IREC

Irrigation Research & Extension Committee

Irrigation Research Update

Presentation Papers

(from our cancelled July 2021 event)

IREC p. 02 6963 0936 | e. irec@irec.org.au | www.irec.org.au

Irrigation Research & Extension Committee

IREC Irrigation Research Update

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Practical lessons learnt from the IREC Field Station

The IREC Field Station at Whitton is where we road test new irrigation layouts, new cropping systems, new products, new gear and sometimes we revisit old crops and old systems with new technology applied. Everything that happens at the field station comes from the suggestions made by IREC members in our annual survey.

Rob Houghton
Chair, IREC
Irrigator, Gogeldrie

At the field station, we endeavour to keep plants actively growing for as many months of the year as practicable. This report follows 3 systems of winter crop followed by summer crop, which were grown directly after cotton in 2019–20.

After the cotton was picked and root cut, crop residue was mulched. The field was then cultivated using a K-line speed buster – this pass also ticked the box for compulsory pupae busting.

A rubber-tyred roller was run over the field before planting the next crop to consolidate the beds.

Winter crops were planted in autumn 2020 and summer crops for 2020–21 were planted off the back of actively growing winter crops.

Three different crop systems were established and observed – Field A, Field B and Field C. These are described and pictured on the following pages.

Here is how it played out.

After cotton – 2020

Click on the image above to watch a short video clip (52 seconds) of cultivation of cotton residue in 2020.

Field A observations

- **Residual nitrogen** left from the chicken litter trial, that ran for 3 seasons, caused yield variation in barley and rice – the higher the litter rate, the higher the yield one season later.
- **Weed pressure** in the field was low due to cotton history and post-emergent control of grass and broadleaf weeds using Agixa®.
- **Good wind protection** from barley stubble helped rice from the seedling stage through to early tillering.
- **Rice did not lodge** because most of the fertiliser nitrogen was applied at early pollen microspore.
- **Good water savings** resulted from delayed permanent water on high water use country.
- **Reasonable water productivity** was achieved 0.62 ML/t (13 ML/ha for average yield of 8 t/ha) – not great but good recovery none the less.

Barley – winter 2020

Baudin barley was planted 11 June 2020. The photo below shows the crop in July. To the left, the crop is green and lush where 16 t/ha of litter was applied previously. In the centre, the crop is growing on the nil strip and is nitrogen deficient.

To ensure the timely sowing of the next crop, the barley was sprayed out 9 August. The photo below was taken 30 September, with the crop still showing patches of green.

Rice – summer 2020–21

Viand rice was planted 2 November into standing barley stubble with a single disc seeder. The field was watered up 30 October. Permanent water was delayed, going on 1 January 2021.

At PI, the plants were very short with poor vegetative growth. The crop was top dressed with 215 kg urea/ha.

Grain yield varied from 3 t/ha to 12 t/ha due to ongoing differences in soil nitrogen from the chicken litter trial.

Field B observations

- **Good planting technology** helped with good seed placement and a dense plant population of the cover crop.
- The green manure was mulched but not sprayed and the oats kept growing. The field looked terrible but the oats **provided wind protection** for cotton at the cotyledon stage. Every plant came through.
- A green manure crop has the potential to **increase arbuscular mycorrhiza** (AM), formerly referred to as vesicular arbuscular mycorrhiza (VAM), but soil tests did not show such a response this season.

Green manure – winter 2020

A cover crop mix for green manure was spread before rain 17 June 2020. The mix contained oats, barley, vetch, peas and canola.

The field was mulched green 5 September. Mulching was followed by hilling up to incorporate green manure and to band fertiliser for the following cotton crop. Up-front urea (280 kg/ha) was applied.

Click on the image above to watch a short video clip (55 seconds) of hilling up and fertiliser application.

Cotton – summer 2020–21

A second pass of the hilling-up rig occurred 18 September to get a deeper furrow, and then there was a pre-plant pass of the ring roller 29 September.

Cotton was sown 7 October, which had an incredible start in an ugly seedbed. The field was watered up 9 October. The oats were cleaned up with an in-crop application of Roundup®. No in-crop nitrogen was applied. Yield was 11.48 bales/ha with no discounts.

Field C observations

- **Short season crops** like mungbeans (90 days) cannot suffer any setbacks, such as poor drainage.
- **One metre spacing** was too wide for mungbeans. The plant population was too low for a plant with poor stem strength. The crop fell into the furrows and late summer rains reduced grain quality.
- **Strong, standing stubble** is essential for mungbeans. The volume of lodged barley stubble in furrows restricted drainage to the detriment of mungbean crop, and barley grain on the ground contaminated the mungbean sample.
- **Drainage is king.** Clean paddocks and furrows are critical in surface irrigated systems.
- **Maintaining winter crop stubble** provided a good mouse breeding environment.
- **Yields of 3 t/ha** are possible for mungbeans in a favourable year and 2 t/ha crops were achieved in the MIA in 2021. Mungbean yield at the field station was disappointing, but much was learned about growing the crop.

Barley – winter 2020

One of the aims of the Field C crop system was to assess the role of barley in a double cropping system with mungbeans. There are good marketing opportunities for mungbeans. While the crop is low cost to grow, it is high risk for getting a good result.

Barley was planted on 1 m hills on a pipe-through-the-bank layout.

The crop grew well but lodged heavily. A substantial amount of grain remained on the ground after harvest, contaminating the sample of the subsequent mungbean crop.

The extent of lodged barley and residue laying in the furrow affected watering up and drainage for the next crop. Irrigation water could not run down the furrows and instead went over the tops of the hills, so the system did not operate as raised beds should.

Mungbeans – summer 2020–21

Opal mungbeans were sown at 1 m spacings into full stubble on hills, using a cotton planter.

The field was pre-irrigated and the crop was sown into moisture. After sowing, watering took 15 hours to get through the layout but establishment was satisfactory. The crop grew well through summer.

Growing season rainfall was satisfactory but 2 in-crop irrigations were required. Poor drainage caused waterlogging and the crop didn't flower well.

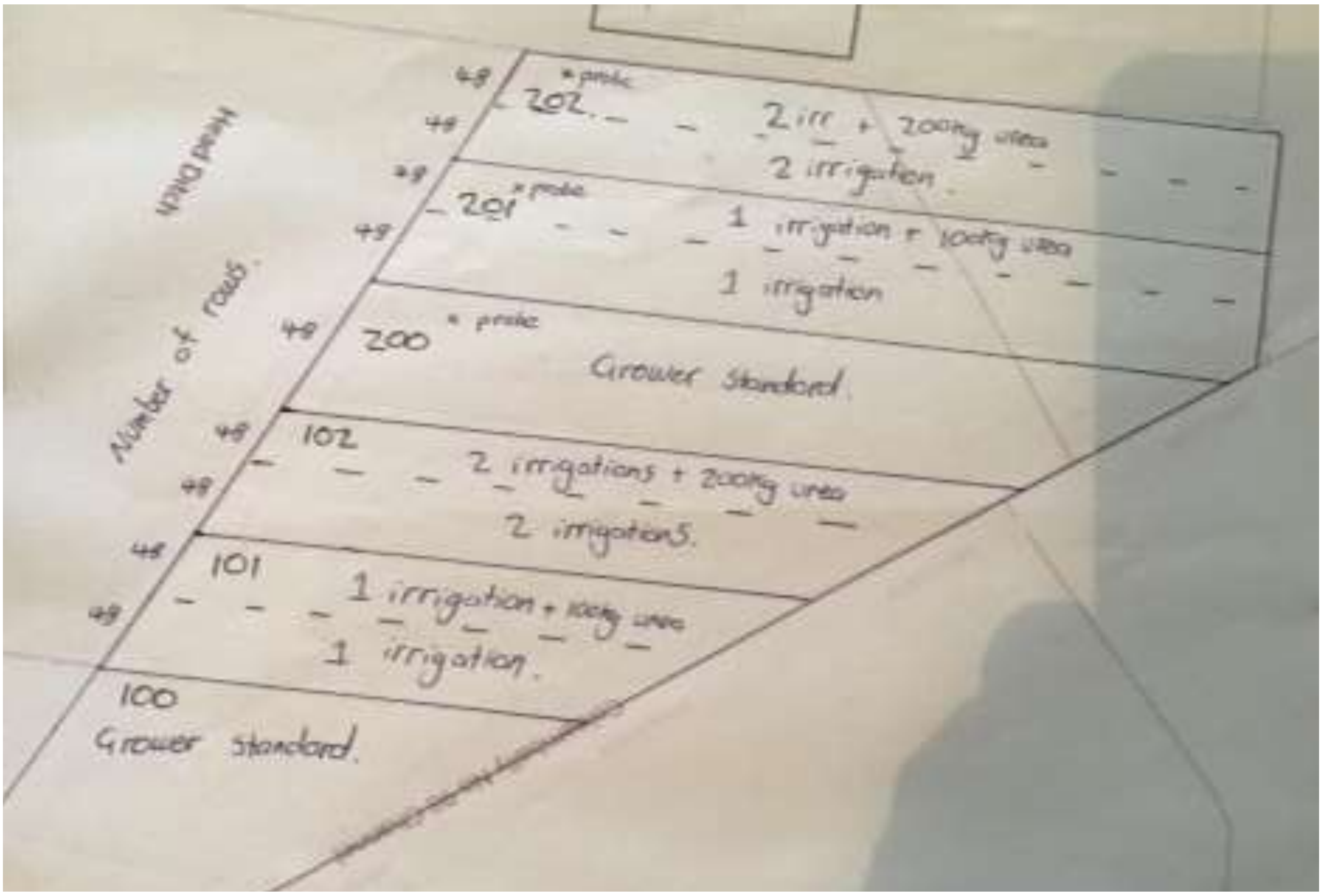
Click on the image above to watch a short video clip (28 seconds) of mungbean harvest.

Contact the author

Rob Houghton
Mobile: 0428 559 249
Email: irec@irec.org.au
Web: www.irec.org.au

High input irrigated Durum

Samual O'Rafferty, Summit Ag



1. Summary

One site in the CIA was established with 6 treatments applied. It was not replicated but was established as a demonstration site.

The treatments applied:

There were 3 irrigation treatments

- Grower standard 3 spring irrigations
- Above + 1 additional water
- Above + 2 additional waters

There were 3 fertiliser treatments overlayed on this as shown above:

- Grower Standard 200kg/ha urea at flag leaf
- 1 additional water + an additional 100kg/ha urea at flag leaf
- 2 additional waters + an additional 200kg/ha urea at flag leaf

2. Introduction

In a changing water market, higher value winter crops are sought after to grow as water value increases. The aim being having a profitable rotation crop that fits in the current cropping systems and allow for land area to be capitalised on.

Many growers are turning to durum wheat to grow high yielding, high protein crops using less water than a traditional summer crop making water go a little further while still producing a good profit margin.

If durum doesn't meet strict protein specification to make milling then it goes into the feed market providing a steep cliff edge type market, so careful nitrogen and water management needs to be undertaken to get the maximum yield and correct protein to insure that return on water investment can be made.

3. Results and Discussion

Establishment

The trial was established in a commercial wheat paddock in Coleambally. It was sown using a tyne seeder, with the aim of establishing 100-150 plants/m2 to target 8-10 tonnes of wheat.

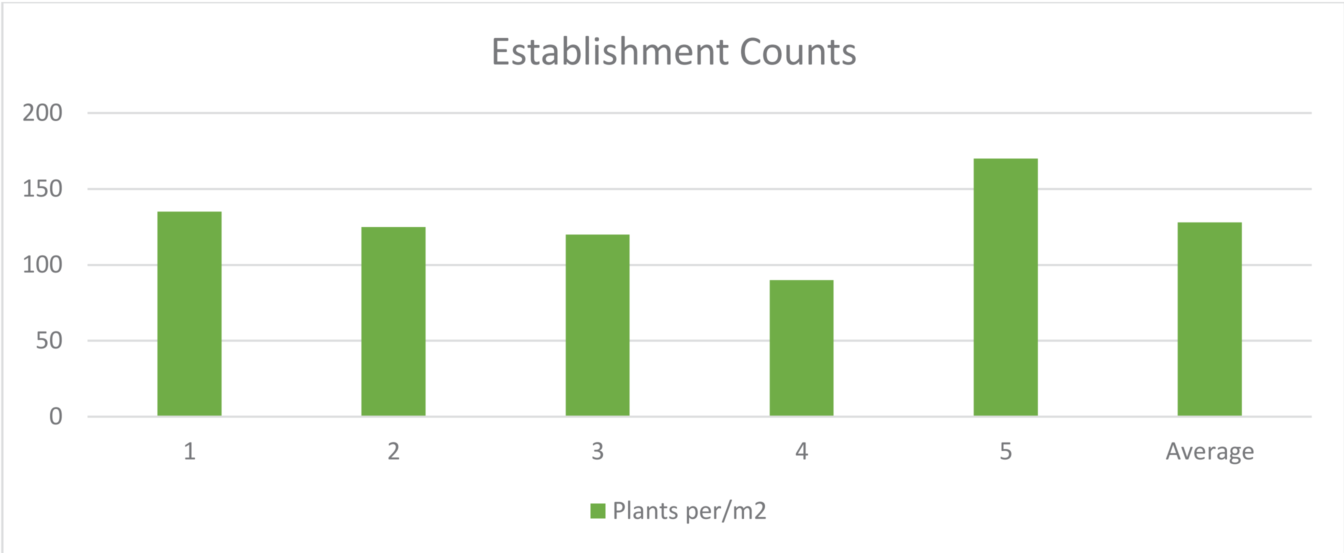


Table 1: establishment counts

Tiller Counts

The number of tillers in the zones were counted to ensure that their starting tiller counts was high enough to suppo high yielding grain crop, as shown below:

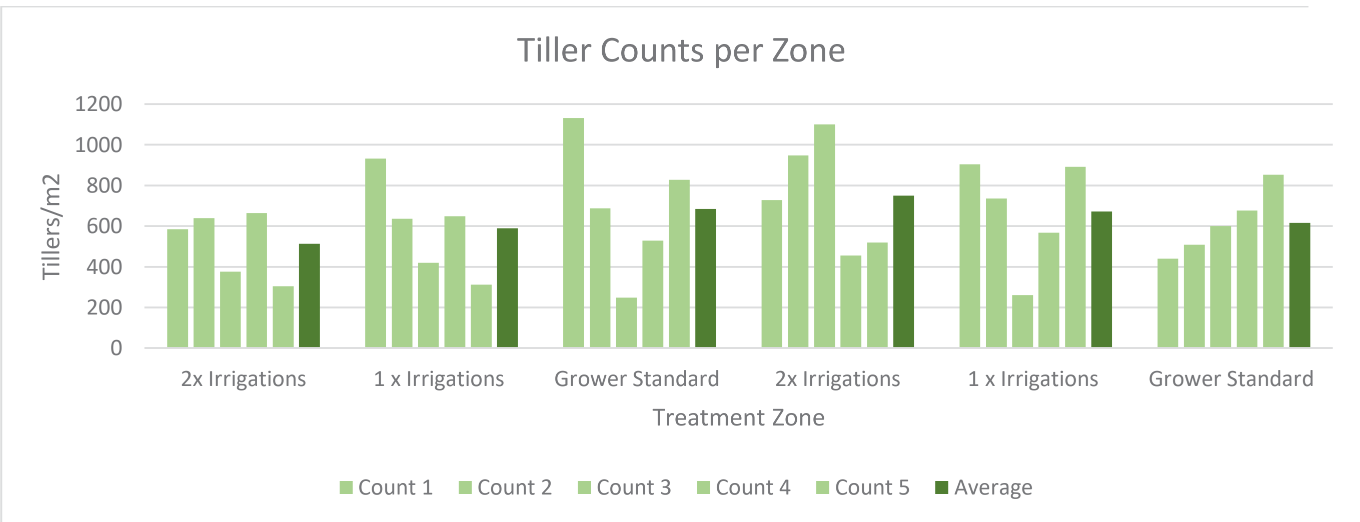
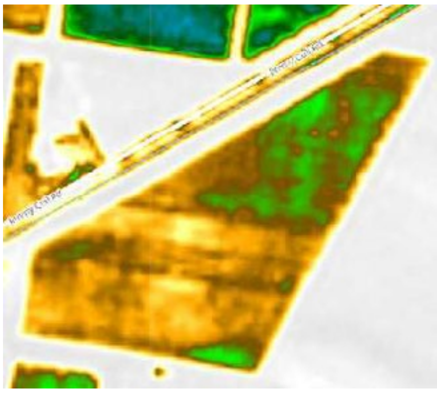
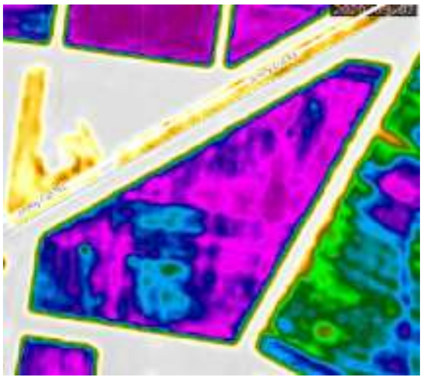
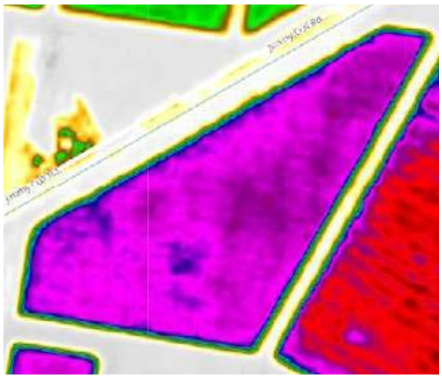


Table 2: Tiller counts per zone

The crop was monitored over the course of the season using NDVI imagery to see if there were any significant biomass differences over the winter. The crop progressed very evenly over the course of the year.







