GRAINS RESEARCH UPDATE

STRATEGIC STEPS – ENDURING PROFIT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Moama

Thursday 26th July

9.00am to 3.30pm

Moama Bowling Club

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Irrigated Cropping Council

MISSION: To improve the profitability and long-term viability of mixed farmers and croppers in the irrigation areas of northern Victoria and southern New South Wales, through research, demonstration, education, discussion and effective communication.

THE ORGANISATION: A not-for-profit grower group lead by a board of local, leading irrigation farmers and agribusiness professionals. The ICC runs a 15ha irrigated field research site and works with farmer collaborators to deliver local, adoptable irrigated research across our region. We co-host the GRDC Update in Moama to ensure the focus remains on irrigation and strive to work with local agribusiness, other farmer and research organisations to ensure irrigated crop research continues in our region.

MEMBERSHIP BENEFITS: Members receive a copy of our annual trial summary, biannual printed newsletters, regular email updates and full access to the ICC website. It provides access to our field days and workshops and helps fund core ICC research such as the variety trials. Membership not only benefits your irrigated cropping business but enables us to continue to deliver farmer lead, locally relevant research and extension to irrigated mixed and cropping farmers.

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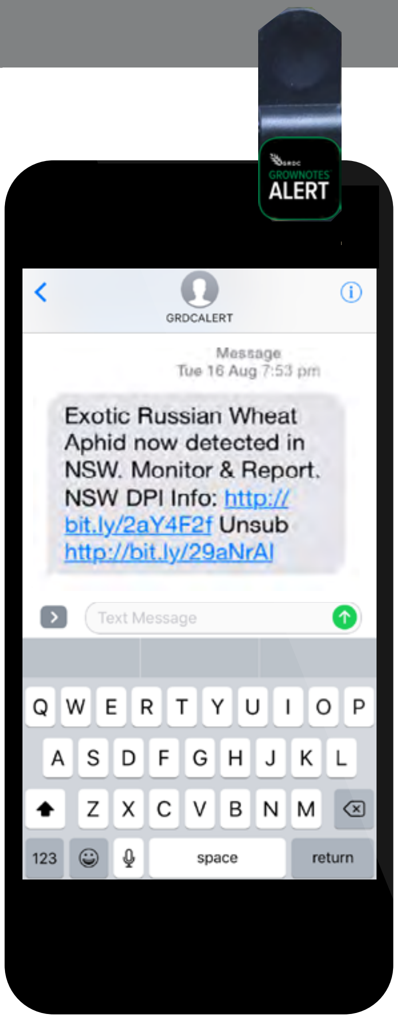

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ICC project learnings – a grower's perspective

Stuart Hodge.

ICC Board Member and Irrigated Cropper at Numurkah.

Keywords

- irrigation, cropping, research, trials

Take home messages

- The ICC has delivered several projects thanks to GRDC investment, and the results have given practical insight into irrigated cropping. Variety trials, irrigated chickpeas and lentils and canola agronomy trials are currently being funded by the ICC making membership, sponsorship and alternative funding so important.

Background

The Irrigated Cropping Council (ICC) has been involved in irrigated trial work since its inception in 1999. The ICC increased its trial program in 2013 after securing GRDC and other investment. This enabled projects such as the Irrigated Cereals and Canola, Soils after Rice, Crop Sequencing in Double Cropping, Maintaining Profitable Farming Systems with Retained Stubble to address issues related to irrigated cropping. This paper and presentation are short summaries of this work.

Projects have delivered practical outcomes but as with any cropping system there are seasonal and long-term issues that need addressing. The relative plateau of canola yields, getting the best out of alternative pulse crops, achieving good drainage (highlighted in irrigated pulse and soil projects as a constraint), and protein contents are issues raised by the projects completed by the ICC.

Results and discussion

Irrigated Variety Evaluation

Take home messages

- It's the only irrigated barley and canola variety evaluation conducted in the region.
- NVT trial results need to state if trials are irrigated or not.
- Increasing yields since 2002, however canola has not seen the same gains as wheat, barley and faba beans.

Background

Not all varieties respond equally to irrigation, so when making decisions it's important to use irrigated variety trial results as part of the selection process. ICC's long term irrigated barley, canola, faba bean and wheat variety trials generate agronomic information about how dryland varieties currently available perform on irrigation.

Since the ICC first started the Trial Block at Kerang in 2002, there has been a rise in the trial averages for all crop types except canola. The variety results from 2017 were the best attained in 16 years at the Trial Block, with barley averaging 9.33t/ha, faba bean averaging 7.4t/ha, wheat averaging 9.97t/ha and the canola equalling 2009 at 4.3t/ha (Figure 1).

Figure 1 indicates that there are some ups and downs but the overall trend is for increasing yields. Low yields from wheat in 2005 was as the result of stripe rust with the decision to rely on promoting resistance rather than fungicides; failure from faba bean in 2006 was as the result of bean leaf roll virus and to a lesser extent in 2009; and the two poor canola years were due to the decision to pre-irrigate and then rely on post sowing rainfall to get the trial established. This is not a strategy to be used going forward.

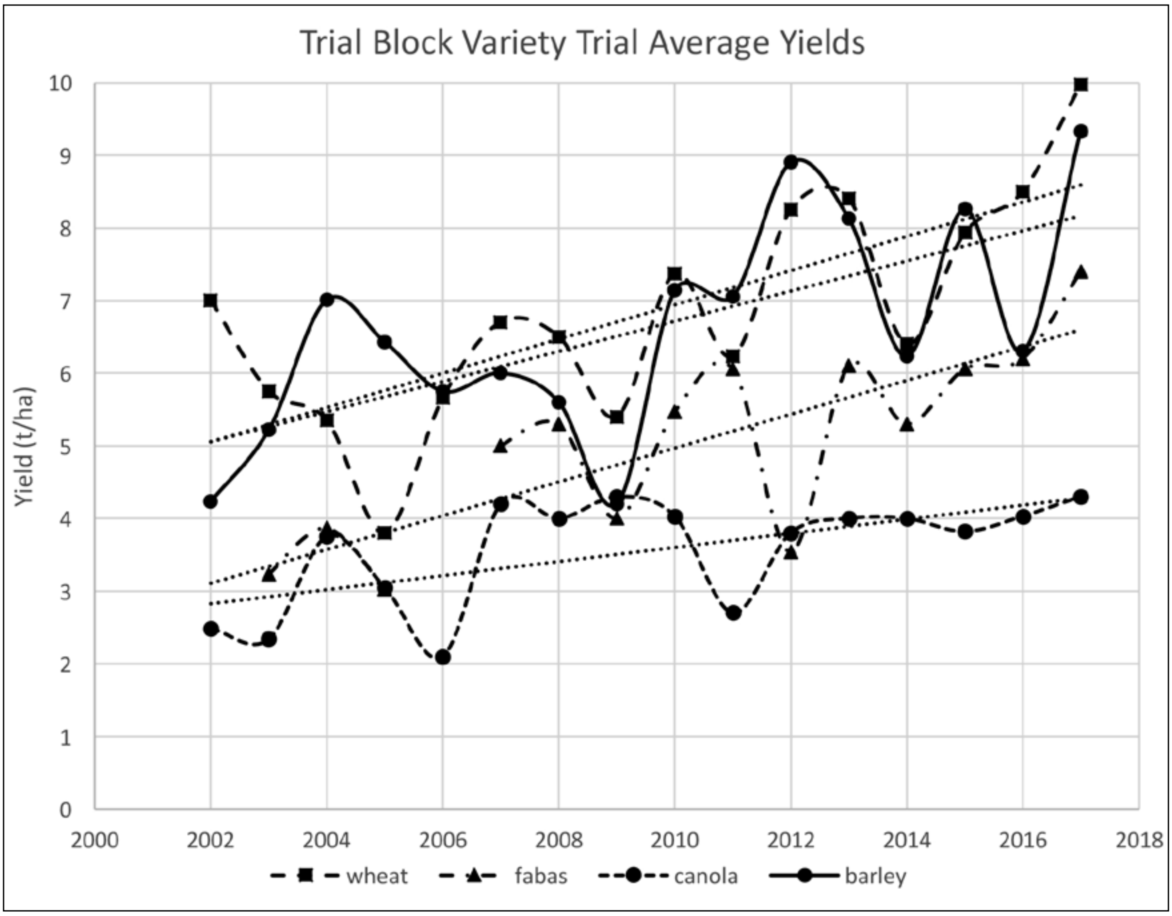

Figure 1. Variety trial averages for barley, canola, fabas and wheat (2000 – 2017).

