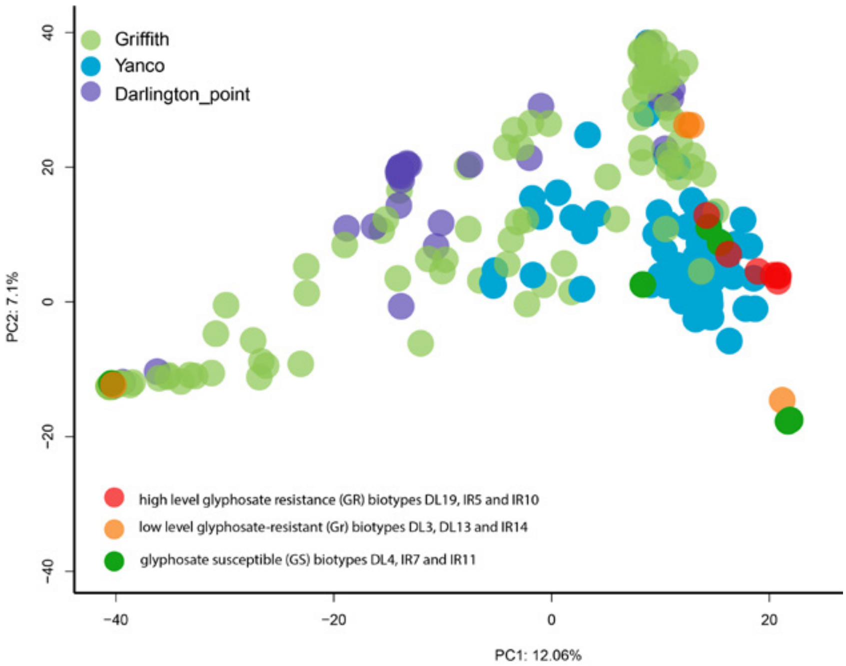




Evidence of long distance dispersal of Fleabane between regions

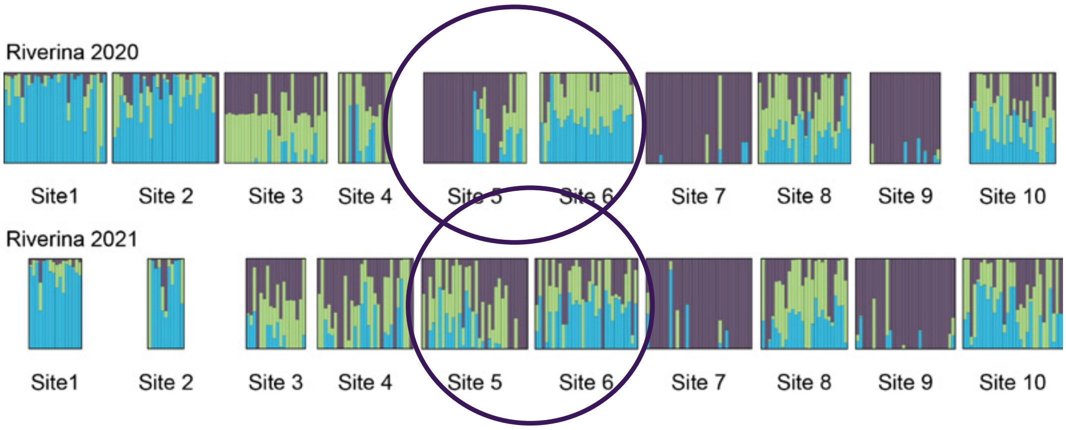
Fleabane
Griffith
2020