21/07/2020 7/09/2020 8/11/2020

Achieve Damage

The crop was sprayed with Achieve on the 14th of July to control ryegrass. Following this the crop suffered some damage which meant that the growth regulant wasn't applied as this damage slowed growth enough to not warrant it.

Irrigation/Moisture Probes

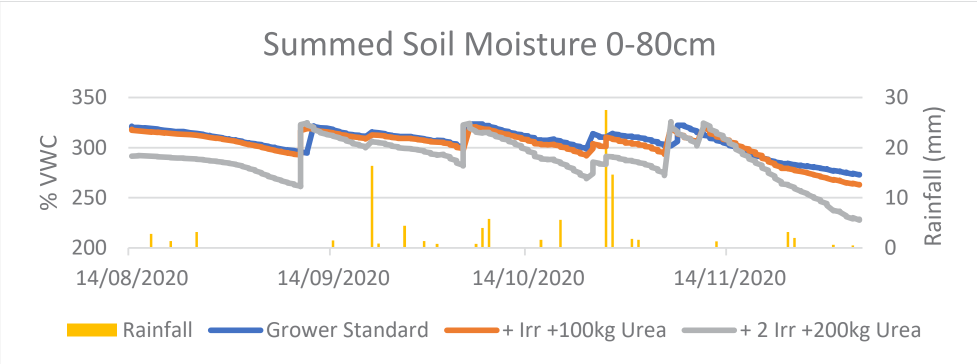


Table 5: Summed moisture probe readings from 3 zones, and rainfall.

A probe was placed in each irrigation treatment to look at water use in the different treatments. The aim of the irrigations was to time the final watering at the same time and stretch/adjust the previous season irrigations and the time between irrigations. Due to significant rain events, we were unable to execute this as desired. The +1 irrigation essentially ended up being the same as the Grower standard as the rain event on the 30th October fulling the profile when not planned on the Grower Standard. The +2 irrigations essentially ended up with + 1 irrigation. The biggest observation was the effect that additional urea had on the amount of water that the crop pulled out compared to the + 100kg and the grower standard.

This tells us that if you are going to look to feed the crop out you need to have enough water to be able to match the crops growth.

Quality Data

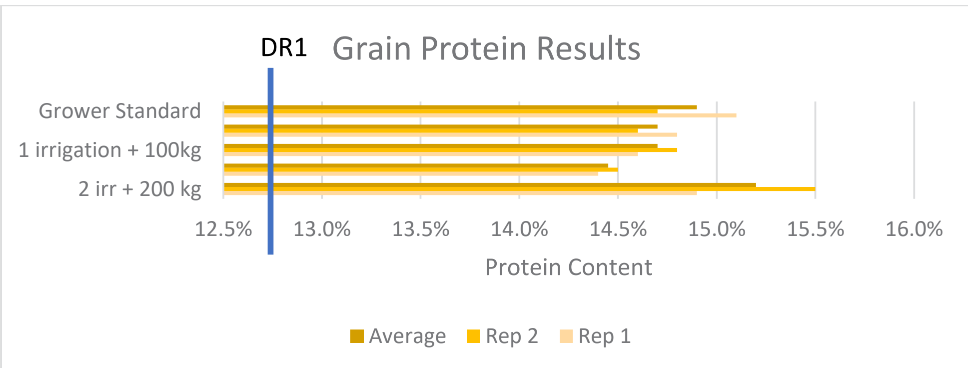


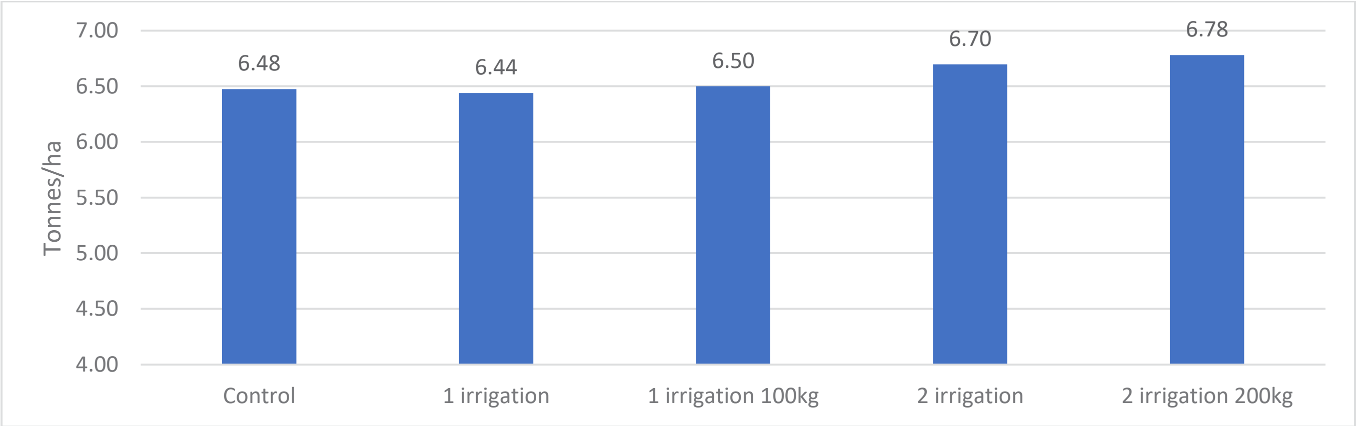
Table 6: Grain protein by treatment

When harvested a subsample of grain from each plot was taken to assess the grain protein content to establish if there were any quality differences based on treatments. Due to the fallow history and nitrogen inputs, there was clearly enough residual N to support protein levels in the crop for the yields achieved. This highlights the need to do soil tests, regardless of the previous history to ensure that the growing conditions are fully understood before planting and managing a durum crop.

Table 7: Final yield average by treatments.

The overall growing season conditions for durum in 2020 were good, with a soft finish and good nitrogen. This resulted in no significant differences between the crop yields that were achieved. There was a response to the additional water and nitrogen in the +2, +200kg urea treatments but there were no economic returns for the additional investment in 2021. It would be expected that under a harsher finish that there would be a significant response to both the different irrigation and nitrogen schedules.

Final Yields



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4. Conclusions

Although this trial wasn't executed exactly as planned due to weather there were some good conclusions that were able to be drawn out of it.

The first is that soil testing is critical prior to planting a durum crop to ensure that the starting nitrogen is known and that the crop can be fertilised and managed to that. Without knowing where the starting nitrogen is for the crop it is easy to over or under estimate and subsequently under fertilise and have low grade, or over fertiliser increasing risk of lodging, higher screenings and wasting resources and money.

When going down the path of fertilising a crop to do 7+ tonnes it is important you the water is able to be committed. As seen in this project when top dressing these larger amounts of nitrogen the water use of these crops increases dramatically with the crop drawing from deeper and harder over the same period of time as crop with less N applied. This indicates that in the planning process the cost of water needs to be considered and secured to ensure that the water applied matches what the likely increase in use will be.

It would be expected in a lower starting N paddock and a drier year there would be much more substantial differences between treatments.

The value of the last irrigation – year 2

Heath McWhirter, Summit Ag

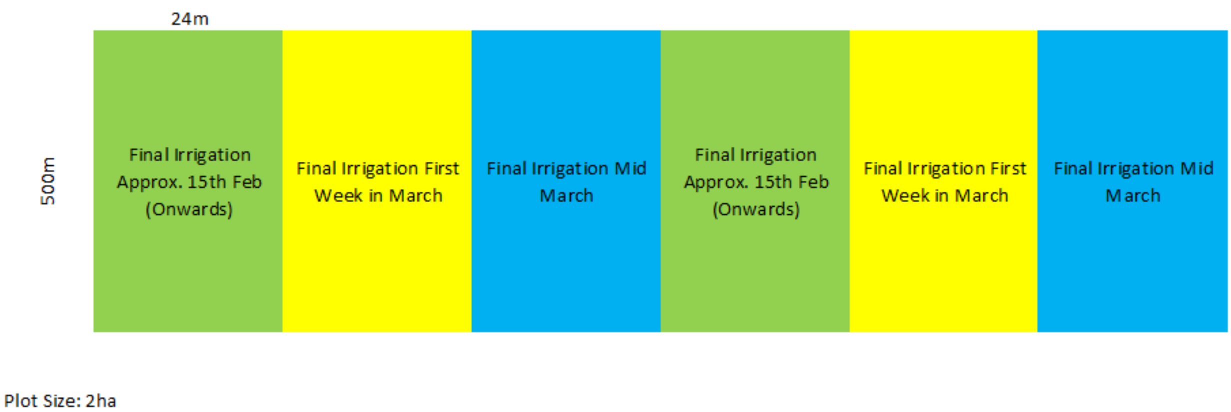
The Value of the Last Irrigation – Year 2

Summary

- The second-year study of the values of the last (terminal) irrigation of cotton was run across 5 sites in the Murrumbidgee Valley this year, season 2019/2020.
- The mid-February final irrigation treatment was removed as the yield penalty seen last season was too high for it to be considered a practical option for growers.
- The value of the data collected this year was confounded by significant rain events in March across most sites with majority having no significant yield reductions.
- The more Western sites that received less rainfall showing some good variation across treatments with one site showing an 18 % yield reduction -3 irrigation when compared to the grower standard control.
- Micronaire results were variable based on location and in all likelihood highly influenced by the amounts and timing of significant rain events.
- The more Western fields, although not significant, did trend to the treatments missing irrigations having lower micronaire results.
- The more Eastern fields around Darlington Point/Griffith had an inverse trend in yield and micronaire with the fields cut off "early" yielding better and having better quality compared to crop irrigated out until mid-March. This could be due to the crop holding more later fruit that was unable to finish in the cool conditions we saw this year, reflective of the area, or the potential for waterlogging slowing development and resulting in slightly lower micronaire.

Year 2 Paddock Scale Investigation

For the 2019/2020 season the same 4 original farms offered to participate in this trial, along with one additional farm at Darlington Point. The plan was to replicate the similar scenario to the previous season, but with only 3 main timings. 2 replicates where applied this year where possible to try and collect a larger data set for more in-depth analysis. The example layout as shown below:



Graph 1: Trial Layout

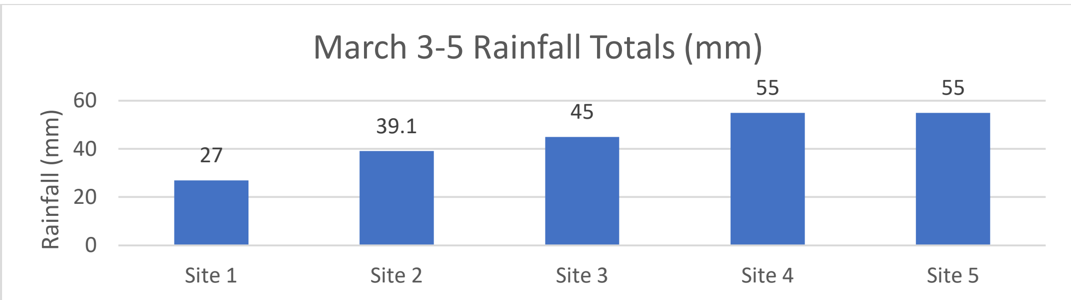
Table 1: Field Details

	Soil Type	Rotation	Variety	Water Up Date
Site 1	Med-Heavy Clay Loam	Fallow	746 B3F	7/10/2019
Site 2	Med-Heavy Clay Loam	Fallow	748 B3F	11/10/2019
Site 3	Med-Heavy Clay	Fallow	746 B3F	7/10/2019
Site 4	Med-Heavy Clay Loam	Fallow	746 B3F	5/10/2019
Site 5	Med-Heavy Clay Loam	Fallow	746 B3F	9/10/2019

Table 2: Final Irrigation timings at each site

	Early Feb	Mid Feb	Early March	Grower Standard
Site 1	8/02/2020	21/02/2020	1/03/2020	13/03/2020
Site 2	-	-	28/02/2020	15/03/2020
Site 3	-	23/02/2020	2/03/2020	13/03/2020
Site 4	-	10/02/2020	20/02/2020	1/03/2020
Site 5		10/02/2020	22/02/2020	13/03/2020

Over the end of the season there were some significant rainfall events recorded in March that in some locations offered a "final water" for the final irrigation in February treatments. For the period of the 3rd-5th of March rainfall totals shown below:



Graph 2: Rainfall from the most significant event that impacted the mid-February final irrigation event.

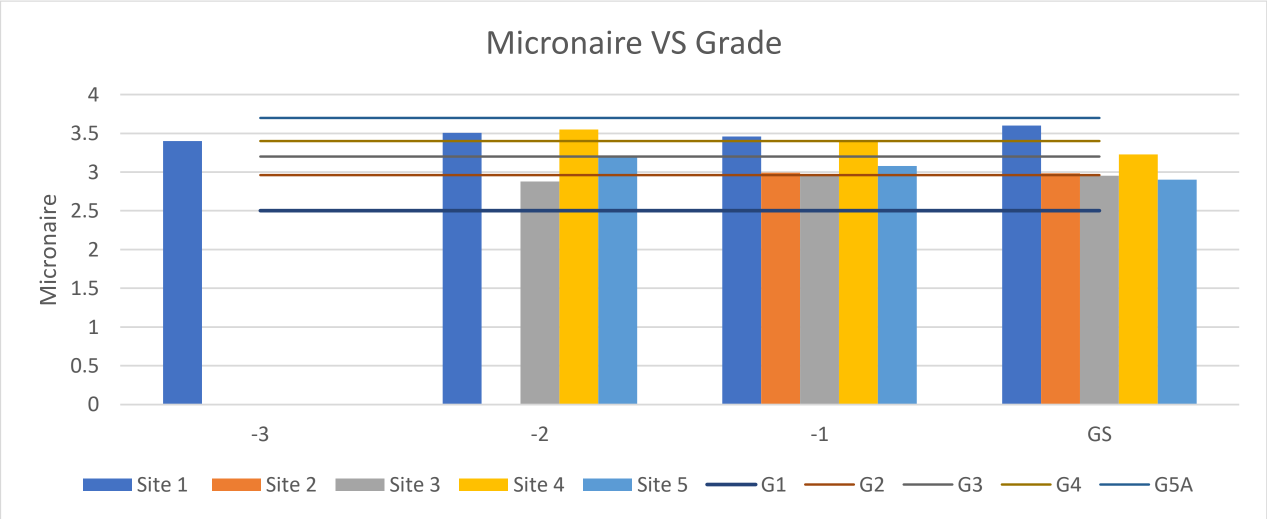
Each of the plots were picked individually with a commercial picker, avoiding areas like tail drains where water backed up where possible. Plant heights, nodes and NAWF were collected at commencement, but as this did not influence the trial were omitted from this report.

The rounds were weighed with a hand sample of lint taken from each round which were then hand ginned by Kieran O'Keeffe (CottonInfo) thanks to the DPI and then classed by ProClass Griffith on a HVI™ (High Volume Instrument) 1000 instrument. The sites in general had similar final irrigation dates, excluding site 4 which was an earlier crop. Due to the cool finish and issues with micronaire the decision was made to take a deeper dive into how this trial effected the quality of the lint produced.

	Treatment	Turnout %	Yield (bales/ha)	Yield % of fully Irrigated	Micronaire	Micronaire Grade	Estimated Discount
Site 1	-3	47.9	8.86	82	3.40	G4	57.14
	-2	47.2	10.15	94	3.51	G5	0.00
	-1	47.9	11.03	102	3.46	G5	0.00
	Grower Standard	46.4	10.84	100	3.60	G5	0.00
Site 2	-1	46.8	6.31	99	2.99	G3	88.00
	Grower Standard	45.9	6.39	100	2.98	G3	88.00
Site 3	-2	45.45	9.42	103	2.88	G3	88.00
	-1	43.7	8.81	96	2.95	G3	88.00
	Grower Standard	44.2	9.18	100	2.95	G3	88.00
Site 4	-2	46.6	12.33	89	3.55	G5	0.00
	-1	46.4	13.83	100	3.41	G4	57.14
	Grower Standard	46.6	13.00	100	3.23	G3	88.00
Site 5	-2	43.9	9.52	104	3.19	G3	88.00
	-1	44.0	10.48	115	3.08	G3	88.00
	Grower Standard	44.0	9.13	100	2.90	G2	109.42

Table 3: Study Summary

The overall yields of most fields were below average due to lower than average day degrees accumulated for the season. With such a mild finish and some significant rain events the crops were not pushed in terms of their end of season water use which saw only small variations in yield. In some fields there was actually a slightly inverse trend of yield to irrigations.