There are a few contributing factors:

1. Sound agronomic strategies – sowing timing, N management and irrigation which are refined every season.
2. Use of soil moisture monitoring to ensure the trial does not suffer from moisture stress, particularly leading into flowering.
3. Varieties are getting better, particularly with faba beans where several trials have seen the 'breeding' lines all out yield the available varieties.
4. Seasonal variation does play a large part in the results – both negative (e.g. wet winters (2014), extreme spring temperatures (2015), rain, wind and disease pressure (2016)) and positive (e.g. cool springs and regular above average rain (2016) and increased sunshine pre-flowering (2017)).

What does stand out is the lack of progress in lifting canola yields. There are some positives:

- There are regularly one or two varieties exceeding 5t/ha.
- There has been a general improvement in the Roundup Ready variety performance.
  - Achievement of a better understanding of the phenology (crop development) of various varieties, in particular; matching sowing date and flowering.

But there are some negatives:

- Yield of the triazine tolerant (TT) varieties still lag behind the other herbicide tolerance groups.
- Seed supply issues which has meant accepting poorer performing varieties or those not quite suited for maximising high yields.
- The rapid turnover of varieties - just when we get a good understanding of a particular variety, it is withdrawn.

Part of the reason the canola yield average was high in 2017 was due to the better, relative performance of the TTs. Over the years, the TTs yield approximately 89% of the trial average. This varies from the low in 2016 at 79% to the high in 2017 at 96%. According to the ICC's Trial

Manager, part of the answer is the lower radiation use efficiency of the TT trait which results in less biomass at maturity. When conditions are wet and cool in winter, the TTs that are already not as efficient at converting the solar radiation into growth, struggle further compared to their non-TT counterparts.

These observations raise questions, are there ways we can lift yields by encouraging vigour in the vegetative phase of the crop, and if conditions are good then maybe the inherent inefficiency of TTs doesn't make as much difference? The ICC field trials this season seek to answer these questions.

Maintaining Profitable Farming Systems with Retained Stubble

Take home messages

- There are positives and negatives to retaining stubble.
- Wheat stubble may not have a large N content, so nutrient losses if burning may be less than anticipated.
- Retaining stubble doesn't necessarily mean retaining organic carbon (OC). Fertiliser, moisture and incorporation are needed to ensure rapid breakdown.
- Stubbles can retain moisture to allow a longer sowing windrow after pre-irrigation, however variable cover can result in wet and dry areas.

Background

The project set out to determine how to maintain the profitability of retained stubble farming systems as growers' experience has shown that stubble can create problems – from requiring new equipment to handle trash to creating conditions that may foster pest and disease if incorrectly managed.

The positives from stubble include soil protection, nutrient retention or addition in the case of pulses, soil biological activity and grazing opportunities. The negatives include issues with pre-emergent herbicides, capacity of equipment able to handle stubble, nitrogen tie-up, a harbor for pests and disease and increasing frost risk.

Retaining stubble is promoted as the 'right thing to do' for several reasons and this project allowed many of these to be tested. A couple that the ICC examined were the loss of nutrients from burning and increasing soil organic carbon by stubble incorporation.

Nutrient losses.

The wheat stubble at the Trial Block demonstration had an N content varying from 5.4 – to 7.7kg N/ha, despite topdressing with 400kg urea/ha. This is a lot less than some studies have cited, which then goes on to affect the estimated $ value of nutrient losses when burning stubble.

Increasing soil organic carbon

An increase in soil organic carbon only happens if the stubble is incorporated with fertiliser and moisture to ensure rapid breakdown. It is then hard to measure unless specialist OC testing is used. Retaining stubble on the soil surface means most of the carbon ends up in the atmosphere.

There are numerous information sheets produced by the project, with many having specific reference to stubble management on irrigation. They can be found on the GRDC website.

Moisture retention

Stubbles can retain moisture to allow a longer sowing windrow after pre-irrigation, however variable cover can result in wet and dry areas.

Correct Crop Sequencing under Irrigated Double Cropping

Take home messages

- Large number of factors contribute to successful double cropping

Background

The Best Management Practice guidebook produced with the trial results from this project is available on the ICC website https://www.irrigatedcroppingcouncil.com.au/wp-content/uploads/ICC-IrrigatedDblCropBMP.pdf. The results of this project highlighted layouts, delivery and drainage, weeds, disease and pests, cost of water, sowing times, soil moisture at sowing, nutrition, irrigation scheduling and timeliness of operations were critical when double cropping.

Even if you are not a double cropper, the Correct Crop Sequencing decision support tool is recommended to determine your gross margins and water requirements and can be used to look at just a single season rather than a planned sequence. The tool is available from the NSW DPI website:

http://www.dpi.nsw.gov.au/agriculture/budgets/costs/cost-calculators/correct-crop-sequencing-decision-support-tool

Soils under an irrigated environment

Take home messages

- Large variation in what yields are being gained from irrigated wheat.
- Need to set realistic yield targets, match inputs and address constraints.

Background

There are several key messages coming from the project – when you should be irrigating to maximise yield potential, setting realistic yield targets, managing wheat after rice plus areas for future research. Much of the information generated was based on data collected from irrigators across all districts in the Murray Valley. It demonstrated large variation in what yields can be gained from irrigated wheat – some variation based on the environment (solar radiation variability between seasons), some variation from having the right plant population (head numbers, grains/head, row spacing and variety interactions) and some variation from varietal tolerance of waterlogging at crucial growth stages such as flowering.

Results highlighted the importance of setting achievable yield targets and matching inputs to achieve these returns. The project monitored 64 wheat crops over three years and found that 40% came close to their water limited yield but only one crop in the three years yielded over 8t/ha. This was backed up by modelling that suggested maximum yields vary between 6.2 and 12.2t/ha and yields over 8t/ha where only achievable once every four years. There are a range of yield limiting factors depending on the season, soil and layout. Record keeping is key to identifying the constraints that are consistently impacting on yields.

Fact sheets have been produced to summarise some of the project findings including what are the critical growth stages for high yields. These are available on the ICC website.

Irrigation Max

Take home messages

- Putting the majority of N upfront as opposed to splitting it throughout the season generally produced better results over the life of the project.
- Shorter irrigation intervals were of more benefit in hotter seasons and longer internal irrigation lead to reduced soil moisture below 45cm

Background

The 2017/18 season completed the project, which looked at two N strategies (majority upfront versus split) and irrigation trigger points based on soil moisture content (25-40kPa versus 50-70kPa).

The 'Upfront' strategy has seen yield increases of just over 1.0t/ha greater than the 'Split' strategy (13.4 versus 12.2t/ha). While not significant in the 2017/18 season, the results from the previous years do suggest the 'Upfront' strategy has performed better over the life of the project. The shorter irrigation interval had been looking promising as a way of improving yield but it made no difference in the 2017/18 season. The shorter strategy may be of more benefit in hotter seasons. One aspect of the project was to monitor soil moisture down the profile. Soil moisture at 45cm under the longer irrigation interval was gradually drying out as the season progressed as the 'fast flows' were too fast and not allowing the profile to be fully recharged.

Irrigated Pulses

Take home messages

- One year's data gave yields of 3t/ha for chickpea and lentil.
- Drainage appears to be a key driver but more data required.

Background

The results from 2017 were promising where good drainage was present. The Trial Block; border-check, grey clay with a slope of about 1:800, but relatively slow delivery of 6 ML/day, averaged just over 3t/ha chickpea and lentil yields from pre-irrigation only. Spring irrigation (either one just at the start of flowering or fully irrigated in the spring) saw no yield or grain quality benefit. Two other sites had trials sown –subsurface drip and overhead irrigation – but suffered from soil drainage issues as they were on flat sites.

Irrigated Durum Wheat

Take home messages

- Achieving 13% protein economically continues to be an issue.

Background

These trials started in 2014 and have had mixed results, with the biggest issue being to economically achieve 13% protein. This project is aiming to develop an agronomic package to ensure irrigated durum wheat achieves DR1 quality. The N inputs required to meet this standard are quite significant in a high yielding irrigated durum crop – around 500kg urea/ha. Some of the N input can be obtained by following a legume crop, but this does add a degree of uncertainty on determining how much N the legume crop will deliver to subsequent crops. Combined with variable yields achieved from the durum crop (2016 yielded 7.7t/ha, 2017 yielded 10t/ha despite later sowing but all other agronomic inputs were similar), calculating a N budget to accurately meet the N requirements is difficult.

Conclusion

Projects funded by the GRDC and ICC have delivered practical insights into irrigated cropping. It's important to ensure we continue to receive local, independent research and extension in our region as irrigated cropping is a valuable industry. Research results from dryland NVT field trials are not directly transferable to irrigated systems as not all varieties and soils respond equally to irrigation, so clear distinction is required when research is delivered on-farm.