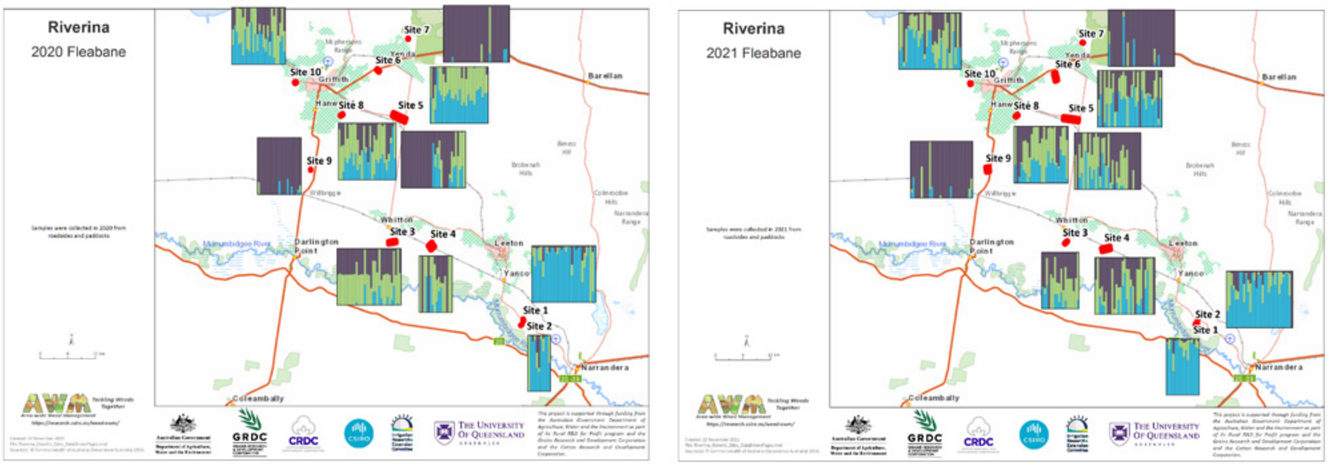
Fleabane
Griffith
2020 and 2021

2020



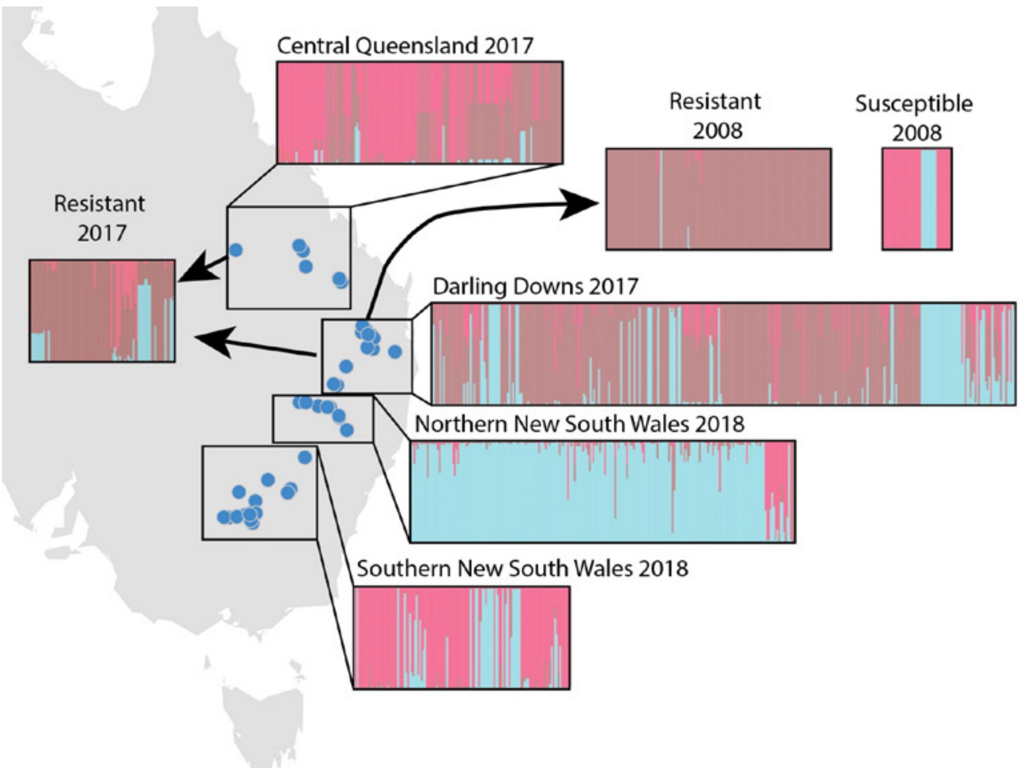
Road road farm road farm road farm farm farm farm