Graph 3: Average micronaire of samples by site and timing with the boundaries of grades shown as horizontal lines.

It can be seen from the data above that there is an inverse trend between the number of irrigations and the micronaire at site 4 and 5. This is an interesting trend that could be hypothesised to be related to geographic area, as they are both the more eastern areas, and could indicate that later irrigation encouraged more late fruit set or got waterlogged due to irrigations and then significant rain events. The true cause is difficult to determine exactly but luxurious water coupled with below average day degree accumulation does appear to have a negative impact on crop micronaire.

Season		Day degrees accumulated
19/20	12th Feb DD accumulated	880.2
18/19	13th Feb DD accumulated	1005.15
12.5% less heat from Oct 1st to 12th Feb		
19/20	Day Degrees Accumulated 12th Feb - 30th April	318.65
18/19	Day Degrees Accumulated 12th Feb - 30th April	492.25
35% Less heat from previous year to finish crop		
19/20	Day Degrees Accumulated LEF to 1st pass 12th April	300.2
18/19	Day Degrees Accumulated LEF to 1st pass 15th April	432.3
31% Less heat from LEF to 1st pass defoliation		

Table 4: Day Degree Accumulation

It can be seen from the information above that the biggest factor effecting the lower micronaire was the lower amounts of day degrees accumulated, it is interesting to see that in the more Eastern blocks increased irrigations compounded on this and resulted in even further reduced micronaire.

There were no other trends from the quality results in terms of strength and length.

Conclusions

The return on investment of the final irrigation in the 2019/2020 season was an interesting study that was ultimately impacted by rain with the more Eastern sites showing no significant differences in yield. The key take home messages from the second year of this trial are:

- That the cut out of irrigations in early February is yield limiting, even in a cooler wetter finish, with the second year of this result supporting the findings from last year.
- In climatic conditions that are cooler and trending towards damper there is no yield benefit to continuing to irrigate into mid-March, with site 3 and 5 having a slightly inverse trend of more irrigation resulting in a slightly lower yield.
- At the two Eastern sites (4 and 5) there was an inverse relationship between irrigations and micronaire indicating that final irrigations when coupled with significant rain events produced poorer quality. Site 4 went from an estimated $88/bale discount at grower standard irrigations to no discount when final irrigation was at the end of February.
- At site 1 we saw a 6% yield increase when going from a late Feb to an early March final irrigation so water at $300/meg, 0.8 megs/ha applied would cost approximately $240, the yield increase of 6% on a 10 bale/ha crop assuming lint price at $600 would be $360/ha, resulting in a positive return on investment.
- Hindsight is a wonderful thing.

Author: Emma Ayliffe, Summit ag, SVCGA, 0458307347, emma.ayliffe@summitag.com.au

Optimising irrigated grains – early pointers from Finley Research Site

Ben Morris[1], Tom Price[1] and Nick Poole[1]
[1]Field Applied Research (FAR) Australia,

GRDC project code: (FAR1906-003RTX)

Background

In 2020, 26 irrigated research trials were established at FAR Australia's Finley Irrigated Research Centre (Southern Growers Irrigation Complex) (GPS - 35.619083°, Longitude: 145.584803°) in southern NSW under the GRDC regional investment *"Optimising Irrigated Grains"* project. A further 22 trials were conducted by Irrigated Cropping Council (ICC) at the Kerang and Griffiths Irrigated Research Centres. The Finley research site is a collaboration between FAR Australia and Southern Growers, whilst the Griffiths Centre is a collaboration between ICC and the Irrigation Research and Extension Committee. The primary objective of the Irrigated Research Centres (IRC) is to look at all aspects of germplasm and input management that can push the productivity boundaries for five irrigated winter crops (barley, faba beans, chickpeas, canola and durum wheat) and one summer crop (grain maize). At Finley on a red duplex soil the majority of trials were set up under overhead irrigation (travelling lateral) with a smaller number of identical trials set up on a surface (flood) irrigation system. At Kerang on the grey clay the reverse was the case, with majority of the research examining surface irrigation. The Finley site was characterised by high fertility following two years of drier conditions iin 2018 and 2019. Trials under overhead irrigation received a total of 125 or 150mm of irrigation (1.25- 1.5 Mega L/ha) applied as five or six applications of 25mm, whilst the surface irrigation bays received 240mm (2.4 Mega L/ha) applied as three 80mm applications. This was in addition to a Growing Season Rainfall (GSR) of 244mm April – October. A summary of the Finley findings is the basis of this article.

Summary of Findings

Finley, NSW

Grain yields and harvest dry matter production under the two irrigation systems

Though not statistically comparable, surface irrigation trials that received more water (484mm compared to 369-394 mm for the lateral overhead) through the growing season were in general higher yielding than identical trials grown under an overhead irrigation system. Of the crops evaluated, all gave higher yields in identical plant population trials (sown on the same day) on the surface irrigation bays with canola yields peaking at 4.91t/ha (cv 45Y28), durum at 8.2t/ha (cv Vittaroi) and fabas at 7.45t/ha (cv PBA Amberley). Compared to peak yields in the overhead irrigation trials of 4.27t/ha with canola, 7.25t/ha with durum and 5.17t/ha with faba beans using the same cultivars.

Water Use Efficiency (WUE)

In most cases at Finley although the yields were invariably higher where more water was applied with surface irrigation, in general water use efficiency measured as kg mm/ha tended to be higher where crops were grown under overhead (again remembering that identical trials on both systems could not be directly compared within the same trial). One of the largest differences in yields between the two irrigation systems was with faba beans where there were differences of approximately 2t/ha in favour of surface irrigation (Table 1 & 2). In these trials higher WUE was recorded with the surface irrigation system.

Table 1. Grain yield (t/ha) of four seed rates (plant populations) with two different cultivars grown under overhead irrigation (sown on the same day as the trial in Table 2 on the same site).

				Yield t/ha			
Plants/m^2(actual)		**PBA Amberley**		**Fiesta VF**		**Mean**	
Amberley	**Fiesta**	**Yield t/ha**		**Yield t/ha**		**Yield t/ha**	
10	11	3.00	-	3.31	-	**3.15**	**b**
16	16	4.50	-	4.93	-	**4.72**	**a**
23	31	4.83	-	4.84	-	**4.84**	**a**
32	45	5.17	-	5.15	-	**5.16**	**a**
Mean		**4.38**	**-**	**4.56**	**-**		
LSD Seed Rate p = 0.05		0.49		**P val**		<0.001	
LSD Cultivar p=0.05		ns		**P val**		0.343	
LSD Seed Rate x Cultivar.		ns		**P val**		0.719	

Total water available (GSR + Irrigation) 394mm

Table 2. Grain yield (t/ha) of four seed rates (plant populations) with two different cultivars grown with surface irrigation.

				Cultivar			
Plants/m^2 (actual)		**PBA Amberley**		**Fiesta VF**		**Mean**	
Amberley	**Fiesta**	**Yield t/ha**		**Yield t/ha**		**Yield t/ha**	
11	13	6.28	-	6.12	-	**6.20**	**b**
20	25	7.45	-	6.75	-	**7.10**	**a**
31	27	7.33	-	7.06	-	**7.19**	**a**
26	31	7.15	-	6.92	-	**7.04**	**a**
Mean		**7.05**	**-**	**6.71**	**-**		
LSD Seed Rate p = 0.05		0.35		**P val**		<0.001	
LSD Cultivar p=0.05		0.42		**P val**		0.083	
LSD Seed Rate x Cultivar.		ns		**P val**		0.381	

Total water available (GSR + Irrigation) 484mm

Nutrition

The research site was characterised by high levels of soil available nitrogen (N) at the start of the season with estimates of over 200kg N/ha at sowing on 0 – 90 cm following the fallow. This resulted in crops of canola and cereals being at their most profitable with lower and or the lowest levels of applied nitrogen fertiliser. In addition to available soil mineral N at sowing there was evidence in durum of 70kg N/ha becoming available through mineralisation during the course of the season. High fertility and N mineralisation were mirrored in results observed with canola nutrition trials (following wheat stubble rather than fallow). Canola yields varied from 3.91 – 4.71t/ha based on 0 to 320kg N/ha of applied N with an optimum of 160kg N/ha applied N fertiliser (Table 3) and 129 kg N/ha soil available N (0 – 90cm). Differences in oil content were small but significant with a 1.2% oil content decline covering N rates between 80 – 320 N applied.

Table 3. Influence of applied nitrogen fertiliser rate (split 50:50) at six leaf (6L) & Green bud (GB) on seed yield (t/ha) and oil content (%).

Nitrogen Treatment Rate & Timing		Total	Grain yield and quality			
		Nitrogen	Yield		Oil	
		N/ha	t/ha		%	
1.	0kg N/ha	0	3.91	d	43.0	ab
2.	40kg N/ha@6L & 40kg N/ha@GB	80	4.30	c	43.3	a
3.	60kg N/ha@6L & 60kg N/ha@GB	120	4.41	bc	42.0	d
4.	80kg N/ha@6L & 80kg N/ha@GB	160	4.55	ab	42.4	bcd
5.	100kg N/ha@6L & 100kg N/ha@GB	200	4.59	ab	42.4	bcd
6.	120kg N/ha@6L & 120kg N/ha@GB	240	4.62	a	42.8	a-d
7.	140kg N/ha@6L & 140kg N/ha@GB	280	4.71	a	42.9	abc
8.	160kg N/ha@6L & 160kg N/ha@GB	320	4.71	a	42.1	cd
	Mean		**4.475**		**42.6**	
	LSD		0.19		0.84	
	P val		<0.001		0.032	

N applied as prilled Urea (46% N content)

A common theme from both winter and summer crop results so far is that frequently higher yielding irrigated crops (canola, grain maize and durum) will remove much larger quantities of nitrogen from the soil than the crop has the ability to respond to in that season. In grain maize crops in 2019/20 similar findings were noted, with grain maize crops not responding to more than 250kg N/ha applied fertiliser yet observed N offtakes at harvest were between 300 – 450kg N/ha at harvest with two thirds of the N in the grain.

Crop structure and lodging

Higher plant populations and associated problems with lodging was a primary constraint to yield observed in both winter barley and durum wheat. The highest yields of durum wheat under a surface irrigation system were observed with a plant population of just less than 100 plants/m^2, despite a mid-May sowing date. Higher durum populations resulted in lower yields as a result of higher levels of crop lodging, particularly in the surface irrigation trials. In barley a comparison of winter and spring germplasm showed that RGT Planet (spring barley) was higher yielding (mean 7.27t/ha in PGR trial) and less dependent on plant growth regulation than Cassiopée (winter barley) (mean 6.13t/ha). The fertility of the research site and earlier sowing (April 24) did not favour barley productivity and overall barley yields were disappointing, although lower fertility scenarios may produce better results. The results served to illustrate the value of canopy management in irrigated cereals, illustrating that frequently crops that are sown too thick (with no regard to planting by seed number) and fail to deliver higher yields, particularly if they lodge.

Chickpea sowing date

Under overhead irrigation two identical chickpea trials were set up to look at yield performance from an April and May sowing. The spatially separate trials were not statistically comparable however both trials gave similar peak yields if population was adjusted. Chickpeas sown 27 April gave an average yield of

3.32t/ha (with a peak yield 3.59t/ha cv Genesis090) compared to 19 May sowing with an average yield of 2.88t/ha (with a peak yield 3.41t/ha cv Genesis090). The optimum plant populations being approximately 30 plants/m^2 with the later sowing and approximately 20 plants/m2 with the earlier sowing. In both trials where plant population fell below the optimum at 10 plants/m^2, yields were reduced to 3.1t/ha and 2.39t/ha for early and late sowing respectively.

Disease Management

Disease management was a key component to maximising yields on the Finley IRC site in chickpeas and durum. April sown chickpeas produced significant increases in seed yield and margins from disease management strategies based on three fungicide applications in 2020. Yields were higher with newer chemistry based on QoI (strobilurins) and SDHI chemistry and the advantage over a chlorothalonil based strategy was statistically significant (1.15t/ha response v 0.83t/ha - average of two cultivars). In canola good visual differences in upper canopy blackleg infection did not result in significant yield differences over the untreated. This would indicate that we need more data on irrigated canola responses to upper canopy blackleg before we adopt prophylactic fungicide strategies for this issue. However, it should be pointed out that no Sclerotinia was observed in the 2020 Finley canola trials, a disease where there is more evidence to suggest a yield response when crops are infected.

Soil Amelioration (in collaboration with NSW DPI)

Following soil amelioration treatments being established by NSW DPI in March 2020 the large block trial area was sown with a commercial seed drill to faba beans on 19 May. The mixture of deep ripping, gypsum and organic amendment treatments produced significant yield increases of between 0.66 – 1.22t/ha over the untreated control but there were no significant yield differences amongst the soil amelioration treatments. Of the treatments it was noted that surface applied organic amendment (15t/ha Lucerne pellets) alone also produced a significant yield increase (0.66t/ha).

Caution: Please note that this article is based on the first-year results from the project. If you like a more in-depth analysis of the results generated in the first year of field trials at all sites, please contact Ben Morris, FAR Australia (ben.morris@faraustralia.com.au)

ACKNOWLEDGEMENTS

FAR Australia would like to place on record their grateful thanks to the Grains Research and Development Corporation (GRDC) for providing this irrigation investment, in particular we would like to thank Kaara Klepper (GRDC) for her input and support in the oversight of the project.

In addition, we would like to acknowledge the collaborative support of our trials research partner Irrigated Cropping Council (ICC) and extension grower group partners across the irrigation regions of SE Australia.

Field Applied Research (FAR) Australia

HEAD OFFICE: Shed 2/ 63 Holder Road Bannockburn **VIC** 3331 Ph: +61 3 5265 1290

Shop 4/ 97-103 Melbourne Street Mulwala **NSW** 2647 Ph: 03 5744 0516

9 Currong Street Esperance **WA** 6450 Ph: 0437 712 011

Email: faraustralia@faraustralia.com.au Web: www.faraustralia.com.au

Practical opportunities for more cost effective weed management using local collaboration

PRESENTED BY

Dr Rick Llewellyn, CSIRO

COLLABORATIONS

- CSIRO
- Universities of Adelaide, Queensland, Wollongong
- Irrigation Research & Extension (IREC); Mallee Sustainable Farming; Milmerran LCG
- Multiple regional-level partners
- *Wine Australia / CSIRO Biosecurity / University of Sydney*
- GRDC; CRDC; AgriFutures
- Australian Government Department of Agriculture Rural R&D for Profit program

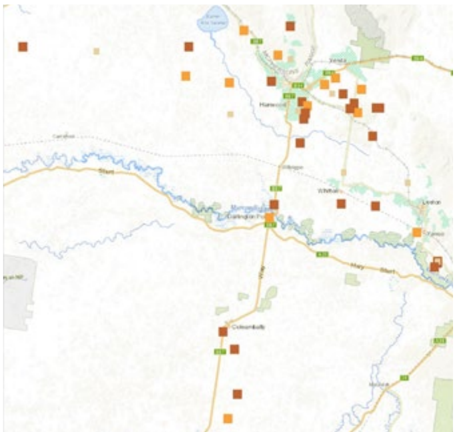
General Aim: reduced impact of major mobile weeds of cropping

In what situations would we be better off using a more collaborative approach in addition to independent farm-level control?

Tackling weeds together

Our objectives

1. **Better understand the mobile weed problem in focus regions:**



- Major mobile weed problems and threats
- Extent
- Resistance status
- Level of mobility
- Costs, economics and social attitudes

- Trial additional control options

2. Identify and test opportunities for an area-wide approach

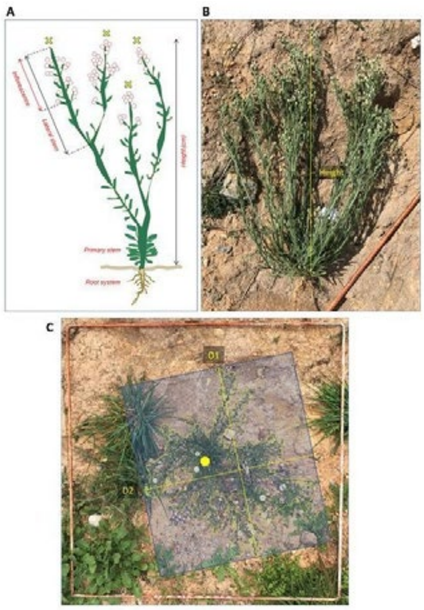
- Engaging multiple local stakeholders/ industries
- Understanding opportunities and costs from a social perspective
- Economic analysis of ‘area-wide’ benefits and feasibility

When and where will it be worth it?