The ICC would like to continue to work with the GRDC and other partners to ensure irrigated research continues in northern Victoria and southern NSW GRDC and government investment make up a considerable portion of our income but equally important is membership, sponsors, philanthropic investors and commercial companies.

Your ongoing support of the ICC will help to ensure a long-term future for irrigated cropping and pasture systems in the Southern Murray Darling Basin.

Useful resources

ICC membership

ICC annual Trial Summary

ICC website

ICC Newsletters

Acknowledgements

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

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A behind the scenes look at the Murray Darling Basin Authority Weekly report

Andrew Reynolds.

MDBA.

Keywords

- Murray Darling Basin Authority weekly report, rainfall, inflows, rivers.

Take home messages

- Subscribe to the River Murray https://www.mdba.gov.au/river-information/weekly-reports

Introduction

The material presented here is an extract from the Murray Darling Basin Authority's (MDBA) weekly report and in particular the report made available week ending 11 July 2018.

Rainfall and inflows

In the past week precipitation was mostly concentrated across the southern divide in Victoria and New South Wales and the Mount Lofty ranges in South Australia with lighter falls around the inland slopes and northern ranges (Figure 1). In Victoria, the highest totals fell as snow in the north-east ranges and included 107mm at Rocky Valley and 57mm at Mount Buffalo; and in the Wimmera where 57mm was recorded at Mount William. In New South Wales, the highest totals were recorded as snow across the Snowy Mountains, including 64 mm at Perisher Valley AWS and 40mm at Thredbo — two stations just outside the Basin. In South Australia, highest totals included 40mm at Macclesfield and 33mm at Mount Barker in the Mount Lofty Ranges and 23mm at Meningie on the Lower Lakes.

In response to this week's rain, the flow in the upper Mitta Mitta River at Hinnomunjie peaked around 2,500ML/day. Biggara, on the upper Murray, reached around 1,200ML/day. Downstream from Hume, inflows from the Kiewa River measured at Bandiana, increased to 1,700ML/day and the flow in the Ovens River at Wangaratta peaked at 2,700ML/day.

River operations

MDBA active storage increased by 44GL this week to 4,967GL (59% capacity). This is around 750GL less than for the same time last year and the long-term average for this time of year (Figure 2).

The storage volume at **Dartmouth Reservoir** increased by 6GL to 3,433 GL (89% capacity). A flow pulse released from Dartmouth Dam to benefit water quality in the lower Mitta Mitta River reached around 2,400ML/day over the weekend before returning to a minimum flow of 500ML/day.

At **Hume Reservoir**, the storage volume increased by 40GL to 1,364GL (45% capacity). The release from Hume was at, or close to the minimum release of 600ML/day for much of the week. Late in the week the release increased, reaching 2,100ML/day, to meet environmental demands downstream of Yarrawonga Weir. The release is expected to increase further over the coming days.

Downstream at **Lake Mulwala**, the lake will commence refilling in the coming week and reach the normal operating level of around 124.7m AHD in early August ready for the start of the irrigation season. Since early June the lake level has been held around 4.5 metres below the normal operating level to help manage the invasive water weed Egeria densa. The drawdown has also provided an opportunity to undertake works on the lake foreshore.

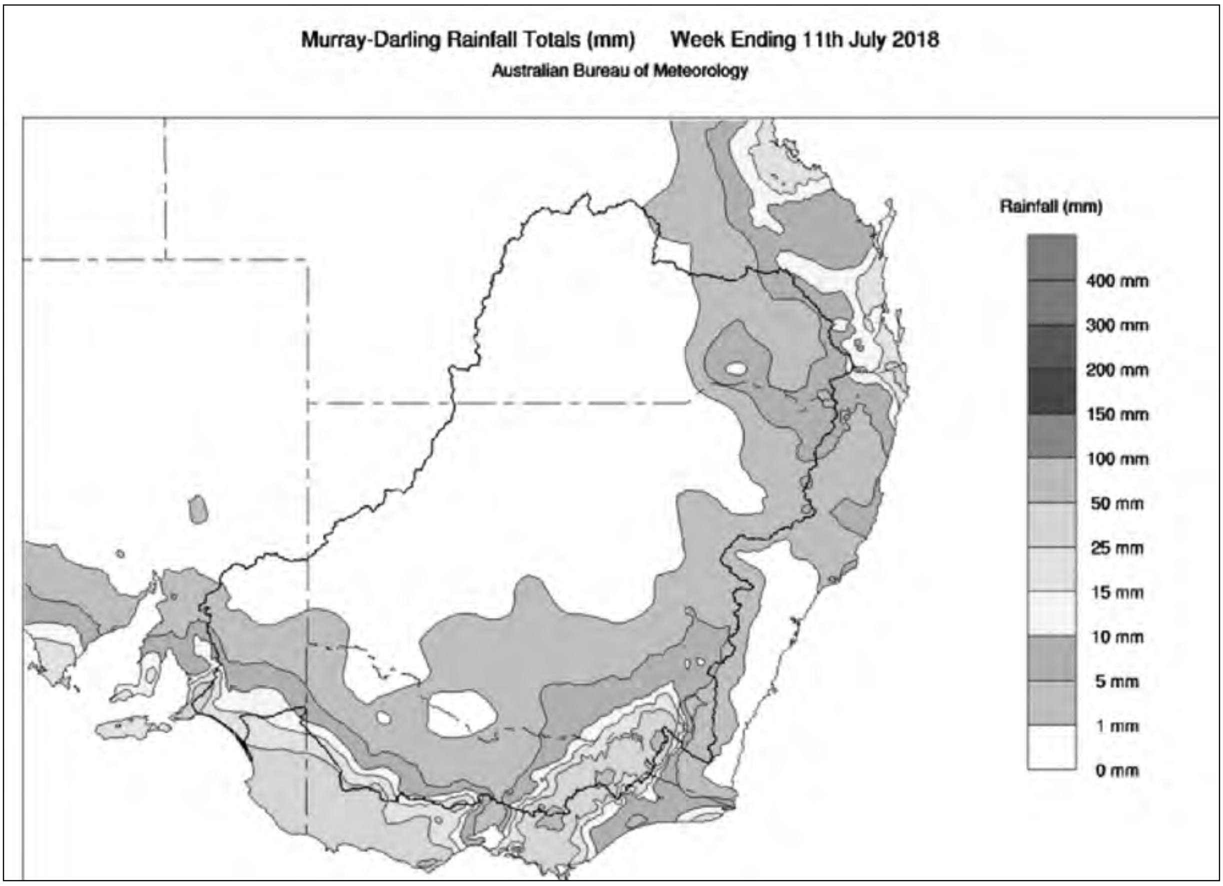

Figure 1. Murray-Darling Basin rainfall map week ending 11 July 2018 (Source: Bureau of Meteorology).