2021



2020 2021

Fleabane
CRDC
Project
UQ1501



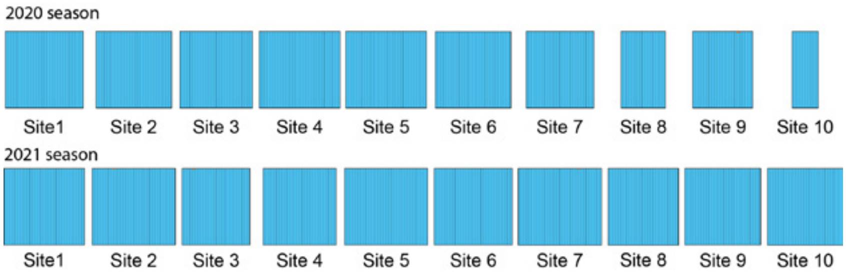
Fleabane
Griffith
2020 and 2021

More genetic structure within the region than expected

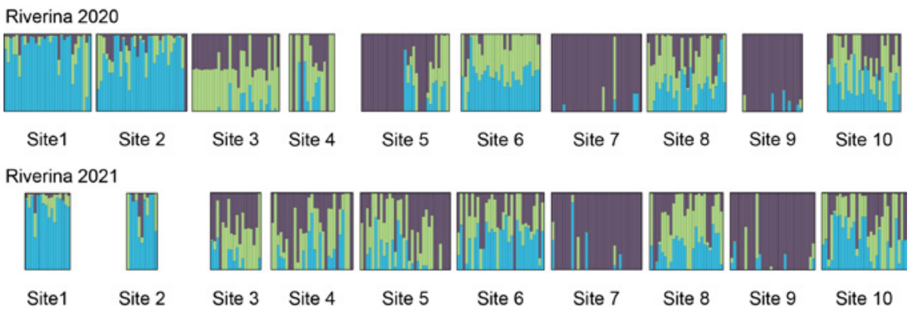
Population structure was similar in 2020 and 2021 – seed set from previous year

Mobile weed but less geneflow than Ryegrass at a regional scale – low pollen flow?

Ryegrass



Fleabane



Coordinated control of highly mobile weeds likely to reduce spread of herbicide resistance and regional resistance levels

Growers' attitudes and practices towards area-wide management of weeds in the Riverina

Gina Hawkes, Sonia Graham, Kaitlyn Height, Rebecca Campbell, Silja Schrader, Louise Blessington, Scott McKinnon, University of Wollongong

UNIVERSITY OF WOLLONGONG AUSTRALIA

Introduction

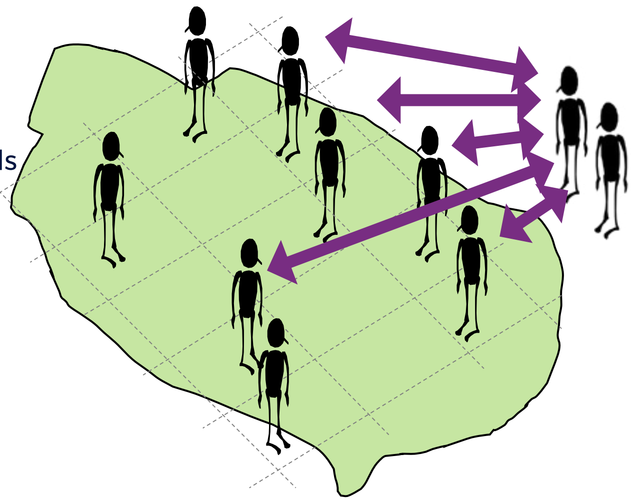
In 2020-2021 growers, agronomists, extension officers and public land managers were interviewed and surveyed.