Sunraysia:
Dryland grains; horticulture; viticulture; tree crops
Photos: MSF/Frontier Farming Systems


Darling Downs:
Dryland grains; cotton; roadsides
Brookstead
Lemontree
Pampas
Yandilla
Millmerran


Riverina:
Irrigated grains; viticulture; cotton
Turf
Turf



All regions: baseline fleabane monitoring for upcoming CSIRO release of Flaxleaf fleabane biocontrol

Rust fungus *Puccinia cnici-oleracei* (ex. *Conyza*)

Next steps

- Project extended to March 2023
- Additional resistance, weed and genetic mapping information to determine extent of weed/resistance movement
- Greater understanding of economics and social factors that will drive greater collaborative opportunities
- 'Catching up' on covid-delayed opportunities for face-to-face collaboration and engagement with trial work and priorities across sectors

Tackling weeds together

For more information:
research.csiro.au/weed-awm

Movement and the evolution of herbicide resistance in fleabane in the Riverina

Dr James Hereward, University of Queensland

Background

The loss of glyphosate and paraquat is estimated to have significant negative impacts on profit and cause large increases in the cost of crop production (Walsh and Kingwell 2021). Increasing numbers of weed species are becoming resistant to key herbicides like glyphosate in Australia. Each species that evolves resistance gradually reduces our ability to rely on these chemistries. Weed movement is the way that herbicide resistance spreads but investigating it can be difficult due to the size of the seeds and pollen, both of which can carry resistance genes around the farming landscape. In the area wide weed management project (https://research.csiro.au/weed-awm/) we are using genetics to try and better understand the movement of key weeds fleabane and annual ryegrass in the Murrumbidgee Irrigation Area. The project is funded by the Australian Government Department of Agriculture as part of its Rural R&D for Profit Program and includes GRDC, CRDC, AgriFutures, and the Irrigation Research and Extension Committee (IREC) in the Riverina.

As part of the area wide weed management project, teams at the University of Queensland and the University of Adelaide are trying a new approach to investigate weed movement using genetics. The two target weed species have been selected based on stakeholder feedback and concerns of growers in the region. In 2020, Iva Quarisa (IREC) sampled 30 fleabane individuals from ten sites across the Riverina (Fig 1) and this update describes the genetic analyses of fleabane from this first year of sampling.

Figure 1. Sampling sites for fleabane genetic testing in the Riverina. Credit. Christina Ratcliff.

Summary of findings

Previous genetic testing of fleabane revealed different genetic populations in Queensland, Northern NSW, and Southern NSW. The results from this study so far show that Southern NSW (Griffith) and Sunraysia fleabane populations are also genetically different from each other (Fig 2). Within regions, populations from both roadsides and farm paddocks were genetically mixed, suggesting that managing fleabane resistance should be co-ordinated across land uses at a regional scale. Two individuals from Sunraysia were genetically very similar to the samples from Griffith and this likely indicates recent movement of the weeds between regions.

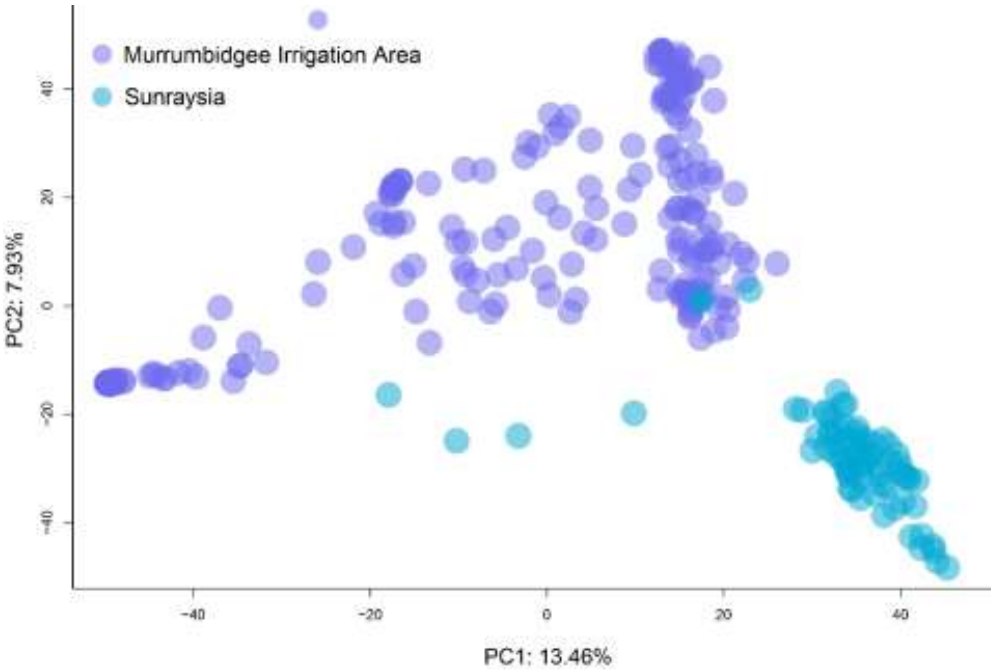


Figure 2. Genetic clustering of fleabane individuals showing the difference between populations from Murrumbidgee Irrigation Area (purple) and Sunraysia (blue).

In Queensland, glyphosate resistance was first detected in 2006, but by 2018 all samples screened from across the state were resistant. The genetic data suggests this was all the result of weed movement following one instance of resistance evolution. We compared the genetic data from the MIA and Sunraysia samples from 2020 to samples originally collected in North-eastern Victoria in 2014 that had been characterised for resistance at the University of Adelaide (Fig. 3). Populations from the Murrumbidgee Irrigation Area cluster with the strong glyphosate resistant samples from 2014, and the genetic data so far indicates a single origin of glyphosate resistance in southern populations of fleabane. These populations are very different genetically from the glyphosate resistant populations in Queensland, indicating that the Queensland and southern fleabane populations evolved glyphosate resistance independently.

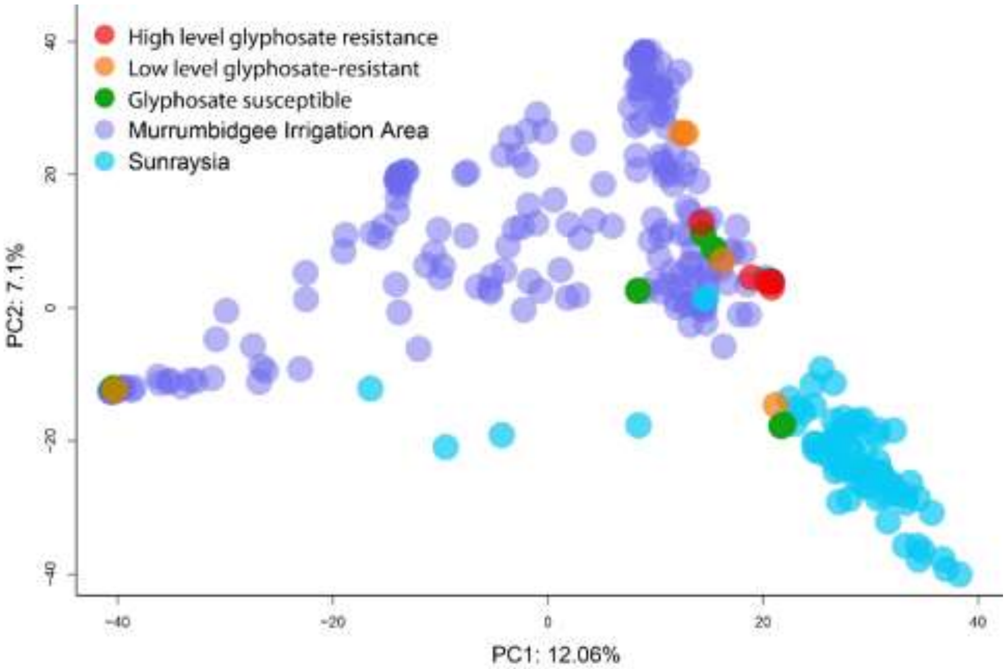


Figure 3. Genetic comparison of fleabane individuals from Murrumbidgee Irrigation Area, Sunraysia, and samples previously characterised for glyphosate resistance from Northeast Victoria in 2014.

Resistance testing was carried out by Chris Preston and the team at the University of Adelaide who found 64% of the 64 fleabane populations sampled from the Murrumbidgee Irrigation Area in 2020 are resistant to glyphosate. Fortunately, all populations tested were susceptible to paraquat. Although it is bad news that glyphosate resistance is quite widespread in the region, the good news is that 36% of populations are still susceptible to glyphosate. It is still possible to slow and reduce the spread of glyphosate resistance in the region. The best way to prevent the spread of resistance is to control survivors with an alternate mode of action and prevent seed and pollen production in resistant populations.

The results so far, and the lessons from Queensland, indicate how rapidly herbicide resistance can spread in a highly mobile species like fleabane. Co-ordinated efforts to control herbicide survivors at a regional scale, and across land uses, are likely to have area wide benefits by reducing the spread of herbicide resistance across the farming landscape.

Reference:

Walsh, Alison, and Ross Kingwell. 2021. "Economic Implications of the Loss of Glyphosate and Paraquat on Australian Mixed Enterprise Farms." *Agricultural Systems* 193 (October): 103207.

Herbicide resistance surveys of Fleabane and Annual Ryegrass in the MIA

Christopher Preston, School of Agriculture, Food & Wine, University of Adelaide
Iva Quarisa, Irrigation Research and Extension Committee (IREC)
Christina Ratcliff, CSIRO

Project Partners:

Summary

Samples of fleabane and annual ryegrass were tested for resistance to glyphosate. Fleabane was also tested for resistance to paraquat + diquat. Resistance to glyphosate was identified in 41 of the 64 fleabane samples tested. Resistance to glyphosate was also found in 10 of the 18 annual ryegrass samples tested from Riverina. None of the fleabane samples tested was resistant to paraquat + diquat. Glyphosate resistance was frequent in both weed species in the Riverina.

Background

Herbicide resistant weeds can be more costly and difficult to manage than weeds that are easily controlled by the herbicide. It is possible for some weeds to gain herbicide resistance through selection in one location and then for seed to move and cause a problem at another location. Movement of herbicide resistant weed seeds is only a problem when land managers are using the same herbicides. For this reason, we have focussed our attention on glyphosate resistant weeds and their potential for movement.

Many land managers including grain farmers, horticulturalists, channel managers and local councils use glyphosate for weed control. This provides plenty of opportunity for glyphosate resistant weeds to spill over from one location to another. It also provides an opportunity to collaborate in reducing the movement of these weeds.

Two weed species were sampled: fleabane and annual ryegrass were collected for testing. Fleabane was collected as seed heads from individual plants at least 10 km apart. Fleabane was collected from roadsides, irrigation channels and fields. Annual ryegrass was collected as intact plants with up to 10 plants from each location. Annual ryegrass was collected from roadsides, irrigation channels and adjacent fields where present. Fleabane was tested for resistance to both glyphosate and top paraquat + diquat. Annual ryegrass was only tested for resistance to glyphosate.

Results

There were 77 samples of fleabane collected from the Riverina, but only 64 of the samples germinated and could be tested. Of these 64 samples, 41 were resistant to glyphosate and none were resistant to paraquat + diquat. This means that paraquat + diquat remains an option for controlling fleabane. However, 64% of the fleabane samples collected were resistant to glyphosate. Glyphosate resistant fleabane was identified across the area sampled. Figure 1 shows the distribution of glyphosate resistant and susceptible samples of fleabane collected in the region.

A total of 24 samples of annual ryegrass were collected focusing on roadsides, irrigation channels and adjacent areas. Of these 18 could be tested for resistance to glyphosate and 12 of those samples were resistant. Like fleabane, glyphosate resistance is common in annual ryegrass. Figure 2 shows the distribution of glyphosate resistant and susceptible samples of annual ryegrass collected in the Riverina.

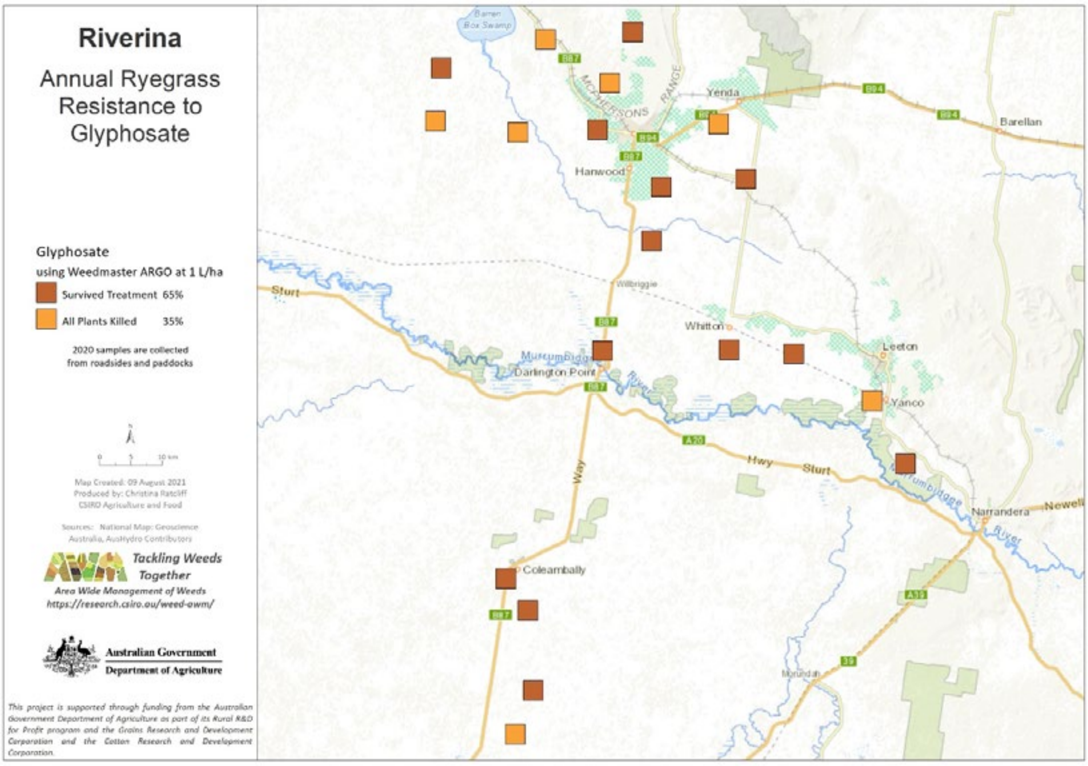


Figure 1. Map of locations resistant and susceptible fleabane samples collected from the Riverina region.

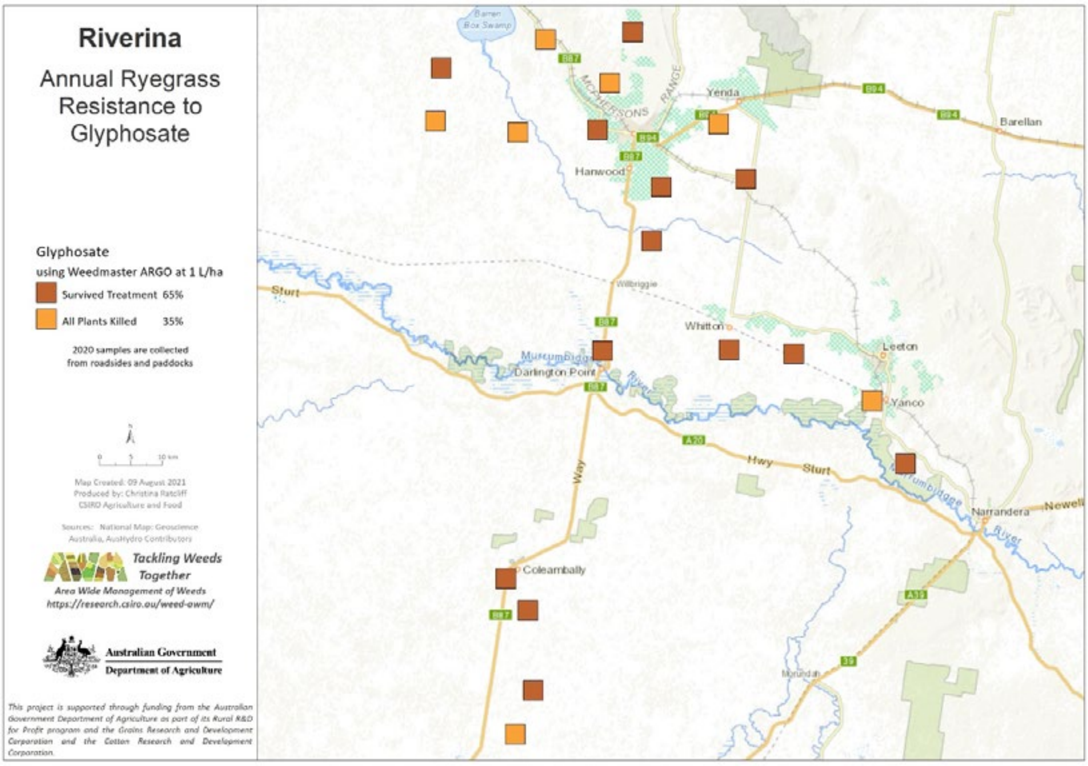


Figure 2. Map of locations resistant and susceptible annual ryegrass samples collected from the Riverina region.