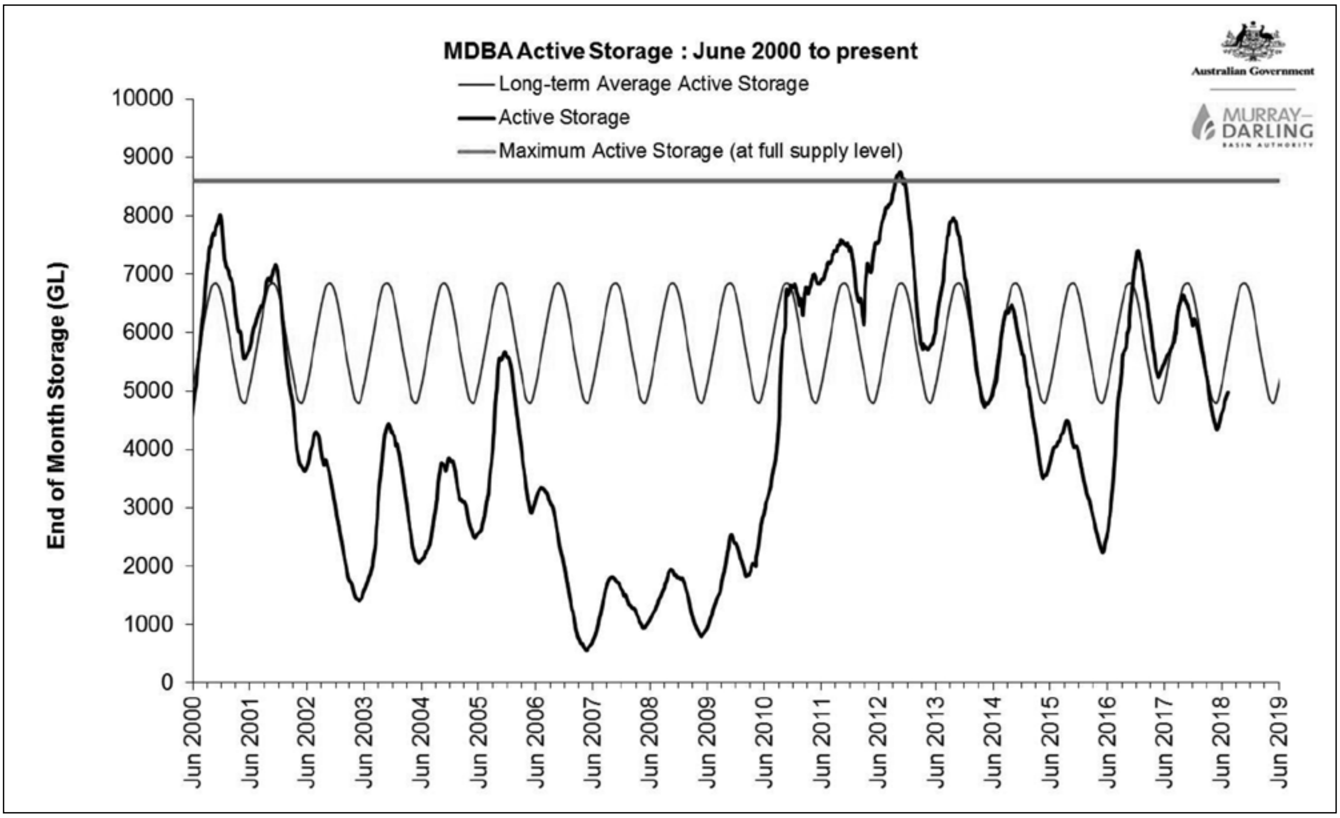

Figure 2. MDBA active storage for the period 1 June 2000 to present (top straight line is maximum active storage level, middle line is long term average active storage and line that drops the most is active storage level).

The release from **Yarrawonga Weir** averaged around 3,000ML/day. Next week the release is expected to increase to around 6,500ML/day as a pulse is delivered downstream on behalf of environmental water holders. Over the coming weeks environmental water may be used to target flows up to 9,500ML/day downstream of Yarrawonga. Releases will be made to vary the flow and will be guided by what would have happened naturally if there were no dams upstream. Regulators into the Barmah- Millewa forest will be opened to allow water to enter the forest. This water will also provide environmental benefits all the way to the Murray Mouth in South Australia.

The **Edward River** and **Gulpa Creek** offtakes are currently passing 410ML/day and 140ML/day, respectively with all gates raised clear of the water. Inflows to the Edward-Wakool system through the Edward and Gulpa offtakes can be expected to fluctuate over winter in response to flow changes in the River Murray downstream of Yarrawonga Weir.

Downstream on the Edward River, WaterNSW will commence filling of **Stevens Weir** pool in the coming week following the completion of maintenance works on the weir and at the offtake regulators (https://www.waternsw.com.au/__data/assets/pdf_file/0006/134097/04-07-2018-Stevens-Weir-refillingv2.pdf). The flow downstream of Stevens Weir reduced to around 700ML/day and will ease further as inflows reduce and the weir pool is filled.

Inflow to the Murray from the **Goulburn River** remained high this week as delivery of the winter pulse continued. Flow at McCoys Bridge eased to 7,200ML/day and is expected to steadily recede back to around 1,000ML/day by the end of July. This winter fresh aims to improve water quality and benefit aquatic animals and vegetation along the Goulburn River and further downstream along the Murray. This pulse has been planned by the Goulburn Broken Catchment Management Authority (CMA) in consultation with the Commonwealth Environmental Water Office and the Victorian Environmental Water Holder. For more information visit the Goulburn Broken CMA website: (https://www.gbcma.vic.gov.au/news_events/winter-environmental-flow-good-for-plants-water-quality-and-migratory-fish.html).

Flow at **Torrumbarry Weir** averaged around 9,700ML/day. Adjustments to the weir pool level helped manage the flow around this rate to protect the lock refurbishment works currently underway on the downstream side of the weir. This included capturing water and temporarily raising the weir pool by 27cm back towards the full supply level (FSL) as the peak passed. As the flow recedes, the pool level will gradually return to around 30cm below FSL and continue to vary around this level. Later in July the pool will be raised back to FSL ahead of the start of the irrigation season. More information is available at the MDBA website: (https://www.mdba.gov.au/media/mr/weir-pool-changes-torrumbarry).

River users in the **Echuca** district and downstream should be aware that water levels will fall noticeably over the coming week. The fluctuations in river level are due to the Goulburn flow pulse moving through the system and the re-lowering of the Torrumbarry weir pool.

The diversion into National Channel was briefly increased to 1,800ML/day over the weekend to help manage the flow downstream of Torrumbarry Weir as the peak of the Goulburn pulse moved through the system. The diversion has now reduced back to around 1,000ML/day. This water is being delivered to the Gunbower Creek and Forest. More information on the Gunbower Forest watering can be found on the North Central Catchment Management Authority (NCCMA) website: (http://www.nccma.vic.gov.au/media-events/media-releases#node-1847).

At **Swan Hill**, the flow rose from 7,400ML/day to the current flow of 9,800ML/day as the Goulburn flow pulse continues to move downstream along the Murray.

Inflow from the **Murrumbidgee River**, measured at Balranald, is around the end of system target for July of 830ML/day.

At **Euston**, the weir pool is being varied to target between 30 and 40 cm below FSL. Lowering Euston weir is part of the weir pool variability program: (https://www.mdba.gov.au/media/mr/river-update-managing-murray-weir-pool-levels-2017-18) which aims to help restore a more natural wetting and drying regime for river banks and wetlands. The downstream release is currently 10,700ML/day and is expected to peak around 11,500ML/day in the coming week.

The **Menindee Lakes** storage volume reduced 5GL to 201GL (12% capacity). WaterNSW continues to manage the Menindee Lakes in accordance with the Lower Darling Annual Operations Plan: (https://www.waternsw.com.au/__data/assets/pdf_file/0006/129831/Lower-Darling-Operational-Plan-December-2017.pdf). The release from Weir 32 (https://www.waternsw.com.au/about/newsroom/2017/lakes-releases-minimal-as-darling-flows-dwindle) is targeting minimum flow rates of around 130ML/day with the aim to maintain flow in the lower Darling at Burtundy. However late this week, as part of drought contingency measures, WaterNSW commenced installation of two temporary block banks across the lower Darling to assist in maintaining supply to domestic, stock and permanent plantings along the lower Darling. Once these are installed the release from Weir 32 will be reduced and flow at Burtundy is expected to reduce further. A red alert warning (high alert) for blue-green algae remains in place for the lower Darling at Ellerslie, directly downstream of Burtundy (https://www.waternsw.com.au/about/newsroom/2018/algal-red-alert-for-lower-darling-river-at-pooncarie-and-burtundy).

On the Murray at **Wentworth Weir**, the release increased to 8,000ML/day and is expected to continue rising over the coming week.

The **Locks 7** and **9** weir pools continue to target a water level 10 cm below FSL and will vary between FSL and 10cm below FSL over the coming weeks. The Lock 8 weir pool is targeting 30cm below FSL.

At **Lake Victoria**, the storage volume decreased by 2GL to 364GL (54% capacity). The inlet to the Lake is currently closed while SA Water test the installation of the bulkhead gates at the Control Regulator. The Control Regulator is designed to stop the lake from emptying if one of the Frenchman's Creek embankments were to burst. The testing is part of normal asset maintenance activities. The storage volume is expected to remain steady over the coming week.

The flow to **South Australia** increased to 6,500ML/day and is expected to reach around 10,000ML/day in the coming week. This flow is comprised of the normal South Australian entitlement flow, the Goulburn flow pulse and environmental releases from Hume.

Downstream at **Lock 3 (Overland Corner)**, the lock remains temporarily closed for a major refurbishment which commenced in mid-June. These works are expected to take up to 14 weeks to complete (https://www.sawater.com.au/news/river-murrays-lock-three-overland-and-out-of-water) .

The 5-day average water level in the **Lower Lakes** is currently 0.65 m AHD with the level expected to continue rising in coming weeks. When conditions allow, small barrage releases have been prioritised through Tauwitchere and Goolwa barrages. Barrages releases averaged 430 ML/day and all fishways remain open.

Water in storage - week ending Wednesday 11 July 2018

Table 1. MDBA storage levels at week ending Wednesday 11 July 2018.