The aim of the interviews was to:

- learn about attitudes towards AWM of weeds
- identify factors that explain participation in individual and AWM of weeds
- identify social costs and benefits of AWM of weeds

The aim of the survey was to collect data on:

- socio-economic characteristics
- the nature of farming operations
- weed management concerns and beliefs
- individual and collective weed management practices



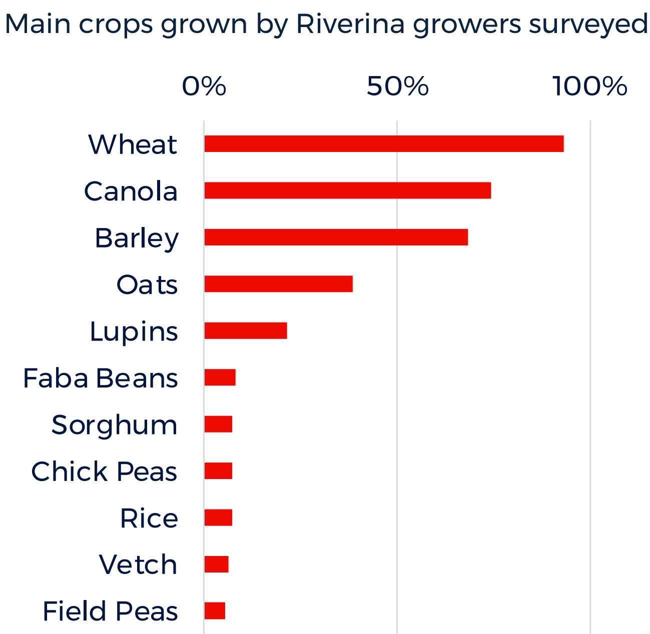
Methods

Intensive interviews:

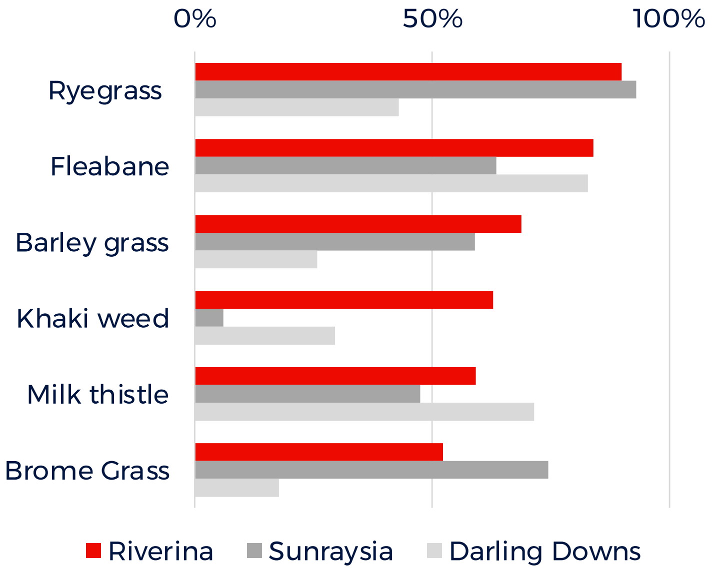
30 from Riverina (84 total)

Growers	14 participants
Advisers	10 participants
Government	6 participants

Survey:
218 growers from Riverina
(604 total – 200 Sunraysia, 186 Darling Downs)