Glyphosate resistant weed seed can move between locations causing problems in control. Fleabane seed is primarily moved by wind, so control of plants before seed is released is important. This can be done by slashing, grazing or other herbicides. Seed released close to the ground will not travel far. Annual ryegrass seed can be moved in farm equipment, other vehicles, by animals and by water. Control of annual ryegrass before it sets seed and improving hygiene of vehicles can help reduce spread of resistant types.

This project is supported through funding from the Australian Government Department of Agriculture as part of its Rural R&D for Profit program and the Grains Research and Development Corporation and the Cotton Research and Development Corporation. For more information visit https://research.csiro.au/weed-awm/

Opportunities for area-wide weed management in the Riverina

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

Background

Weeds are one of Australia's most persistent agricultural and environmental challenges. The mobility of weeds, biological controls and herbicide resistance mean that weed management is a landscape-scale problem that requires community-wide solutions.

For weed management to work effectively across property and institutional boundaries, an in-depth understanding of the attitudes, practices and relationships of various actors involved in weed management is needed.

In mid-2020 we interviewed over 80 growers, agronomists, consultants, contractors, researchers, extension officers, biosecurity officers and public land managers as part of this social research project. Thirty people were interviewed from the Riverina.

The aims of these interviews were to:

- learn about the diverse attitudes towards area-wide management of weeds;
- identify factors that explain participation in individual and area-wide management of weeds; and
- identify social costs and benefits of area-wide management of weeds and related practices.

Weeds of most concern

A list of thirty-two weeds were mentioned by interviewees as being in their top three weeds of most concern. Five weeds (Figure 1) were considered to be particularly concerning in the Riverina:

Ryegrass was the most commonly reported concern because of glyphosate resistance and it is problematic for winter and summer crops.

Fleabane was concerning because it is highly resistant to glyphosate, which makes it difficult to control. It is easily dispersed because it is small-seeded and is a surface-germinator.

Silverleaf nightshade is a prolific spreader, is spread easily by livestock and is transported onto properties from roadsides. It grows well over the summer and thrived during the drought.

Feathertop Rhodes grass is often glyphosate resistant and is frequently found along roadsides. It is labour intensive to remove. There was concern about this grass on dryland farms with increasing presence on irrigation farms.

Barnyard grass was easier to control than the above-mentioned weeds, but challenging for rice growers, affecting yields because it won't be outcompeted by rice.

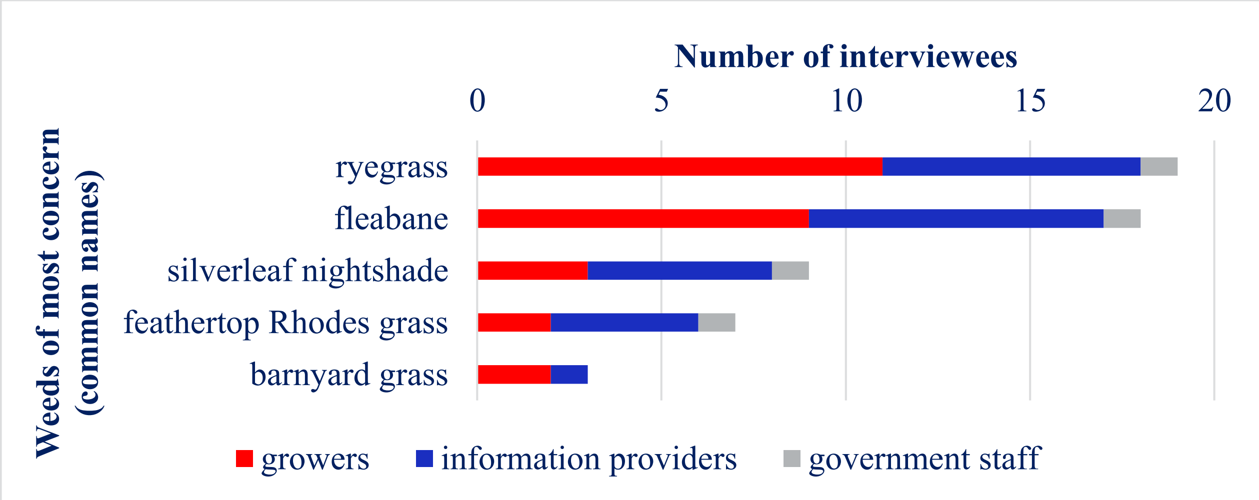


Figure 1. Number and occupation of Riverina interviewees who identified each weed as being in their top three weeds of most concern. Information providers include agronomists, industry extension workers and researchers.

Most significant weed management issues

Nine significant issues affecting the management of weeds were identified by interviewees. Herbicide resistance was the most frequently mentioned. The last five items listed in the box were only identified by one or two interviewees each.

- Herbicide (glyphosate) resistance is an issue for a number of reasons, including affecting the chemical and other weed control options applied, as well as the timing of activities. Resistance affects all land managers, including those who use integrated weed management practices and rotate chemicals.
- Funding was mostly an issue reported by government staff. Concerns were raised about not having sufficient funds to cover the area of land affected by weeds.
- Spray drift was a particular concern among cotton and organic growers. There were also concerns raised that people are not using the chemicals that they say they are using.
- Roadsides and waterways were seen to be problematic because they represent common areas where weeds establish and then move onto neighbouring land. These areas are also of concern because the organisations responsible for managing weeds on roadways and in channels are limited in the chemicals they can use.
- Lack of coordination was a concern among adjoining councils, between various government departments, among researchers, and with private land managers. Inadequate coordination makes it more difficult to prevent the spread of weeds and manage weeds across boundaries.

The most significant Riverina weed management issues

1. Herbicide (glyphosate) resistance
2. Insufficient funding for government work
3. Spray drift
4. Roadside and waterway management
5. Lack of coordination between different stakeholders
6. Lack of understanding of integrated weed management
7. Timing of chemical application
8. Use of dirty water
9. Diverse weed priorities across cropping systems

Area-wide management of weeds

There was little consensus about what area-wide management of weeds means, the size of the area it would cover and the activities it would include (see Table 1). Most interviewees said that everyone should be involved in area-wide weed management, including one grower who explained that:

> *when I mean everyone, I don't mean just mean the landholders, or your landowners, I also mean council, I mean state government. It's a whole community control of certain weeds which would be causing issue, (Grower)*

Some interviewees referred to an industry-wide or cross-industry approach, rather than focusing on a particular geographic area. In doing so, interviewees recognised that different "crops have very different needs, even around the same weeds". Interviewees often stated that "working together" was a key element of area-wide weed management.

Other activities mentioned include coordinated communication and working to develop best management practice to control weeds.

Ryegrass, silverleaf nightshade, fleabane and boxthorn were the most common suggestions for specific weeds that would be well-suited to an area-wide weed management program. Ryegrass was described as a good contender for area-wide weed management because "everyone seems to have [it]" because it is resistant to glyphosate. Silverleaf nightshade was described as suited to area-wide management because it spreads so easily and is a local priority. Fleabane was also commonly listed because is highly visible and "widespread throughout the district".

Table 1. Characteristics of area-wide management of weeds most commonly described by Riverina interviewees.

Geographic area

Region
Community
Large area
Neighbouring land

Activities

Weed control
Working together
Communicating
Identifying best management practice
Monitoring
Education
Planning
Preventing weed spread
Getting together

Who is involved

Everyone
Local government
Farmers
Landholders
Local Land Services
Department of Primate Industries
Roadside managers
Murrumbidgee Irrigation

Which weeds

Ryegrass
Silverleaf nightshade
Fleabane
Boxthorn

Benefits, costs and challenges of area-wide management of weeds

Perceived benefits of area-wide management include greater awareness of an issue as well as showing more landholders what is possible and what help is available. Learning new techniques for use on-farm can also improve best-practice. Interviewees also discussed how area-wide weed control can be more effective because more people are encouraged to control weeds, the pressure from weeds is lessened, seedbanks are reduced and there can be fewer on-farm weed issues. Pooling resources can also lead to a better return on investment in weed control and spending less on weed control over the long-term.

A lack of time was the most commonly mentioned cost associated with area-wide weed management. This included the time required to attend meetings and undertake the weed control. Interviewees also mentioned the financial cost associated with undertaking weed control, including the cost of chemicals, and the impact of such costs on gross margins.

Challenges that may undermine area-wide efforts include the need for a leader to coordinate an area-wide weed management program. Some interviewees suggested that organisations broader than one industry are required because "they'll be able to target everybody". It can also be challenging to bring people together to talk about weeds. Some people don't want to be involved in area-wide programs because of the cost involved, neighbourly disputes, or because they want to do their own thing:

> *There are those who are willing to engage, interested in making improvements and those who will just say "Just leave me alone and let me do what I'm doing, but if I need help, I'll come and find it, thank you very much." (Grower)*

Interviewees also noted the long time it takes to demonstrate the benefits of an area-wide approach to managing weeds and that it is challenging to show individual benefits of participating.

Conclusions

These interviews have shown that there are several weed management issues in the Riverina that could benefit from area-wide management, including management of the three most concerning weeds. There is little consensus on what the area of management should be or activities involved, but many people said everyone should be involved. Potential benefits from area-wide management include improving awareness, practice, effectiveness and financial efficiency of weed control. Challenges in finding leadership, bringing people together and showing benefits need to be tackled before area-wide weed management programs can be established.

Acknowledgements

This project is supported by funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program in partnership with Research and Development Corporations, commercial companies, state departments and universities.

The project involves 11 research and development partners: Grains Research and Development Corporation, Cotton Research and Development Corporation, AgriFutures Australia, CSIRO, University of Queensland, University of Adelaide, University of Wollongong, Mallee Sustainable Farming, Millmerran Landcare Group, Irrigation Research & Extension Committee and the Toowoomba Regional Council.

The influence of poultry litter on fertilizer-N recovery and soil nutrient availability

Jackie Webb*, Rakesh Awale, Wendy Quayle

Rationale

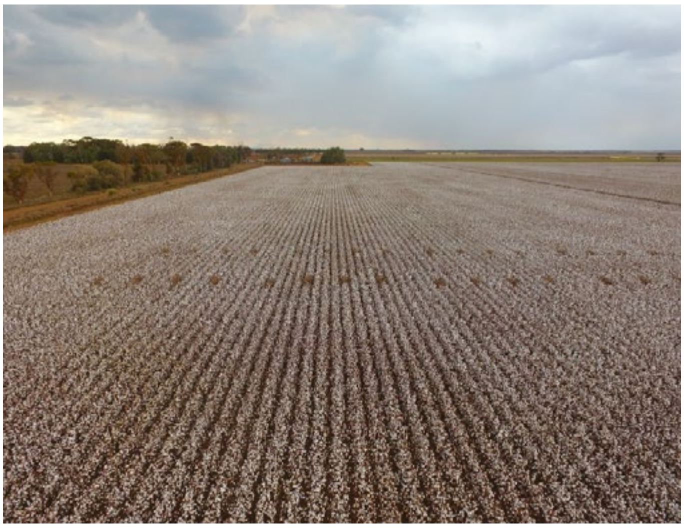
Poultry litter (PL) boosts soil microbial health and can provide a supplemental crop nutrient source. However, there is a lack of knowledge on how much and when plant available nutrients are released from soil when PL is amended. In studies of other animal manures, amendments have been shown to greatly improve soil N retention, which reduces N losses from the field. With PL being locally abundant in the Riverina, there exists an opportunity to investigate how PL affects N cycling in southern cotton crops.

To address these knowledge gaps, a micro-plot field trial was established on a commercial cotton farm in Benerembah. The aim was to track the fate of nitrogen (N) fertiliser in soil and cotton to see if PL improves soil N retention and plant uptake. We used a combination of field techniques, including spiking urea fertiliser with the heavy ^{15}N isotope and *in situ* measurements of soil nutrient supply.

Timing of nutrient release from litter over the growing season

To achieve both the sustainable and optimal use of manure-based organic amendments in crops, we must first understand how the organic amendment behaves under field conditions. Timing soil nutrient release to match the crops needs is key to maximising the use of manures for supplemental nutrients. Using Plant Root Simulator (PRS™) probes, we measured in situ soil N, P, K release every month from litter application through to defoliation.

Recently dug-up PRS™ probes used to measure nutrient release rates from the soil in situ. Photo source: Jackie Webb



Aerial view of the hand-picked microplots in a cotton field at harvest where ^{15}N-labelled urea was applied. Photo source: Matt Champness

These probes were placed in root exclusion collars in the field and left for one week to absorb anions (NO_3^-, $H_2PO_4^-$) and cations (NH_4, K^+) as they become available in the soil.

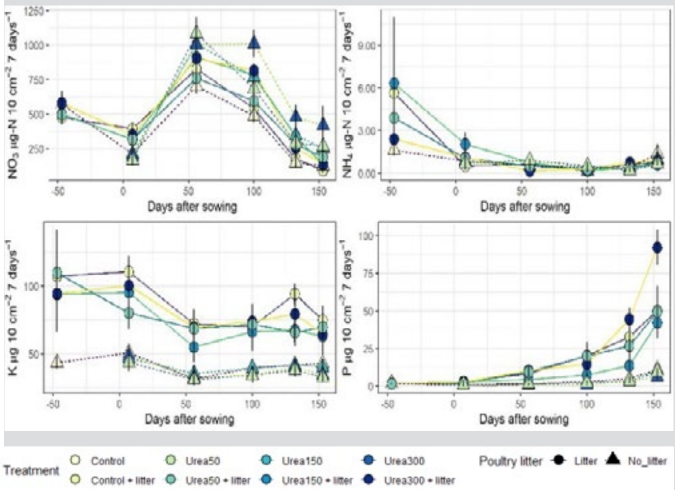
Does litter affect the fate of fertiliser N?

Low nitrogen fertiliser use efficiencies (NFUE) are an ongoing area of concern in the cotton industry. When less fertiliser is recovered by the plant relative to the amount applied, there risks substantial N losses to the environment. We decided to investigate if using litter in combination with urea for N fertiliser improves plant fertiliser recoveries.

The most accurate way of determining where fertiliser goes in the soil-plant system and how much is through the ^{15}N isotope technique. Essentially, we enrich our urea fertiliser solution with the heavy nitrogen isotope to give it a unique "fingerprint". The effect of litter was tested on three urea rates equivalent to 50, 150, and 300 kg N/ha. Micro-plots were used to minimise contamination of the field for any future N research.

We measured the unique isotope levels in the plants and surface soil every month over the growing season. Soil microbial biomass was also measured over time, which gives an indication of the amount of living organisms in the soil. The benefits of having a healthy soil biological community is well documented for agricultural soils.

Key findings

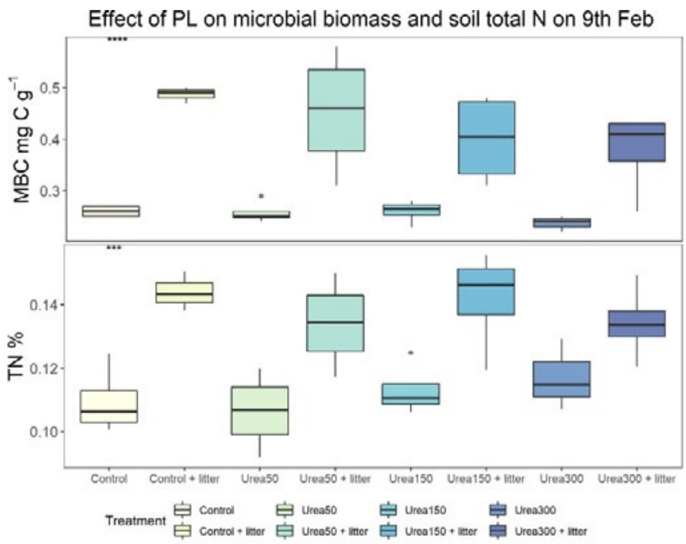


Soil nutrient release

The only time litter treatments caused significantly higher soil NO_3 and NH_4 release was 7 days after sowing. This suggests that most supplemental N benefits provided by litter occurs early in the season. It dispels the notion of using litter as a slow release fertilizer that may become available in appreciable amounts at early flowering.

There was evidence of some NO_3 immobilisation from urea occurring in the litter treatments between 56 and 132 DAS.

Litter was a significantly strong source of K and P over the growing season. Interestingly, soil P release continued to increase over time. In contrast to N, supplemental benefits of P from litter seems to occur later in the season.