MDBA Storages	Full Supply Level (m AHD)	Full Supply Volume (GL)	Current Storage Level (m AHD)	Current Storage (GL)	Current Storage %	Dead Storage (GL)	Active Storage (GL)	Change in Total Storage for the Week (GL)
Dartmouth Reservoir	486.00	3 856	479.32	3 433	89%	71	3 362	+6
Hume Reservoir	192.00	3 005	181.91	1 364	45%	23	1 341	+40
Lake Victoria	27.00	677	24.20	364	54%	100	264	-2
Menindee Lakes		1 731*		201	12%	(- -) #	0	-5
Total		9 269		5 362	58%	- -	4 967	+39
Total Active MDBA Storage							59% ^	

Table 2. Major State storages.

Burrinjuck Reservoir		1 026		415	40%	3	412	+0
Blowering Reservoir		1 631		1 126	69%	24	1 102	+11
Eildon Reservoir		3 334		1 796	54%	100	1 696	-12

* Menindee surcharge capacity – 2050 GL** All Data is rounded to nearest GL **

NSW has sole access to water when the storage falls below 480 GL. MDBA regains access to water when the storage next reaches 640 GL.

^ % of total active MDBA storage

Snowy Mountains Scheme

Table 3. Snowy River diversions for week ending 10 Jul 2018.

Storage	Active Storage (GL)	Weekly Change (GL)	Diversion (GL)	This Week	From 1 May 2018
Lake Eucumbene - Total	739	-9	Snowy-Murray	+16	321
Snowy-Murray Component	325	-11	Tooma-Tumut	+0	34
Target Storage	1 170		Net Diversion	16	287
			Murray 1 Release	+20	373

Murray and Lower Darling

Table 4. Major diversions from Murray and Lower Darling (GL) *

New South Wales	This Week	From 1 July 2018	Victoria	This Week	From 1 July 2018
Murray Irrig. Ltd (Net)	0.0	0	Yarrawonga Main Channel (net)	0	0
Wakool Sys Allowance	-0.3	0	Torrumbarry System + Nyah (net)	8.4	11
Western Murray Irrigation	0.1	0	Sunraysia Pumped Districts	0.4	0
Licensed Pumps	0.6	1	Licensed pumps - GMW (Nyah+u/s)	1	0
Lower Darling	0.1	0	Licensed pumps - LMW	4.6	1
TOTAL	0.5	1	TOTAL	14.4	12

* Figures are derived from actual and estimates where data is unavailable. Please note that not all data may have been available at the time of creating this report. ** All data above is rounded to nearest 100ML for weekly data and nearest GL for cumulative data

South Australia

Table 5. Flow to South Australia (GL).

Entitlement this month	108.5*
Flow this week	38.6
Flow so far this month	57.8
Flow last month	132.5

*Flow to SA will be greater than normal entitlement for this month due to environmental flows.

Salinity (EC)

Table 6. Salinity levels (EC) (microSiemens/cm at 25°C) at various locations within MDBA.

	Current	Average over the last week	Average since 1 August 2017
Swan Hill	130	120	100
Euston	120	120	-
Red Cliffs	130	130	150
Merbein	110	120	150
Burtundy (Darling)	710	700	680
Lock 9	120	120	160
Lake Victoria	190	170	230
Berri	250	250	290
Waikerie	390	410	340
Morgan	440	440	350
Mannum	400	400	370
Murray Bridge	410	410	400
Milang (Lake Alex.)	530	770	720
Poltalloch (Lake Alex.)	690	660	650
Meningie (Lake Alb.)	1 620	1 590	1 590
Goolwa Barrages	11 060	10 120	3 020

River Levels and Flows Week ending Wednesday 11 July 2018

Table 7. River levels and flows at the end of week ending Wednesday 11 July 2018.

River Murray	Minor Flood Stage (m)	Gauge Height		Flow (ML/day)	Trend	Average Flow this Week (ML/day)	Average Flow last Week (ML/day)
		local (m)	(m AHD)				
Khancoban	-	-	-	6 580	F	3 650	5 670
Jingellic	4.0	2.10	208.62	7 820	R	5 000	6 430
Tallandoon (Mitta Mitta River)	4.2	1.67	218.56	1 140	F	1 590	790
Heywoods	5.5	1.54	155.17	1 010	R	740	1 050
Doctors Point	5.5	1.81	150.28	2 790	R	1 740	1 780
Albury	4.3	0.94	148.38	-	-	-	-
Corowa	4.6	0.65	126.67	1 750	R	1 510	2 330
Yarrawonga Weir (d/s)	6.4	0.60	115.64	3 190	R	3 030	3 950
Tocumwal	6.4	1.12	104.96	3 170	S	3 380	4 130
Torrumbarry Weir (d/s)	7.3	3.02	81.57	9 340	R	9 710	7 720
Swan Hill	4.5	1.76	64.68	9 840	F	9 530	5 240
Wakool Junction	8.8	3.65	52.77	10 520	R	9 260	5 780
Euston Weir (d/s)	9.1	1.99	43.83	10 660	R	8 810	5 860
Mildura Weir (d/s)		-	-	8 580	F	6 950	5 900
Wentworth Weir (d/s)	7.3	3.01	27.77	8 010	R	6 410	5 500
Rufus Junction	-	3.48	20.41	6 400	R	5 060	4 470
Blanchetown (Lock 1 d/s)	-	0.66	-	4 970	R	4 270	4 420
Tributaries							
Kiewa at Bandiana	2.8	1.81	155.04	1 680	R	1 170	920
Ovens at Wangaratta	11.9	8.83	146.51	2 680	S	1 800	1 100
Goulburn at McCoys Bridge	9.0	4.49	95.91	7 240	F	7 750	7 560
Edward at Stevens Weir (d/s)	5.5	1.04	80.81	690	F	800	1 010
Edward at Liewah	-	1.89	57.27	1 170	S	1 180	1 170
Wakool at Stoney Crossing	-	1.28	54.77	220	F	230	250
Murrumbidgee at Balranald	5.0	1.33	57.29	850	F	930	600
Barwon at Mungindi	6.1	3.10	-	0	F	0	0
Darling at Bourke	9.0	4.03	-	130	S	200	310
Darling at Burtundy Rocks	-	0.68	-	60	S	60	50
Natural Inflow to Hume						5 500	4 930

(i.e. Pre Dartmouth & Snowy Mountains scheme)

Table 8. Water levels at weirs and locks.

Murray	FSL (m AHD)	u/s	d/s		FSL (m AHD)	u/s	d/s
Yarrawonga	124.90	-4.89	-	No. 7 Rufus River	22.10	+0.05	+1.16
No. 26 Torrumbarry	86.05	-0.17	-	No. 6 Murtho	19.25	+0.05	+0.17
No. 15 Euston	47.60	-0.32	-	No. 5 Renmark	16.30	+0.12	+0.18
No. 11 Mildura	34.40	+0.02	+0.20	No. 4 Bookpurnong	13.20	+0.04	+0.66
No. 10 Wentworth	30.80	+0.00	+0.37	No. 3 Overland Corner	9.80	+0.00	+0.25
No. 9 Kulnine	27.40	+0.05	-0.07	No. 2 Waikerie	6.10	+0.04	+0.17
No. 8 Wangumma	24.60	-0.19	+0.27	No. 1 Blanchetown	3.20	+0.01	-0.09

Pool levels above or below Full Supply Level (FSL)

Table 9. Water levels at Lower Lakes .	
Lake Alexandrina average level for the past 5 days (m AHD)	0.65
FSL = 0.75 m AHD	

Table 10. Water levels at Barrages.

	Openings	Level (m AHD)	No. Open	Rock Ramp	Vertical Slot 1	Vertical Slot 2	Dual Vertical Slots
Goolwa	128 openings	0.62	All closed	-	Open	Open	-
Mundoo	26 openings	0.66	All closed	-	-	-	Open
Hunters Creek	-	-	-	-	Open	-	-
Boundary Creek	6 openings	-	1	-	Open	-	-
Ewe Island	111 gates	-	All closed	-	-	-	Open
Tauwitchere	322 gates	0.67	2	Open	Open	Open	-

AHD = Level relative to Australian Height Datum, i.e. height above sea level

River Levels and Flows Week ending Wednesday 11 July 2018

NSW - Murray Valley	
High security	97%
General security	0%

NSW – Murrumbidgee Valley	
High security	95%
General security	3%

NSW - Lower Darling	
High security	100%
General security	0%

Victorian - Murray Valley	
High reliability	41%
Low reliability	0%

Victorian - Goulburn Valley	
High reliability	32%
Low reliability	0%

South Australia – Murray Valley	
High security	100%

Useful resources

- http://www.water.nsw.gov.au/water-management/water-availability
- http://nvrm.net.au/seasonal-determinations/current
- http://www.environment.sa.gov.au/managing-natural-resources/river-murray
- https://www.mdba.gov.au/river-information/weekly-reports

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Basin systems - bankless channels need faster drainage for higher yields

Sam North[1], Nima Zoriasateyan[2] and Lloyd Chua[2].