Weeds of most concern in survey

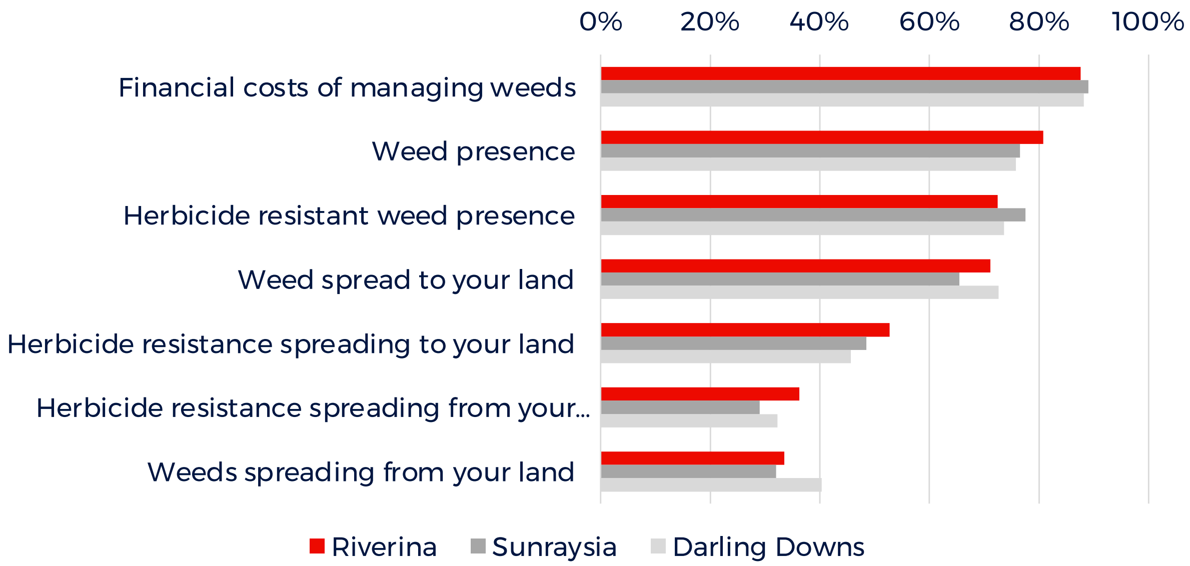


"You rarely find ryegrass that isn't Roundup resistant" (Grower)

"fleabane was never a weed 20-30 years ago and whereas probably in the last ten it's been a major summer fallow weed" (Adviser)

"Barley grass is another nuisance… when it goes to the head it's a problem with sheep because it sticks into their wool." (Grower)