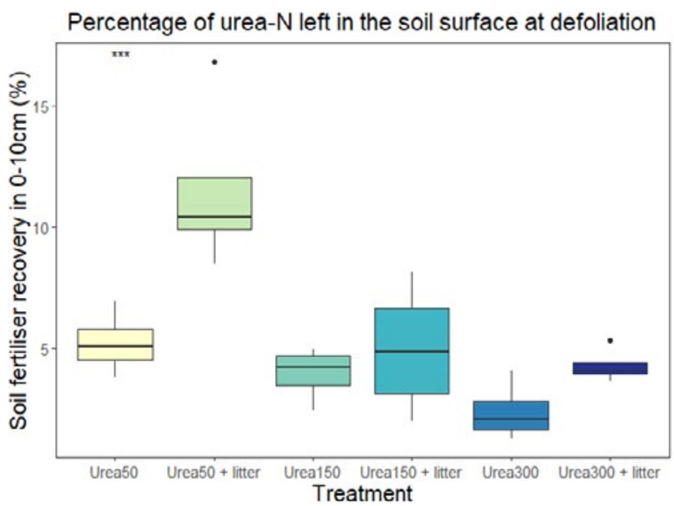


Litter boosts microbial biomass and organic N

All litter treatments, regardless of urea rate, maintained higher microbial biomass throughout the season.

Litter amendment also boosted total soil nitrogen in the form of organic N, which consistently remained higher than non-litter treatments throughout the season.

This demonstrates that poultry litter can improve soil biological health and surface soil N stocks, maintaining fertile soils for the next crop.



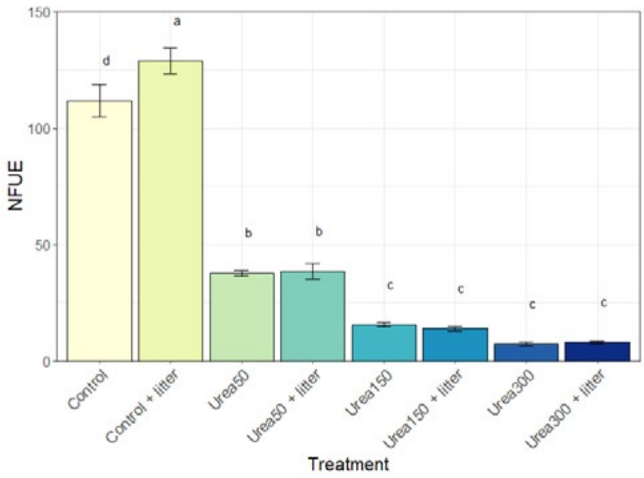
Litter helps soils retain more fertiliser N

Although we do not have the final data analysed from harvest yet, surface soil samples (0-10 cm) taken at defoliation suggest the litter is helping to retain more fertiliser N compared to urea-only treatments.

When litter was present, fertiliser recoveries in the top surface soil were significantly higher, at least in the lowest and highest urea treatments. The greatest recovery was seen in the lowest urea treatment, where 12% of the applied fertiliser remained in the surface compared to 5% when no litter had been applied.

Stay tuned for the full picture once we receive results for our 90 cm soil core samples.

Key findings



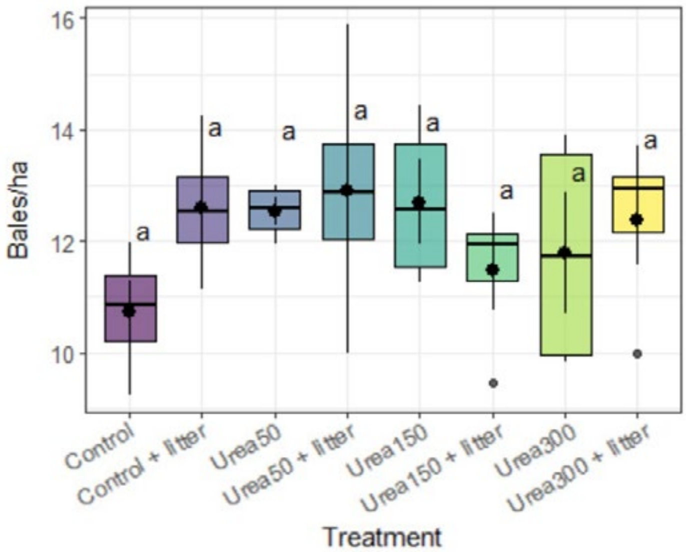
Plant fertiliser recovery

At this stage we are still waiting on the final harvest ^{15}N results, so we cannot definitively say how PL affects total plant fertiliser recoveries. However, plant samples collected over the season are indicating that the amount of urea has a significant effect on the proportion of fertiliser N used by the plant, with potential fertiliser recoveries >50% in the lowest urea treatment.

Calculation of NFUE's across our treatments also suggests that lower fertiliser is certainly better. In this trial, PL only significantly improved NFUE in the control plots which had received a base dose of 20 kg N ha^{-1} (from MAP application).

Summary

- Data from soil N release measurements indicated that plants were likely getting all their N requirements across all treatments, besides the control, during the key N uptake phase. In fact, yield results from this experiment indicated that N inputs above 50 kg N ha^{-1} did not result in higher cotton yield.
- Litter has an immediate positive impact on soil health. The effect of PL on sustaining soil N and microbial health beyond one season remains to be investigated.
- When to apply poultry litter to maximise supplemental nutrients to crop? This depends on what nutrient you want litter to contribute to. To maximise N, applying just before sowing would work best, while applying litter months prior to sowing is better for maximising P.
- Watch this space for updates on how littler affects final fertiliser recoveries in the soil-cotton system.



Trial yield results. Letters indicate no significant difference among treatments. Cotton was handpicked from micro-plots

Hand picking cotton from micro-plots at the Benerembah trial site. Photo source: Jackie Webb

Acknowledgements

This work is funded by Deakin University, CRDC, and National Landcare Smart Farming Partnerships Program. We thank Darrel Fiddler for providing access to the farm site, Kieran O'Keefe for initial site discussions, and John Hornbuckle, Rodrigo Maia, Arbind Banija, and Matt Champness for fieldwork assistance

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Australian Government Department of Agriculture

Contact

Dr Jackie Webb for more information
j.webb@Deakin.edu.au
Connect with @JackieRWebb and @CeRRF_Griffith on Twitter for future updates on this research.

CeRRF CENTRE FOR REGIONAL + RURAL FUTURES

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There's money in manure: if you know how to use it

Wendy Quayle[1], Rakesh Awale[1], Jackie Webb[1], Johannes Biala[2] Daniele De Rosa[3], David Rowlings[3]

[1] Centre for Regional and Rural Futures (CeRRF), Griffith NSW, Deakin University
[2] Centre for Recycling of Organic Waste & Nutrients (CROWN), University of Queensland
[3] Centre for Agriculture and the Bioeconomy, Queensland University Technology
w.quayle@deakin.edu.au 0417 436 775

Thought about using organic amendments but not sure how to calculate this into synthetic fertiliser budgets?

A national project, led by the Queensland University of Technology and working with researchers from La Trobe University, CeRRF, Deakin University and the University of Queensland, is validating a cross-industry, manure management app for organo-mineral nutrient budgeting.

The first prototype has undergone some testing across different industries and has provided support in selecting the best site-specific synthetic-organic plant nutrient management practice that allow savings in synthetic fertiliser up to 30 per cent in cotton, 70 per cent in grain (sorghum and winter wheat) and 40 per cent in a vegetable crop rotation, without yield penalties.

The app builds on research projects supported by CRDC and partner organisations, quantifying the effect of organic amendments, and in particular chicken litter on cotton crops. The integration of organic and mineral (from bagged fertilisers) nutrient sources remains a low-hanging opportunity that could boost Australian farming sustainability credentials.

Incorporating plant nutrients released from organic soil amendments into cotton fertiliser budgets allows the reduction of synthetic fertiliser rate without compromising crop yield.

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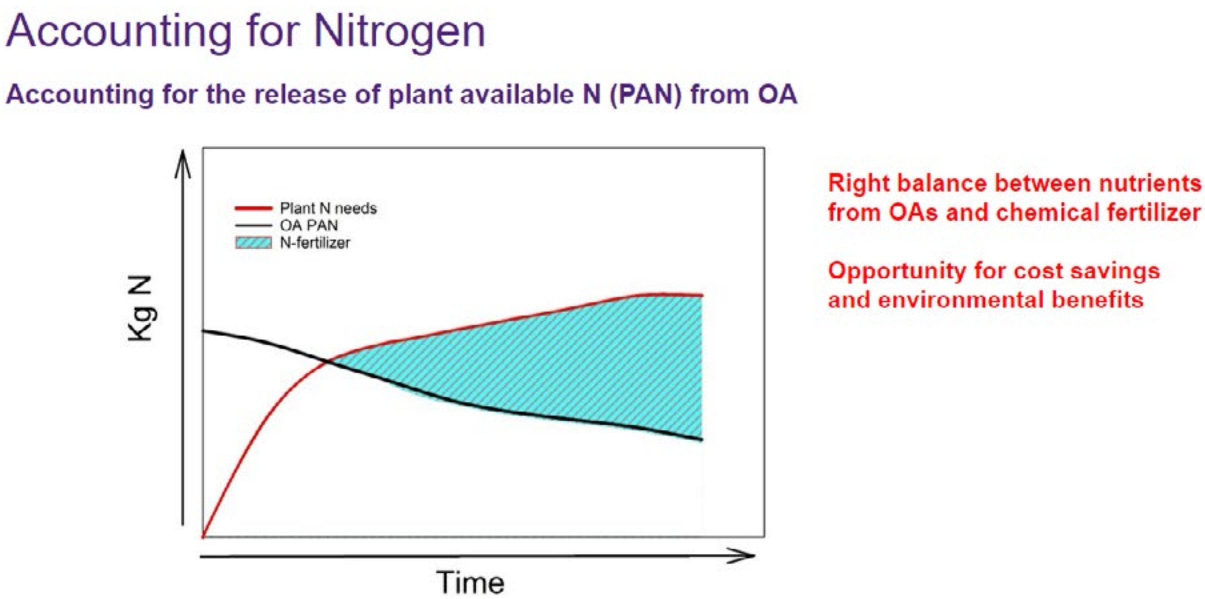
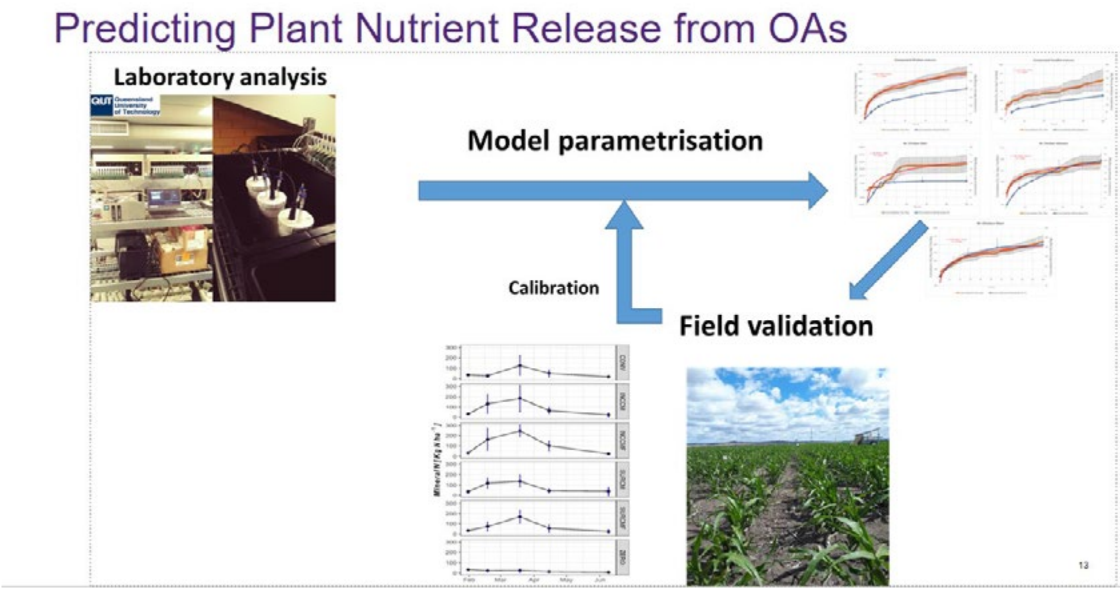
QUT ife Institute for Future Environments

The research is contributing to a series of experimental trials conducted across Australian agricultural industries of cotton, horticulture, dairy and grain.

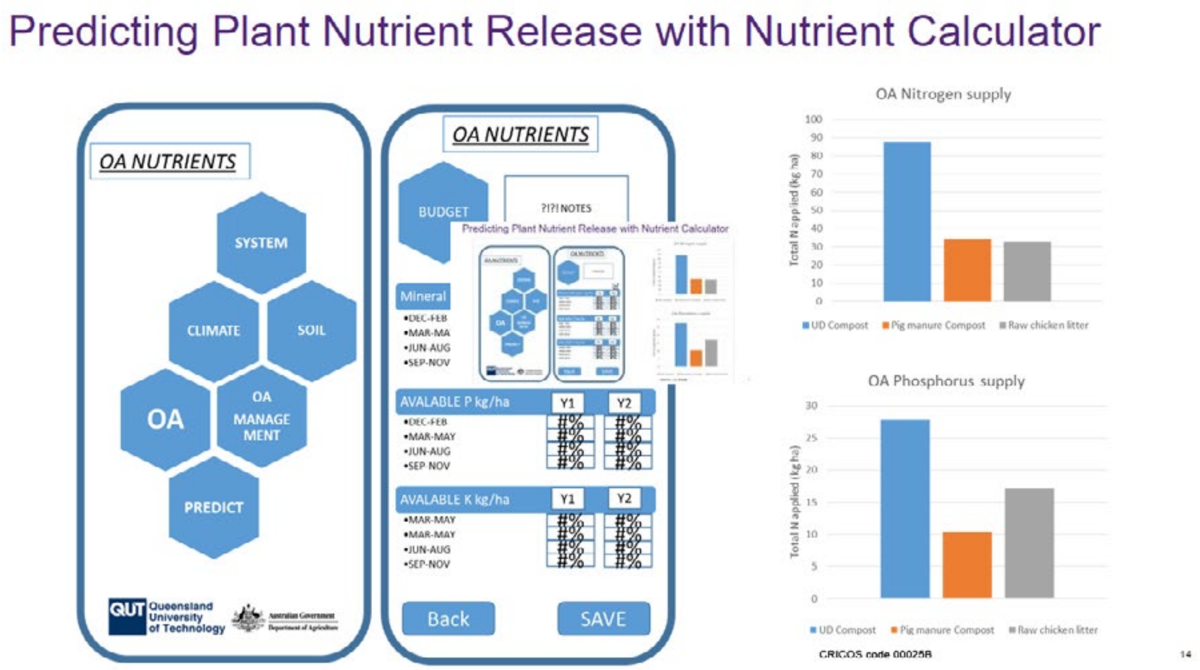
The app will help growers get the most out of manure by calculating not just the total amount of nutrients contained in these products and supplied at a given application rate, but also the timing of nutrient supply over time and the subsequent potential for making mineral fertiliser savings, nutrient use efficiency and economic benefit.



Data obtained from incubation experiments and compared against field results in different seasons, crops and manure types has allowed assessment of application rates and calculation of what is being provided in terms of available nutrients and fertiliser value.



The data has enabled the development of this first prototype of the user-friendly organic amendments nutrient release calculator, involving an input-led calculator from a mobile phone user interface, which will be available from Appstore or Google Play.



Users input information in on manure spreading rates and the calculator determines the amount of crop available nitrogen and phosphorus. The apps helps decide how much manure to spread to meet the crop requirement, and to assess the economic benefits with mineral fertiliser for different rates and ratios. For example, in cotton, 15m^3/ha Autumn incorporated chicken litter provided 80 kg available N/ha, 35 kg available P/ha and reduced pre-plant fertilizer costs by $80-100/ha.

The information may also be retained for longer term farm records and potentially combined with precision agriculture digital platforms for variable rate fertiliser management.

Soil health under poultry litter amended and non-amended cotton systems of the Riverina

Authors

Dr Rakesh Awale, Jackie Webb, and Wendy Quayle
Centre for Regional and Rural Futures (CeRRF), Deakin University

Highlights

- A soil health index has been developed simplifying 37 soil health indicators using a range of cotton growing, with and without poultry litter application histories, and native soils sampled from 10 farms across the MIA (81 soil samples).
- The index has identified that there is no difference between poultry litter amended sites compared with cotton farm native vegetation sites. However, both of these are healthier than sites with a mineral fertilizer only history.
- The soil health index evaluated lint yield with soil health at the IREC Whitton field trial which had 3 years of consecutive, differing rates of chicken litter compared with mineral fertilizer application only.
- There was a significant linear relationship (R2=0.71) between cotton lint yield and the soil health indicated by the new index at Whitton.
- Poultry litter amendments exhibited higher index values and lint productivity compared with mineral fertilisation alone.