[1]NSW DPI, Deniliquin; [2]Deakin University.

Keywords

- bankless channel, basin surface irrigation.

Take home messages

- Consistent high yields can be achieved with quick draining surface irrigation systems.
- Individually draining bays into a field drain OR skip-watering should be considered if water is on bays for longer than 10 hours. This is a good option for bankless channels on flat terrain (<1:1000) which suffer from water backing up.

Background

Eighty three percent of all irrigated land in the southern Murray Darling Basin use surface irrigation. There are two main types of surface systems; border check, which predominate on lighter soils and steeper terrain (slopes > 1:1250) and basin systems, which are best suited to low permeability soils on flatter terrain (slopes < 1:1250). While considerable work has been done to improve border check systems (e.g. Campbell, 1989; Austin and Prendergast, 1997; Lavis et al., 2006), the same cannot be said for basin systems, with published design recommendations (Swinton, 1994) being outdated, not evidence based, and unable to support developments such as bankless channels.

Irrigation systems should be designed to minimise crop losses to waterlogging and water losses to deep drainage. This is achieved by applying a target depth of water in the shortest possible time. In basin systems, this means bays need to be designed so they have quick advance and recession phases. Infiltrated depth can then be managed by varying cut-off times. If this can be done, the correct target depth will be applied with control, precision and uniformity. However, this is generally not the case with contour basin systems and it has been found (North et al., 2010) that:

- Opportunity times in the commonly used bankless channel, contour basin systems are in the order of 30 to 40 hours. These long opportunity times are primarily due to slow drainage. This slow drainage is primarily caused by the hydraulic connection created between bays by the bankless channel, with water backing up in the outlet structure and impeding outflow. To minimise the risk of yield loss to waterlogging in basin systems, water should be on and off bays in less than 10 hours.

A recently completed NSW DPI and Deakin University project *(Maximising on farm irrigation profitability)* conducted with the irrigated cropping groups and funded through the Australian Government's Rural R&D for Profit program, Cotton Research and Development and AgriFutures Australia examined ways of improving basin system design. One of the aims was to examine the affect bankless channels had on drainage times and see whether watering and draining bays individually (i.e. without water backing up against outflows) can reduce irrigation ponding times to 10 hours.

Methods

Water advance, flow and depth data were collected during irrigations in two adjacent 3.5ha bays (85m by 410m) in a contour basin layout at Deniliquin, NSW. Bays could be supplied from both a channel and a bankless channel in this layout, so the difference in watering and draining times between the two systems was able to be assessed. Because the two bays were 'paired', the effect of surface roughness was also able to be assessed by comparing irrigations with different operating conditions. The collected field data was used to validate an irrigation model (WinSRFR; Strelkoff et al., 1998; Bautista et al., 2009). This model was used to simulate irrigation ponding times where drainage was not obstructed for comparison with actual ponding times where outflow through the bankless channel was impeded by the head of water rising in the bay being filled.

Results and discussion

The field data confirmed that opportunity times of 30 to 40 hours are typical of commercial, bankless channel basin systems on flat terrain (slope 1:2000). Eliminating the hydraulic connection between bays which occurs through the bankless channel, and watering and draining bays individually cut opportunity times to around 15 hours and reduced run-off volumes by 65%.

Because there is no slope along the bay, there needs to be a head of water at the supply end to drive water to the far end. The measurements of water depth showed that this head of water increases with both increasing bay length and surface roughness (Figure 1). Depths of 75mm, 125mm and 150mm above the bay surface were needed at the supply end to drive water to the far end of the 410m long bay at Deniliquin when irrigating with a flow rate of 15ML/day across bare earth, through mown, and through standing senesced pasture, respectively.

If 15ML/day is being delivered into the block from the farm inlet, then the flow through each structure in a bankless channel within a paddock needs to be equal to or greater than 15ML/day. If it isn't, then water will accumulate in the bay, upstream of the structure. Measurements of the head difference between the inlet and outlet sides of the 600mm pipes between bays showed that a head difference of 25mm was required to drive a 15ML/day flow rate through the pipe (Figure 2).

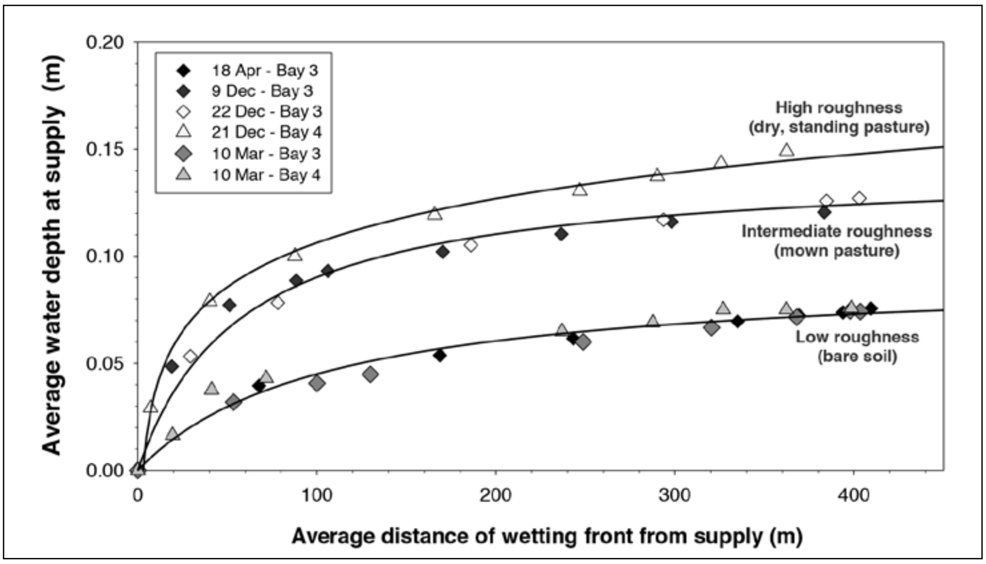

Figure 1. The relationship between the head of water at the supply end of an 85m wide by 410m long bay and the average distance of the wetting front during six irrigations with varying surface roughness conditions in the contour basin system at Deniliquin.

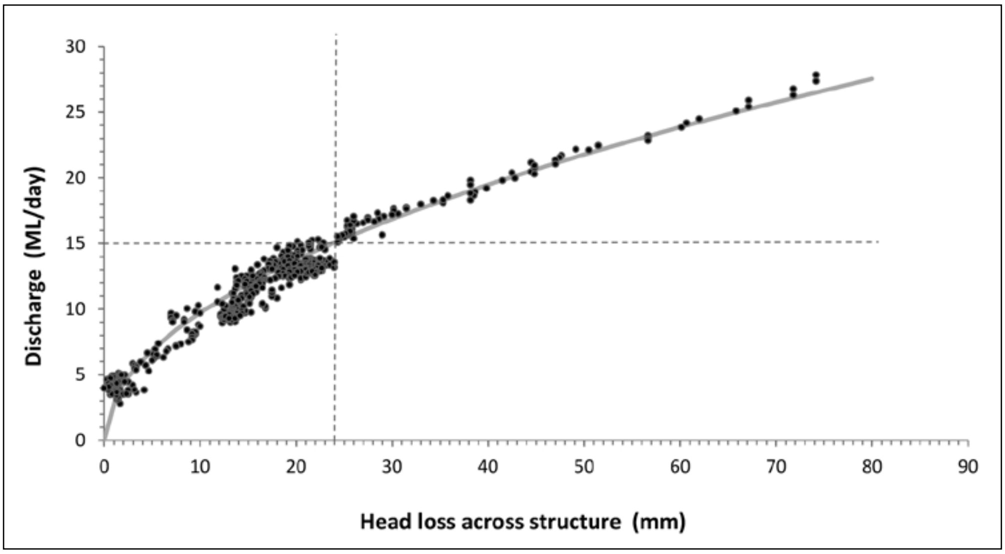

Figure 2. The relationship between discharge and head loss for the 600mm pipes between bays in the bankless channel of the contour basin system at Deniliquin.