Growers concerned or very concerned about weed issues

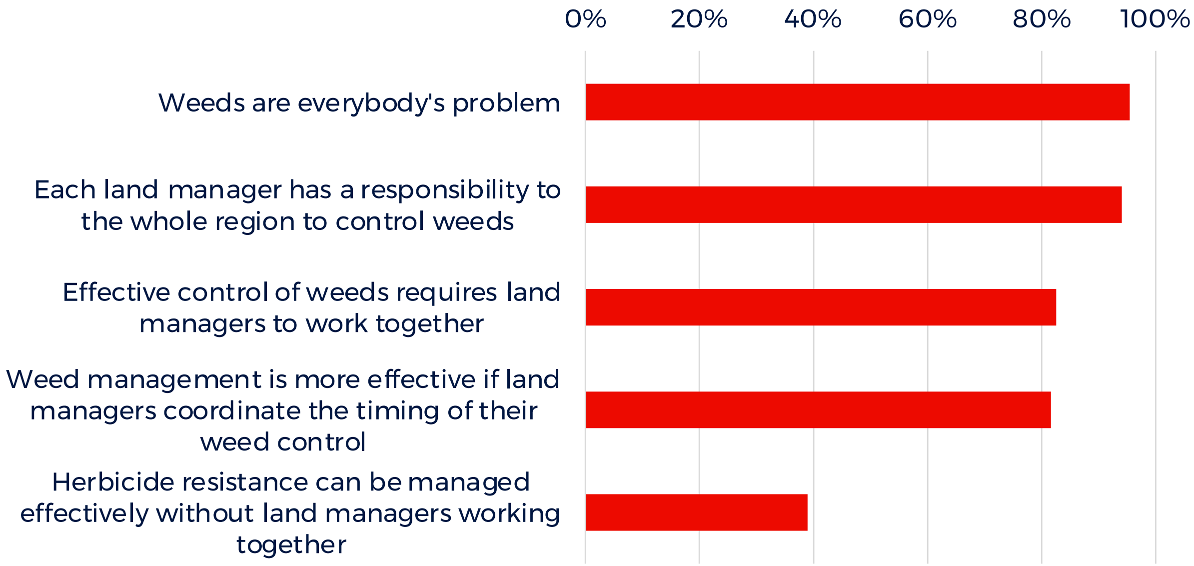


Grower agreement about AWM

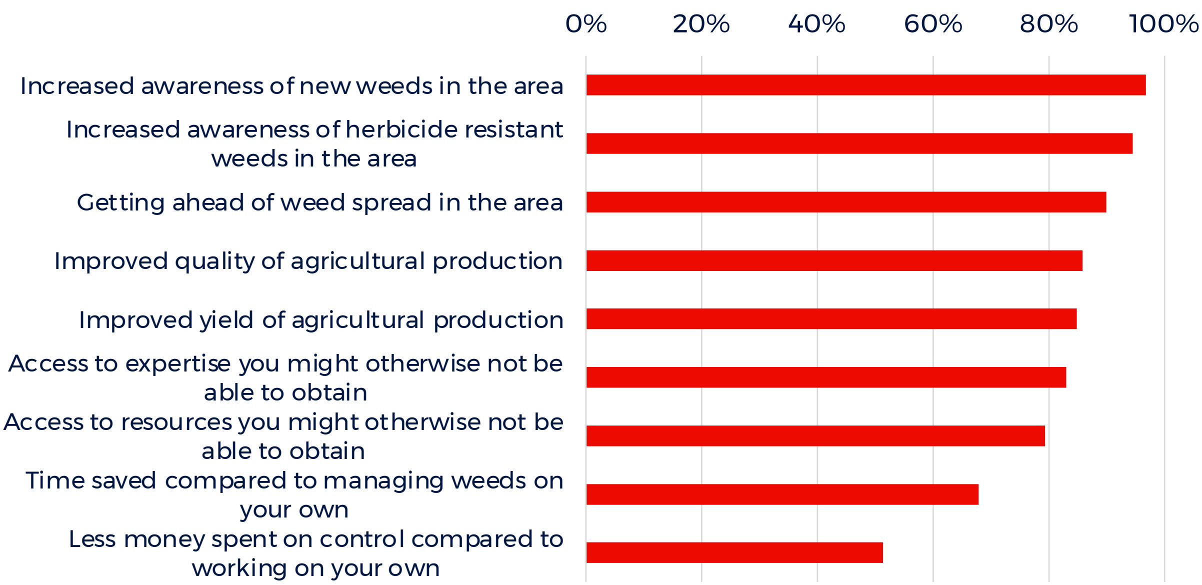
Belief in the importance of working together

"wind borne seed spread can be an issue too, so if you've got a neighbour who's got fence lines and areas of high weed population and things like mustard weed, and just difficult to kill weeds, particularly in a broadleaf sense. So this is where I think the area-wide management strategy is a good thing because if we can all work together, so in terms of machinery hygiene, keeping our boundaries and in-field stuff controlled to a certain level, we can prevent cross boundary spread" (Grower)