Background

A healthy soil is essential for sustaining high cotton productivity in the Riverina. In this region, some cotton growers are applying available poultry litter in combination with mineral fertilisers, mainly with a view to improve soil physical condition and enhance biological health. Due to a lack of quantitative soil health assessment measures, it is usually unclear if the management intervention actually has a beneficial effect on soil health and crop productivity and therefore cost benefit. Therefore, we have identified soil indicators that have enabled the development of a practical soil health index for assessing cotton producing soils of the Riverina.

Poultry litter application in a cotton field

In early-Spring of 2020, 81 soil-samples (0-15 cm depth) were collected from cotton paddocks, fertilised using mineral fertiliser alone (conventional) or in combination with poultry litter amendments (2.5 to 16 t/ha), and undisturbed native lands in close proximity to the cropped paddocks across 10 commercial cotton-growing farms of the southern Riverina. These soils were analysed for physical, chemical, and biological properties (Table 1).

Table 1. Selected soil (0-15 cm) characteristics across sites (managements)

Soil properties	Native	Conventional	Poultry litter
pH	6.92	7.72	7.26
% Organic C	1.42	0.87	1.15
% Total N	0.11	0.08	0.10
Available N (mg/kg)	11.6	38.1	60.2
Available Zn (mg/kg)	1.49	1.56	2.84
Ca:Mg	2.20	1.38	1.61

Poultry litter amendment effects on soil properties

Assuming the native sites represent baseline soil conditions of the farmed areas, cultivation has considerably depleted SOC on average by 39% and 19% for non-organic amended and organic amended sites, respectively. Soil microbial biomass and labile C availability followed a similar trend to SOC. Poultry litter amendments have maintained total N similar to the native sites, while at the time of sampling, conventional sites have lost about 25% of their initial total N. Soil macro and micronutrient levels were also higher at the poultry litter sites than the conventional sites. Soil Ca:Mg ratios for the conventional sites (1.38) were relatively lower than those of the poultry litter sites (1.61). Overall, poultry litter amendments can restore and maintain organic matter and build-up fertility status of cotton producing soils of the Riverina.

Quantitative Assessment of Soil health

This study examined 37 soil chemical and biological properties, which were moderately to highly correlated amongst each other. Using statistical techniques, five soil factors (soil organic matter, cation balance, N-availability, soil pH, and Zn-availability) explained about 70% variability in the soil health index model. For example, total C, total N, SOC, labile C, dissolved organic C, microbial biomass C, microbial activity, and K availability could be interpreted as soil organic matter-factor, and SOC was selected to represent this factor because of its highest loading of 0.90. Similarly, Ca:Mg ratio, total available N, soil pH, and available Zn were selected for the other factors, respectively.

A prepared cotton field at pre-planting and a native vegetation in proximity

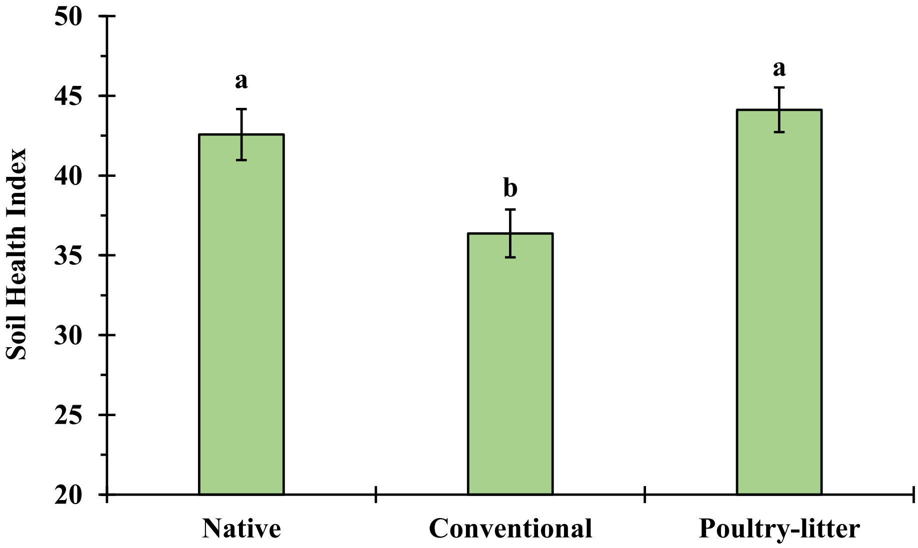


Fig. 1. Overall soil health index under different soil managements.

Soil health across the sites according to the Soil Health Index (SHI)

Overall, the SHI indicated that there was no difference between native and poultry-litter sites. However, both of these types of sites had significantly higher SHI compared with the conventionally cultivated sites (Fig 1). The improvement in soil health with poultry-litter amendment over mineral fertiliser application may be attributed to the litter amendments favouring soil cation balance with the supply of more Ca than Mg; increasing soil organic matter content, nutrient availabilities, microbial biomass, and activity; and buffering against soil pH change. Higher exchangeable Ca and lower exchangeable Mg (or high Ca:Mg) in the CEC are required for stable soil aggregation (flocculation) and increased oxygen diffusion in the soil that support microbial activity and root growth. Similarly, high soil organic matter content sustains the growing microbial biomass and activity which in turn regulate many soil biogeochemical processes such as nutrient (e.g., N, P) cycling and storage, secretion of binding products critical to the maintenance of soil structure, and C-stabilisation in the soil.

The SHI model was validated by evaluating the relationship of SHI against mean cotton lint yield (2017-2019) data from the IREC Whitton field trials consisting of six different treatment combinations of mineral N fertiliser and poultry litter amendments (Fig. 2). There was a significant linear relationship (R2=0.71) between cotton lint yield and the modelled SHI at this site, with poultry litter amendments exhibiting higher SHI and lint productivity compared with mineral fertilisation alone.

Conclusions

- Soil health, under cotton production systems of the Riverina can be quantitatively assessed using the newly developed soil health index from a combination of soil properties, including Ca:Mg ratio, organic C content, N availability, pH, and Zn availability.
- The index enables properties that are provided in routine soil tests to be used to evaluate soil health of cotton systems in the southern region.
- Assessed soil health for a particular soil may be compared against undisturbed site (in proximity) whenever available or be monitored over a period of time in situations when no reference site is available.

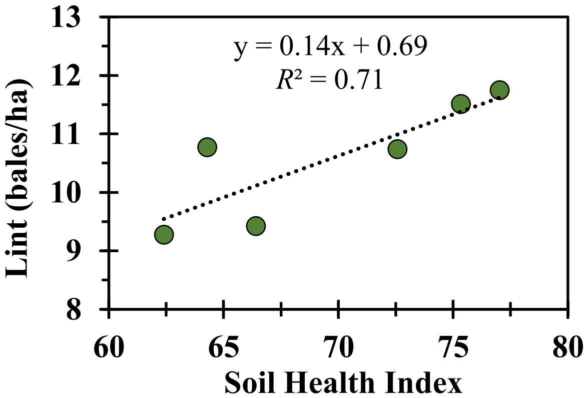


Fig. 2. Relationship between lint yield and soil health at the IREC Whitton site

- Further research will enable the index to be used as a tool that can more readily quantify soil health as a dollar value. This will allow the cost benefit of manure application to be truly estimated.
- Overall, poultry litter amendments improve soil health over the sole applications of mineral fertilisers under cotton production systems of the Riverina.

Acknowledgements:

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For Further Information:

Rakesh Awale rakesh.awale@deakin.edu.au

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Australian Government Department of Agriculture, Water and the Environment
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Automated irrigation as an enabling technology to achieve aerobic rice

Authors

Matt Champness, Rodrigo Filev Maia, Carlos Ballester, John Hornbuckle
Deakin University, Centre for Regional and Rural Futures

Objective

Develop linked sensing, forecast and automation systems to achieve optimal water management in aerobic rice systems. Systems capable of sensing soil, water and crop stress that together with automated Internet of Things (IoT) irrigation control structures and weather forecasts will allow water and labour savings to be achieved.

Background

Water is a key input into the rice industry. Water scarcity and increased competition across multiple irrigation industries is raising the interest of the rice industry in irrigation techniques that minimise water application, such as the alternate wetting and drying (AWD) and delayed permanent water (DPW). Moving to a 'Dry Rice' system, which aims to minimise water application and use, will be critical in ensuring the future of the Australian rice industry in a water-constrained environment.

Moving from a traditionally ponded watering strategy to a partly ponded or ultimately aerobic rice growing system will need significant advancements in water management for the rice industry.

Soil moisture, water control, crop stress monitoring and timely irrigation management are critical to minimally ponded or non-ponded rice cropping systems to maximize water productivity. Sensing systems capable of sensing soil, water and crop stress, integrated with weather forecasts and automated Internet of Things (IoT) irrigation control structures have the potential to be used in rice- growing systems to reduce labour cost and improve water productivity, assisting the industry achieve their target of 1.5T/ML by 2030.

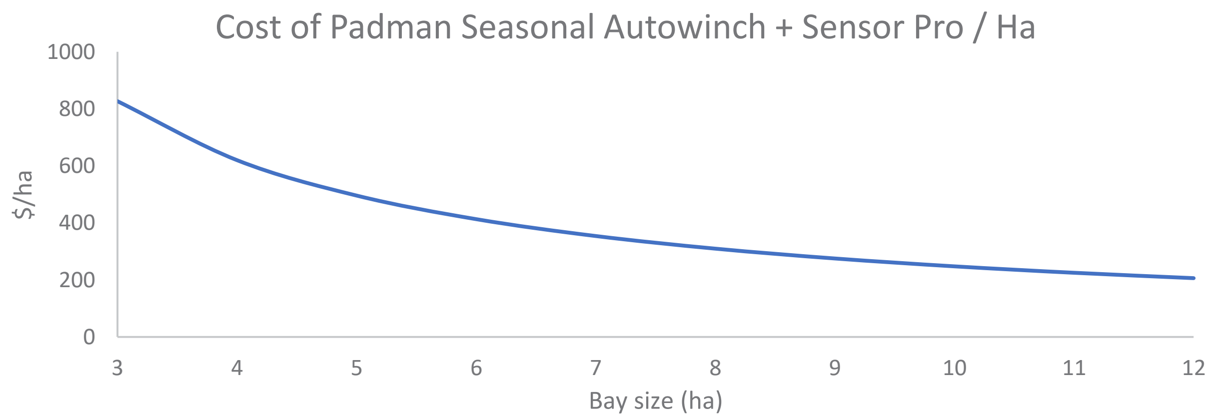

Figure 1 - Cost of Padman Automation seasonal autowinch & sensor pro per hectare. This set up enables real time sensing of soil moisture tension and water height and automated control of winches.

Irrigation scheduling

Initially the system was irrigated manually before Padman Rubber inserts, Seasonal Autowhich's and Sensor Pro's were installed.
Note: This trial was conducted on a 35ha, 9 bay border check layout. Labour & water savings will differ between farms and layouts.

Figure 2 - Commercial aerobic rice with automated irrigation – harvest April 2021

Manual Irrigation - 1st Irrigation

- Over 4 days the farmer drove to the field and back 12 times to check or change water (including a 5:00am, 4:00am and 1:00 am water change).
- This totalled 7 hrs of labour and 168 km travelled.
- 7 hrs X $45/hr + 168 km x $0.72/km = $436 plus sleep deprivation, missed opportunities doing other jobs (e.g. spraying) as well as some bays over irrigated resulting in greater tail water.

Automated irrigation – rest of the season

- Irrigation controlled via webapp from workshop/tractor/holidays.
- Irrigation triggered based off soil moisture sensors in field and water ordering assisted by soil moisture forecasting.
- IoT control structure (Padman Autowinch) open/close irrigation stops.
- In-field water height sensors (Padman Sensor Pro) in bays used to trigger closing/opening of current/next bay.

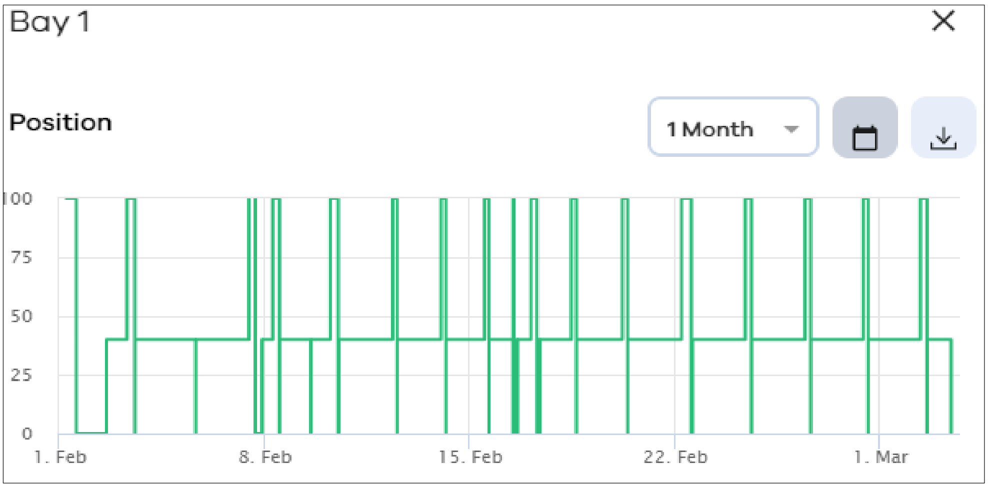

Figure 3- Autowinch position in February - 17 irrigation events in for the month

Outcomes/results

- Successful automated irrigation of aerobic rice: 264 automated irrigation events for the season.
- Refined sensors to include in field and channel pressure transducer water height sensor to alert user of potential overflow issues (Padman Sensor Pro)
- Aerobic rice is possible & feasible at a commercial scale with cost effective automated irrigation scheduling & smart sensing.
- Water Productivity >1 T/ML in an exceptionally cold year.
- Whole grain yield 67%

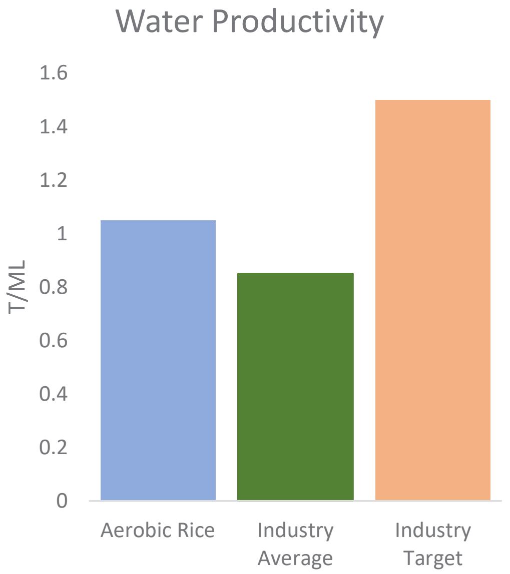

Figure 4 - Water productivity of aerobic rice v's long term industry average and industry target of 1.5T/ML by 2030.

Moving forward

- This coming season will see further smart sensing automation trials to continue to refine sensing and automation technology and further reduce the cost of automation.
- Aerobic rice appears to be a viable option; however, smart sensing and automation systems have the potential to enable 'strategic ponding' if needed in the event of cold weather forecast, providing a 'safer' alternative to aerobic rice. This strategy will be investigated in the 2021/22 season.

Figure 5- Aerobic Rice Field Walk - DeBortoli Wines

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The effect of sowing date and irrigation management on faba bean

Authors

Tony Napier and Daniel Johnston (NSW DPI, Yanco); Mark Richards, Dr Aaron Preston and Dr Lance Maphosa (NSW DPI, Wagga Wagga)

Key findings

Sowing date affected grain yield under both irrigated and non-irrigated treatments. Delayed sowing after 24 April resulted in reduced grain yields for both dryland and irrigated treatments.

An irrigation efficiency of 1.51 t/ML was achieved with faba beans when sown on 24 April. Any delay in sowing after 24 April resulted in reduced irrigation efficiency.

Sowing on 24 April resulted in a header yield of 6.86 t/ha averaged across all varieties when irrigated.

In the irrigated treatment, PBA Nasma[A] achieved the highest grain yield of 5.73 t/ha when averaged across sowing dates and the highest grain yield when sown on 24 April with 7.50 t/ha.

Introduction

An irrigated faba bean experiment was established at Leeton Field Station (LFS) in 2020 to determine the effect of sowing time and irrigation on four varieties of faba bean in southern NSW.