Putting these two pieces of information together explains why drainage is often impeded in bankless channel systems. Even when the bay is bare earth and as smooth as it can be, the water height above the bay surface at the supply end will need to be 75mm to get water to the far end of the bay. Add to this the 25mm head difference required across the outlet to maintain a 15ML/day flow, and it can be seen that a step between bays of at least 100mm will be needed to prevent water backing up in the draining bay. If the bay surface is rougher, the step needed between bays will be more like 150 to 175mm. For a 100m wide bay, this equates to a paddock slope of 1:670 to 1:570, which is roughly 3 to 4 times steeper than most basin layouts, which have slopes of 1:1500 to 1:2500.

The end result of what happens when a 100mm head difference between bays is needed in basin systems which only have a 50mm fall between check banks is best illustrated by the aerial photograph in Figure 3. All bays in the contour basin system at Deniliquin were watered and drained through the bankless channel on 21 March 2017. The fall across five bays that are 85m wide on a slope of 1:2000 is 210mm. If the head of water at the supply end of the bay being irrigated is 75mm and there is 25mm of head loss through each structure between bays, then the surface of the water upstream of the bay being irrigated will meet the surface of the soil at the top of the fifth bay upstream. This can be seen in Figure 3. In effect, this means that five bays (17.5ha) need to be filled with water to irrigate just

Figure 3. Aerial photograph of the irrigation of the contour basin system at Deniliquin being irrigated on 21 March 2017 (second autumn irrigation). The whole paddock was irrigated through the bankless channel and the image shows how water has backed up in the five bays upstream of the one being watered (in the bottom right of the photo) and is only beginning to drain from the sixth bay upstream.

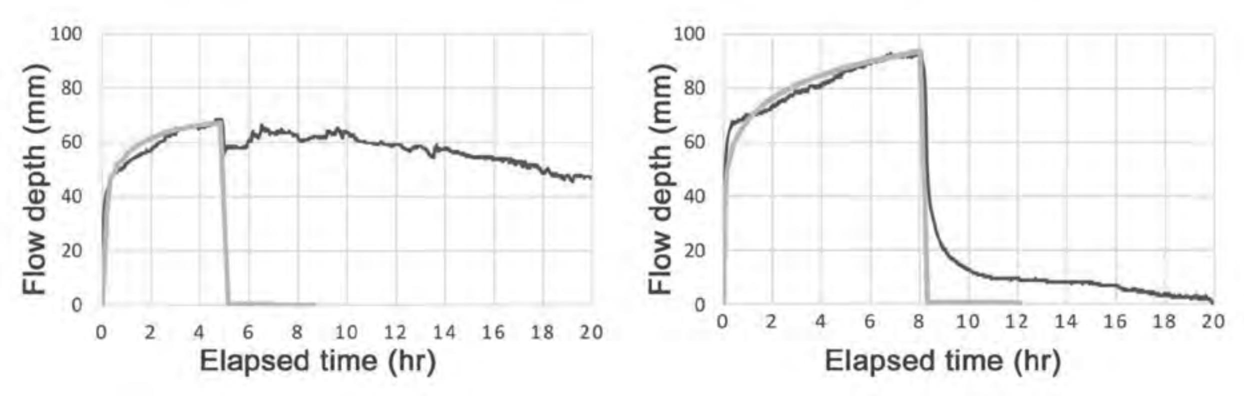

Figure 4. Actual water depths (blue lines (i.e. top lines)) at the supply end of a 3.5ha contour basin that was (1) irrigated and drained using a bankless channel (left) and (2) irrigated from the farm channel and drained to a field drain (right). Orange lines (i.e. lines that drop the most) show modelled hydrographs for the same irrigations with water supplied from a farm channel and drained to a field drain in both cases.

one 3.5ha bay when using a bankless channel in this system.

The effect of the bankless channel in slowing drainage is clearly seen when the irrigation on the 21 March 2017 (Figure 4 left) is compared with the earlier irrigation of the same bay on 10 March 2017 (Figure 4 right). On the 10 March, water was supplied directly to the bay from the farm channel and drained so that water could run away feely. This irrigation was the first autumn irrigation and the soil was dry, so it took longer to fill the bay than it did for the second irrigation 11 days later. The main difference between the two events, however, is in the drainage times: 4 hours to drain on the 10 March compared to 40 hours on the 21 March. The modelling indicated drainage times for both these irrigations of around 4 hours when drainage is not impeded (lines that drop the most in Figure 4), which agrees with the data from the 10 March. Thus, it is reasonable to assume that the time water was ponded on the trial bay on the 21 March could have been reduced from over 40 hours to under 10 if the paddock had been watered using the channel rather than the bankless channel, and drained into a farm drain.

Conclusion

The bankless channel is the principal cause of excessively long ponding times in basin layouts. The fact that water backs up in contour bays through the bankless channel has been clearly demonstrated, and the effect of this on drainage times has been measured. A pre-condition for consistently achieving high yields and returns per ML in basin surface irrigation systems will be to design and manage them so water is on and off bays in less than 10 hours. Both the field trials and the irrigation modelling show this is clearly possible if bays are supplied individually from a channel, rather than a bankless channel, and not drained into a filling downstream bay.

If high yields are to be consistently achieved from frequently irrigated crops in basin layouts, then either the bays need to be supplied and drained individually, or bays need to be skip watered.

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Notes

Notes

Recent advances in border-check bay design

Mike Morris, Amjed Hussain and Faith Githui.

Agriculture Victoria Research, Tatura.

Keywords

- border-check, flow rate, irrigation uniformity.

Take home messages

- Surface drainage from conventional border-check bays on low infiltration soils is slow and causes non-uniform irrigations.
- Installing shallow surface drains on bay surfaces provides rapid surface drainage and more uniform irrigations better suited to precise irrigation scheduling.
- Modified bays require high standard surface drainage and reuse systems.

Background

Border-check is a very common irrigation practice. It is relatively inexpensive to set up and to operate, which is why over 90% of irrigated dairy farms in the southern Murray-Darling Basin use border-check systems (Ashton and Oliver, 2014). It is commonly used on sites that have elevation gradients of less than 1 in 300 and soil profiles that have relatively low permeability.

With billions of dollars spent modernising irrigation delivery systems in south-eastern Australia, it is now possible to supply water to plants at short notice and at known flow rates, enabling more precise irrigation scheduling. Irrigation automation and a growing range of soil moisture, remote sensing and cloud based scheduling tools can take the effort and guesswork out of precise scheduling. Now the limitation to precise scheduling can be the precision of the bay itself.

The precision of bay problem arises on low permeability soils because the drainage of excess surface water from bays is very much slower that the process of applying the water. Excess surface water at the top of bays must find its way to the drain by flowing across the entire downslope surface of the bay. With modernised systems, applying irrigation water can be relatively quick, but once the supply is cut off, system energy rapidly dissipates. This leaves the excess surface water slowly finding its way down the length of bays in a process that can take days to complete, leading to non-uniform irrigations and deep drainage losses.

Method

To address this problem, the ANUGA inundation model for use as a two-dimensional surface irrigation model was adapted. ANUGA was developed by the Australian National University and Geosciences Australia to study the impacts of tsunamis striking coastlines and has since been used in a variety of applications. Our adaptation of ANUGA included code to simulate infiltration (Githui et al, 2015) and code to track and summarise the duration of inundation across a simulated bay surface. The use of ANUGA for simulation of border-check irrigations was validated (Morris et al, 2015) and then the model was used to compare potential bay surface modifications under a wide range of bay dimensions and slopes, inflow rates, soil types and crops.

A bay surface modification that reduced both the duration of inundation and the variation in duration of inundation was found and then compared with the performance of conventional and modified bays over an irrigation season at two sites in Victoria.

Results and discussion

Simulations

The bay surface that substantially reduced both the duration and variation of inundation across all conditions proved to be a simple modification that has been used on a few dairy farms in northern Victoria for more than a decade. It consists of very shallow surface drains that run parallel to the check-banks (Figure 1).

Figure 1. Shallow drain installed in a perennial pasture bay.

The drains are installed only a few centimetres deep. The two outer drains are spaced 7m in from each check-bank with the remaining drains evenly spaced 10m to 15m apart, starting roughly 15m from the top of the bay and extending to the paddock drain at the foot of the bay. Advantages of this bay surface over all the others that were simulated include:

- Robustness – the simulated design performed well over a wide range of bay dimensions and slopes, soils and crops.
- Simplicity – it can be installed using simple and accessible technology.
- Cost-effectiveness – it is relatively cheap to install with no disruption to production.
- Implementation can be staged.

Field measurements

In the past few years detailed measurements to compare irrigations on modified and conventional bays at three sites have been taken (Table 1).

For brevity, this paper will focus on results from Site 1, as Both Site 2 and Site 3 produced results consistent with results from Site 1.