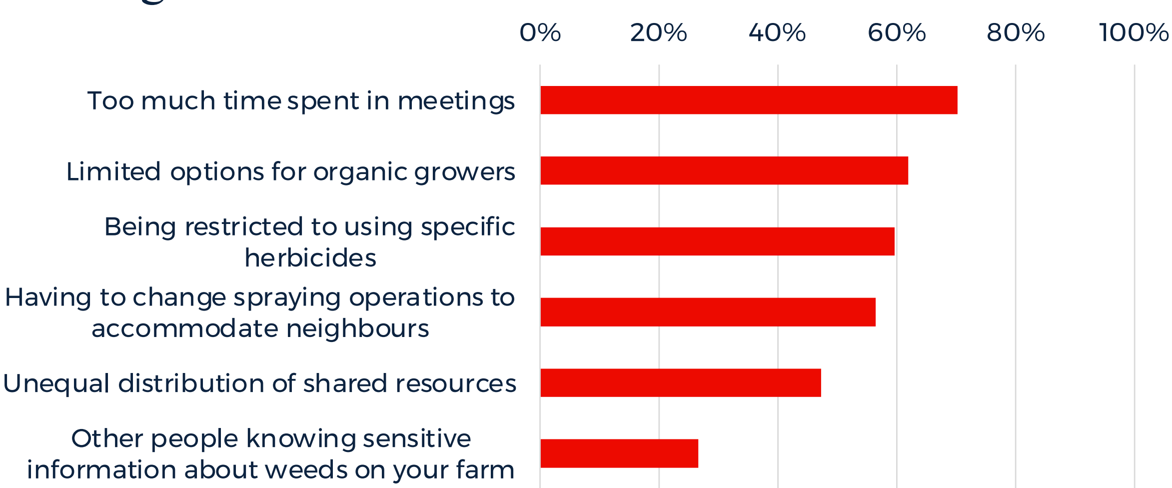
Grower agreement about AWM



Grower agreement benefits of AWM



Grower agreement about costs of AWM



"There could be a number of people that just don't like to get together, so they're not involved. But they could be encouraged to be involved…we probably ask a lot of growers' time to go to meetings. So, they've got to go and get something out of it" (Adviser)

There is an attitude-behaviour gap for AWM of weeds

Growers believe collective weed management is more effective but few collaborate

ATTITUDES

- **83% growers** believe effective weed control requires land managers to work together
- **82% growers** believe weed management is more effective if land managers coordinate timing of weed control

?

BEHAVIOUR

- Less than one-fifth **(18%) of growers in the Riverina** participate in weed management activities that involve land managers working together

There are several factors that make growers more likely to collaborate

Area-wide management of weeds

Little consensus in interviews about what the term means

1. Geographic Area
- Nearly state-wide
- Valley
- Floodplain
- Local govt area
- Irrigation area
- Common areas
- Group of farms
- Whole farm
- Large-scale area
- Big area
- Whole area
- Broad location

2. Who and What
- "everyone"
- "everybody"
- "all"
- "working together"
- Other key terms included "collaboration", "cooperation" and "coordination".

3. When
- Synchronised timing: "same thing at the same time"
- Multi-year to multi-decadal

4. Which Weeds
- Ryegrass
- Silverleaf nightshade
- Fleabane

The term 'area-wide management' is too vague

There is no consensus about what "area wide management of weeds" means.

AWM programs need to begin by determining:

1. **What area?**
2. **Which weeds ?**
3. **Who should be involved?**
4. **What practices are required?**
5. **When should they be applied?**

Factors that make growers more likely to collaborate

Factor	Riverina growers
Concern about herbicide resistance spreading to neighbouring land	36% concerned
Awareness that other land managers work together on weeds	39% aware
Discuss weed management with neighbours	27% discuss weeds with neighbours
Receive external support for weed management, e.g. government funding	4% receive support
Likely to attend meetings on managing local weed issues	74% likely
Likely to share information on weeds with other land managers	87% likely
Likely to work with others on weed management	53% likely

Greater uptake of AWM starts with good neighbours

There are many ways to encourage greater collaboration

1. Organise short meetings on **local** weed issues that are **achievable**
2. Highlight the **mobility of herbicide resistance**
   (e.g. results of the genetic analysis and/or offer to provide HR testing)
3. Encourage growers to **talk to their neighbours** about weed management
4. Provide **funding** for collaborative weed management
5. Encourage **agronomists** to take the lead on linking growers
6. **Start** with a **small** group of dedicated landholders, document the benefits of AWM then scale up

Fleabane is ideal candidate for an AWM program

Fleabane is locally mobile, building herbicide resistance and of widespread concern

In both the stakeholder interviews and grower survey, fleabane was frequently identified as a weed of concern.

- 60% interviewees listed fleabane as one of the top weeds of most concern to them
- 84% Riverina growers surveyed identified fleabane as a weed of concern

Widespread concern about fleabane as well as *regionally-contained HR genetic diversity* makes it a useful weed to galvanise area-wide management programs within and across regions.

THANK YOU

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