Treatments

Table 1. Varieties evaluated in the LFS faba bean experiment, 2020

Variety	Comment
PBA Bendoc[A]	Released in 2018 with tolerance to imidazolinone herbicides
PBA Marne[A]	Shorter season variety and recommended for lower rainfall areas
PBA Nasma[A]	Large seed variety and recommended for Northern NSW
PBA Samira[A]	Mid-season variety and recommended for southern NSW

Table 2. Sowing dates evaluated in the LFS faba bean experiment, 2020

SD	Sowing date	Comment
SD1	24-Apr-20	Earlier than recommended sowing window (irrigated)
SD2	15-May-20	Late in recommended sowing window (irrigated)
SD3	5-Jun-20	Later than recommended sowing window

Table 3. Rainfall totals and irrigation estimates for the LFS faba bean experiment, 2020

	Irrigated treatments	Non-irrigated treatments
Pre-irrigation	50 mm (0.50 ML)	50 mm (0.50 ML)
In season rainfall	144 mm (1.44 ML)	115 mm (1.15 ML)
10 September irrigation	80 mm (0.80 ML)	0 mm
8 October irrigation	80 mm (0.80 ML)	0 mm
Total	354 mm (3.54 ML)	165 mm (1.65 ML)

The "In season" rainfall was higher in the Irrigated treatments due to the growing season being approximately two weeks longer.

Results - Grain yield

All irrigated treatments achieved a significantly higher grain yield than any non-irrigated treatments with a significant interaction between irrigation treatments and varieties observed. PBA Nasma[A] achieved a significantly higher grain yield than all other varieties in the irrigated treatments with 5.73 t/ha while PBA Bendoc[A] recorded a significantly lower header yield than all other varieties in the irrigated treatments with 4.40 t/ha (Table 4). In the non-irrigated treatment, there were no statistical differences in grain yield across all varieties.

Table 4. Grain yield results for irrigation treatment × varieties (averaged across all sowing dates) in the LFS faba bean experiment, 2020

Treatments	PBA Nasma[A] (t/ha)	PBA Marne[A] (t/ha)	PBA Samira[A] (t/ha)	PBA Bendoc[A] (t/ha)
Irrigated	5.73	5.24	4.90	4.40
Non-irrigated	3.80	3.75	3.90	3.68
l.s.d (<0.05)	0.204			

There was a significant interaction between the sowing dates and irrigation treatments for grain yield. The irrigated treatments in SD1 achieved the highest grain yields when averaged across all varieties with 6.86 t/ha and was significantly higher than all other treatments (Table 5). The non-irrigated treatments in SD3 recorded the lowest header yields when averaged across all varieties with 3.07 t/ha.

Table 5. Grain yield results for irrigation treatment x sowing date treatment (averaged across varieties) in the LFS faba bean experiment, 2020

Treatments	SD1 (t/ha)	SD2 (t/ha)	SD3 (t/ha)
Irrigated	6.86	4.71	3.71
Non-irrigated	4.46	3.83	3.07
l.s.d (<0.05)	0.167		

Even though PBA Nasma[A] achieved a grain yield of 7.5 t/ha when irrigated on 24 April, a significant three-way interaction between irrigation treatments, sowing date and varieties was not observed in the 2020 LFS faba bean experiment. (Graph 1).

Graph 1. Grain yield results for irrigation treatment x sowing date x varieties in the LFS faba bean experiment, 2020.

The yield increase from the application of two spring irrigations (1.6 ML) was the highest in the 24 April sowing with an extra 2.41 t/ha recorded (Table 6). With a yield increase of 2.41 t/ha, the first sowing date achieved the highest irrigation efficiency of 1.51 t/ML. Sowing on 5 June recorded the lowest irrigation efficiency of 0.41 t/ML with an average yield increase of 0.65 t/ha.

Table 6. Irrigation efficiency for the three sowing dates (averaged across all varieties) in the LFS faba bean experiment, 2020

Treatments	24 April	15 May	5 June
Yield increase from Irrigation	2.41 t/ha	0.89 t/ha	0.65 t/ha
Irrigation quantity	1.6 ML/ha	1.6 ML/ha	1.6 ML/ha
Irrigation efficiency	1.51 t/ML	0.56 t/ML	0.41 t/ML

Results - Total biomass

Total biomass averaged 12.02 t/ha across all variety, sowing dates and irrigation treatments. PBA Nasma[A] achieved the highest average total biomass at 12.82 t/ha and PBA Marne[A] recorded the lowest average total biomass at 11.35 t/ha and was statistically similar in total biomass with PBA Bendoc[A] (not shown).

Sowing on 24 April achieved the highest total biomass with 13.77 t/ha and sowing on 5 June recorded the lowest total biomass with 10.34 t/ha (Table 7). The irrigated treatments produced significantly more total biomass than the non-irrigated treatments when averaged across all varieties and sowing dates. The irrigated treatments averaged 14.35 t/ha while the non-irrigated treatment averaged 9.70 t/ha (Table 8).

Table 7. Total biomass, harvest index and grain weight results for sowing date treatments in the LFS faba bean experiment, 2020

Treatments	Total Biomass (%)	Harvest index	Grain weight (g/1000 grains)
24 April	13.77	0.46	691.1
15 May	11.96	0.49	697.0
5 June	10.34	0.52	693.0
l.s.d (<0.05)	0.757	0.008	n.s.

Table 8. Total biomass, harvest index and grain weight results for irrigation treatments in the LFS faba bean experiment, 2020

Treatments	Total Biomass (%)	Harvest index	Grain weight (g/1000 grains)
Irrigated	14.35	0.48	739.7
Non-irrigated	9.70	0.49	647.7
l.s.d (<0.05)	0.482	n.s.	9.1

Results - Harvest index

Harvest index (HI) averaged 0.47 across all variety, sowing dates and irrigation treatments. PBA Marne[A] achieved the highest average HI at 0.51 and PBA Samira[A] recorded the lowest average HI at 0.47 (not shown). Sowing on 5 June achieved the highest average HI at 0.52 and sowing on 24 April recorded the lowest average HI at 0.46 (Table 7).

The irrigated treatment achieved a HI of 0.48 which was statistically similar to the non-irrigated treatment of 0.49 (Table 8) indicating that irrigation did not affect HI.

Results - Grain weight

Grain weight averaged 693.70 g/1000 grains across all varieties, sowing date and irrigation treatments. PBA Nasma[A] achieved the highest average thousand grain weight at 744.3 g while PBA Bendoc[A] recorded the lowest average thousand grain weight at 604.6 g (not shown). Sowing date did not affect grain weight (Table 7).

The irrigated treatment achieved a significantly higher grain weight than the non-irrigated treatment when averaged across all varieties and sowing dates. The irrigated treatment averaged 739.7 g/1000 grains while the non-irrigated treatment averaged 647.7 g/1000 grains (Table 8).

Summary

With the application of two spring irrigations, the irrigated treatments achieved significantly higher grain yield than the non-irrigated treatments for all three sowing dates. Sowing on 24 April recorded the highest yield increase due to irrigation with a gain of 2.41 t/ha compared to the non-irrigated treatments. With 2.41 t/ha grain yield increase from the application of 1.6 ML of irrigation water, sowing on 24 April achieved an irrigation efficiency of 1.51 t/ML.

Sowing date had a significant effect on grain yield with average grain yields significantly decreasing as the sowing date was delayed. In the irrigated treatments, header yields decreased from 6.86 t/ha to 3.15 t/ha when sowing was delayed by six weeks from 24 April to 5 June. In the non-irrigated treatments, header yields decreased from 4.64 t/ha to 3.07 t/ha when sowing was delayed by the same time period. Even though this experiment demonstrated that sowing faba beans on 24 April achieved the highest yield in the 2020 LFS faba bean experiment, the sowing date is earlier than recommended for the irrigated production area of the MIA. This experiment will be repeated in 2021 to confirm any yield increase to the earlier sowing date for faba beans.

PBA Nasma[A] was the best performing variety, achieving the highest grain yield when averaged across sowing dates and irrigation treatments. PBA Nasma[A] achieved an average header grain yield of 5.73 t/ha in the irrigation treatments which was more than any other variety. While there were significant yield differences between varieties in the irrigated treatments, there was no varietal differences observed for grain yield in the non-irrigated treatments.

Acknowledgments

This research is part of the Matching adapted pulse genotypes with soil and climate to maximise yield and profit, with manageable risk in Australian cropping system (BLG118) project which is jointly funded by GRDC and NSW Department of Primary Industries. We would also like to thank Michael Hately for his assistance in crop maintenance and data collection.

Further information

Tony Napier

NSW Department of Primary Industries, Yanco Agricultural Institute

Email: tony.napier@dpi.nsw.gov.au

Mobile: 0427 201 839

The effect of delayed sowing and reduced irrigation on Soybeans and Mung beans — Leeton 2020/21

Authors

Tony Napier and Daniel Johnston (NSW DPI, Yanco Agricultural Institute)

Key findings

Soybean yields were maximised when sown at the beginning of December and fully irrigated.

Mung bean yields were maximised when sown at the end of December with minimal irrigation.

Mung beans achieved a water-use efficiency of 0.57 t/ML with reduced irrigation when sown at the end of December.

Mung beans can be sown later and mature faster than soybeans, which makes them more suitable as a summer pulse option in double cropping systems.

Introduction

The benefits of having a legume in a cropping rotation is well known as they can provide a disease break, provide alternative weed chemical control options, and usually require zero nitrogen input. Soybeans has been the summer legume of choice in the Riverina for many years but there is growing interest in mung beans as an alternative. A series of five experiments were conducted in 2020/21 to compare soybeans and mung beans as a summer cropping legume option for the Riverina.

Experiments

Table 1. Sowing date and estimated water use for the five summer pulse experiments at LFS, 2020/21

Trial no	Sowing date	Pre-sowing irrigation	Number of post-sowing irrigations	Post-sowing irrigation quantity	Useful rainfall	Total water quantity
Trial-1	1-Dec-20	2.0 ML/ha	weekly	5.0 ML/ha	40 mm	7.4 ML/ha
Trial-2	1-Dec-20	2.0 ML/ha	3	2.4 ML/ha	60 mm	5.0 ML/ha
Trial-3	1-Dec-20	2.0 ML/ha	2	2.0 ML/ha	60 mm	4.6 ML/ha
Trial-4	30-Dec-20	2.0 ML/ha	2	1.8 ML/ha	70 mm	4.5 ML/ha
Trial-5	30-Dec-20	2.0 ML/ha	1	1.2 ML/ha	70 mm	3.9 ML/ha

Treatments

Table 2. Varieties evaluated in the five summer pulse experiments at LFS, 2020/21

Crop	Variety	Comment
Soybean	Bidgee	Short season variety developed for double cropping
Soybean	Burrinjuck	Clear hilum variety developed for culinary market
Mung bean	Jade	Large seed broadly adapted to many growing areas

Trial establishment and assessments

All experiments included three varieties (Table 2) and replicated six times. Every experiment was pre-irrigated prior to sowing and sown on 1.83m beds with two plant rows per bed. All plots were sown with a target of 40 plants/m2. At physiological maturity, hand cuts were collected to determine total biomass and harvest index. Grain yield was obtained with a header from the remainder of the plots at harvest maturity.

Results

Table 3. Results for Trial-1 sown on 1 December with weekly irrigations

Variety	Header Yield (t/ha)	Hand yield (t/ha)	Total biomass (t/ha)	Harvest Index	seed size (g/200 grains)
Bidgee	2.81	3.80	15.72	0.241	30.86
Burrinjuck	3.03	3.95	16.96	0.233	37.33
Mung bean	1.25	1.45	15.28	0.095	12.39
l.s.d (<0.05)	0.18	0.33	1.31	0.013	0.59

Table 4. Results for Trial-2 sown on 1 December with three post sowing irrigations

Variety	Header Yield (t/ha)	Hand yield (t/ha)	Total biomass (t/ha)	Harvest Index	seed size (g/200 grains)
Bidgee	1.94	2.46	11.36	0.216	26.31
Burrinjuck	2.27	2.44	11.73	0.208	30.09
Mung bean	1.25	1.66	15.81	0.105	14.02
l.s.d (<0.05)	0.13	0.32	1.77	0.010	1.67

Table 5. Results for Trial-3 sown on 1 December with two post sowing irrigations

Variety	Header Yield (t/ha)	Hand yield (t/ha)	Total biomass (t/ha)	Harvest Index	seed size (g/200 grains)
Bidgee	1.51	2.43	10.38	0.234	28.21
Burrinjuck	1.85	2.46	10.95	0.225	33.26
Mung bean	1.44	1.82	16.14	0.113	15.58
l.s.d (<0.05)	0.17	0.29	1.45	0.012	1.93

Table 6. Results for Trial-4 sown on 30 December with two post sowing irrigations

Variety	Header Yield (t/ha)	Hand yield (t/ha)	Total biomass (t/ha)	Harvest Index	seed size (g/200 grains)
Bidgee	1.73	2.14	10.40	0.206	21.47
Burrinjuck	1.74	2.47	11.34	0.219	31.05
Mung bean	1.70	1.95	15.81	0.123	12.93
l.s.d (<0.05)	n.s.	0.31	0.83	0.022	1.46

Table 7. Results for Trial-5 sown on 30 December with one post sowing irrigations

Variety	Header Yield (t/ha)	Hand yield (t/ha)	Total biomass (t/ha)	Harvest Index	seed size (g/200 grains)
Bidgee	1.20	2.12	10.31	0.205	23.11
Burrinjuck	1.36	1.93	9.04	0.213	28.73
Mung bean	2.11	1.97	15.22	0.130	14.01
l.s.d (<0.05)	0.32	n.s.	0.78	0.013	1.22

The yield increase from the application of two spring irrigations (1.6 ML) was the highest in the 24 April sowing with an extra 2.41 t/ha recorded (Table 6). With a yield increase of 2.41 t/ha, the first sowing date achieved the highest irrigation efficiency of 1.51 t/ML. Sowing on 5 June recorded the lowest irrigation efficiency of 0.41 t/ML with an average yield increase of 0.65 t/ha.

Table 6. Irrigation efficiency for the three sowing dates (averaged across all varieties) in the LFS faba bean experiment, 2020

Treatments	24 April	15 May	5 June
Yield increase from Irrigation	2.41 t/ha	0.89 t/ha	0.65 t/ha
Irrigation quantity	1.6 ML/ha	1.6 ML/ha	1.6 ML/ha
Irrigation efficiency	1.51 t/ML	0.56 t/ML	0.41 t/ML

Results - Total biomass

Total biomass averaged 12.02 t/ha across all variety, sowing dates and irrigation treatments. PBA Nasma[A] achieved the highest average total biomass at 12.82 t/ha and PBA Marne[A] recorded the lowest average total biomass at 11.35 t/ha and was statistically similar in total biomass with PBA Bendoc[A] (not shown).

Sowing on 24 April achieved the highest total biomass with 13.77 t/ha and sowing on 5 June recorded the lowest total biomass with 10.34 t/ha (Table 7). The irrigated treatments produced significantly more total biomass than the non-irrigated treatments when averaged across all varieties and sowing dates. The irrigated treatments averaged 14.35 t/ha while the non-irrigated treatment averaged 9.70 t/ha (Table 8).

Table 7. Total biomass, harvest index and grain weight results for sowing date treatments in the LFS faba bean experiment, 2020

Treatments	Total Biomass (%)	Harvest index	Grain weight (g/1000 grains)
24 April	13.77	0.46	691.1
15 May	11.96	0.49	697.0
5 June	10.34	0.52	693.0
l.s.d (<0.05)	0.757	0.008	n.s.

Table 8. Total biomass, harvest index and grain weight results for irrigation treatments in the LFS faba bean experiment, 2020

Treatments	Total Biomass (%)	Harvest index	Grain weight (g/1000 grains)
Irrigated	14.35	0.48	739.7
Non-irrigated	9.70	0.49	647.7
l.s.d (<0.05)	0.482	n.s.	9.1

Results - Harvest index

Harvest index (HI) averaged 0.47 across all variety, sowing dates and irrigation treatments. PBA Marne[A] achieved the highest average HI at 0.51 and PBA Samira[A] recorded the lowest average HI at 0.47 (not shown). Sowing on 5 June achieved the highest average HI at 0.52 and sowing on 24 April recorded the lowest average HI at 0.46 (Table 7).

The irrigated treatment achieved a HI of 0.48 which was statistically similar to the non-irrigated treatment of 0.49 (Table 8) indicating that irrigation did not affect HI.

Results - Grain weight

Grain weight averaged 693.70 g/1000 grains across all varieties, sowing date and irrigation treatments. PBA Nasma[A] achieved the highest average thousand grain weight at 744.3 g while PBA Bendoc[A] recorded the lowest average thousand grain weight at 604.6 g (not shown). Sowing date did not affect grain weight (Table 7).

The irrigated treatment achieved a significantly higher grain weight than the non-irrigated treatment when averaged across all varieties and sowing dates. The irrigated treatment averaged 739.7 g/1000 grains while the non-irrigated treatment averaged 647.7 g/1000 grains (Table 8).

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Further information

Tony Napier

NSW Department of Primary Industries, Yanco Agricultural Institute

Email: tony.napier@dpi.nsw.gov.au

Mobile: 0427 201 839

Irrigation Research & Extension Committee

p. 02 6963 0936 | e. irec@irec.org.au | www.irec.org.au