Inundation duration

At Site 1, three irrigations were measured on a conventional bay before the installation of shallow drains, with a further three irrigations measured after installation. Figure 2 shows the effect of the bay modification on the duration of inundation. Only once the shallow drains have been installed does the entire bay get a very similar irrigation with minimal time for deep drainage losses.

Irrigation runoff

The shallow surface drains increase both the total volume of runoff and the peak runoff flow rate and for this reason efficient surface drainage and re-use systems are needed. Figure 3 provides an indication of the increase in runoff volume and flow rate experienced with installation of the shallow drains at Site 1. Runoff volume was 20mm with a maximum flow rate of 1.8ML/d prior to installation of the surface drains, increasing to approximately 27mm and a maximum flow rate of 2.9ML/d after installation. At Irrigation 6 the farmer reduced the volume of inflow and achieved a full irrigation while reducing runoff to 16mm with a maximum flow rate of 1.4ML/d.

Costs

An analysis of modified bay surface installation and maintenance costs has been prepared based on the management practices of a dairy industry irrigator who has been using the bay modification for several years. His current practice on dairy pastures

Table 1. Characteristics of measurement field sites.

Site	Soil	Crop	Bay length (m)	Bay width (m)	Bay gradient	Inflow rate (ML/d/m)
1	Lemnos loam	Perennial pasture	254	39	1:650	0.31
2	Wanalta loam	Sorghum	342	58	1:770	0.20
3	Wooundellah loam	Perennial pasture	213	53	1:550	0.17 - 0.25

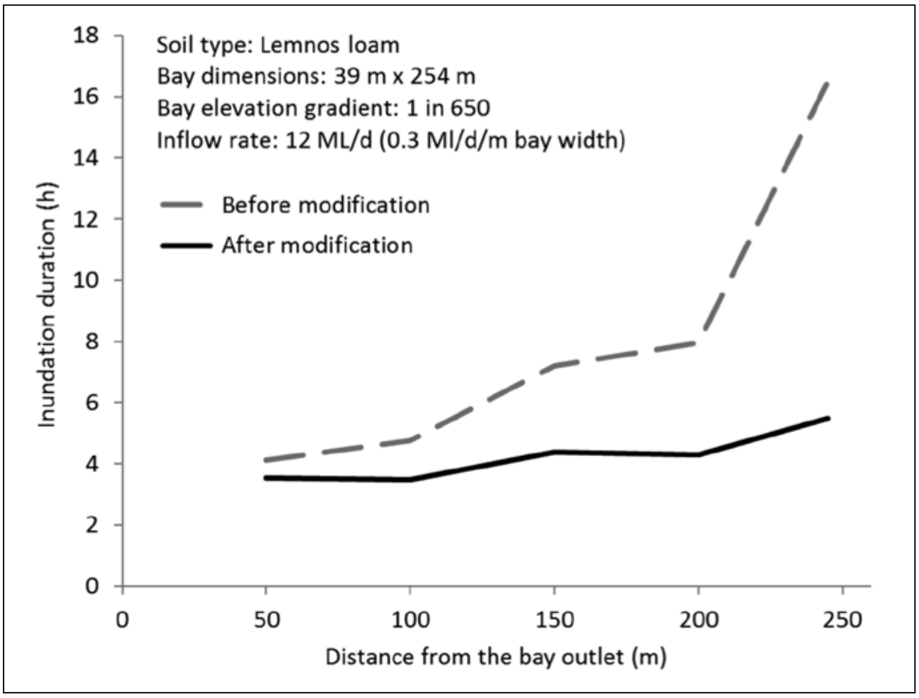

Figure 2. Effect of surface drains on inundation duration at Site 1.

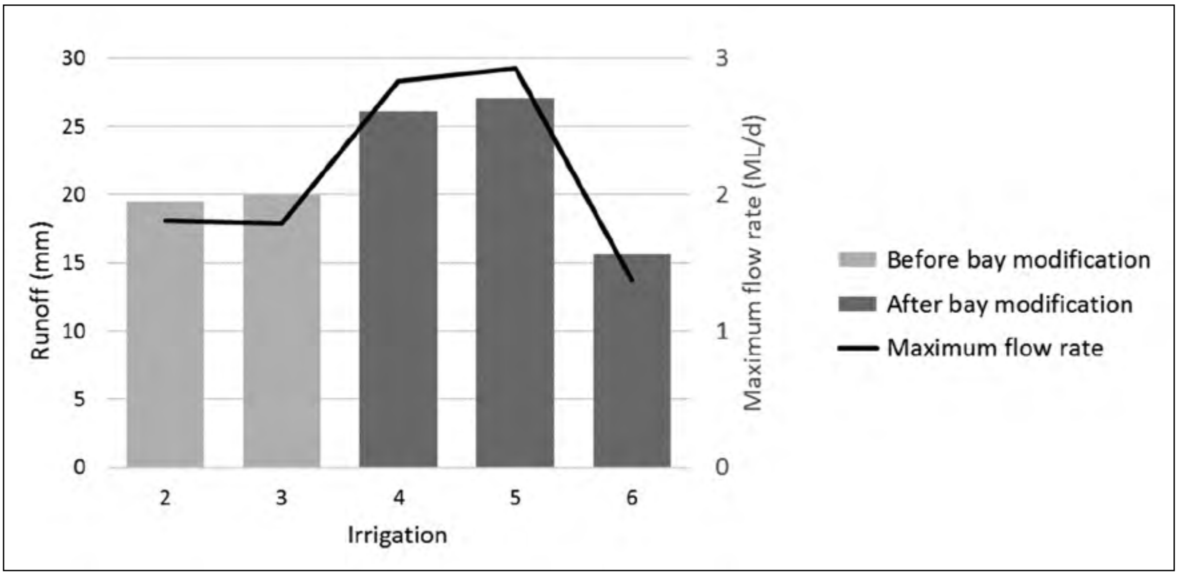

Figure 3. Site 1 runoff before and after installation of surface drains.

is to regularly clean the shallow drains with a rotary digger after every second grazing, taking care to not deepen the drains. Estimated cost to install the drains was $29/ha, with ongoing maintenance of $71/ha each year.

Implications

If irrigation runoff is efficiently captured and reused, the modified bay surface provides efficient and uniform irrigations across an entire bay, meaning that the entire crop gets the same irrigation with minimal deep drainage losses. This makes feasible precision scheduling of automated border-check irrigations.

A more efficient bay surface may also allow for the relaxation of conventional bay design guidelines with respect to maximum bay dimensions and minimum bay slopes.

Next steps

It is yet to be demonstrated; best practice border-check surface irrigation as a package using

- The modified bay surface for irrigation uniformity,
- automated irrigation scheduling with forecasting, and;
- integrated automation of irrigations and reuse systems.

The modified bay surface can provide uniform irrigations across an entire bay, enabling precise, automated scheduling of irrigations for the entire bay. Automated scheduling with forecasting has the potential for substantial improvements in water productivity and the reduction of off-site impacts caused by irrigation, while integrating automation of irrigations and reuse systems enables optimal farm surface water management with labour and water savings. Putting all this together and demonstrating it as a package is a logical next step.

Conclusion

Shallow surface drains that cut into the surface of border-check bays can substantially improve irrigation efficiency and uniformity, if surface runoff is efficiently reused. The modified bay surface enables the effective implementation of precise scheduling of automated irrigations and can allow relaxation of current conventional border-check bay design guidelines relating to bay dimensions and slope.

Useful resources

A fact sheet and technical note on this work have been prepared, and a YouTube video is undergoing final edits. These will be available on the Agriculture Victoria website in the next few months. In the meantime, please contact the author for a copy of these resources.

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Notes

Getting the most out of a centre pivot or a linear move system

Dennis Watson.

Agriculture Victoria.

Keywords

- centre pivot, linear move, coefficient of uniformity.

Take home messages

- Ensure the system is designed right at the start.
- Ensure the system can apply the right amount of water.
- Understand the changing costs of running the system, compared to the value of the crop.
- Ensure the machine is working as it is meant to and as you thought it would.

Ensure the system is designed right at the start

Determine the required system capacity for what you want; factoring in climate and the type of crops that will be grown. Match flow rates and delivery pipe diameter to minimise friction loss and pumping cost. Ensure the pump and motor are matched to the job at hand. The larger the centre pivot or linear move the cheaper the capital cost per hectare. However, for a centre pivot system ensure the soil infiltration rate at the extremities can handle the instantaneous application rate of the system. For larger centre pivots, question if an end gun is worth it and whether it can apply enough water.

Ensure the system can apply the right amount of water

The design system capacity required can be calculated using the following equation:

Application rate = Evapotranspiration rate (ETo) x Crop Coefficient ÷ efficiency of system.

Using the ETo from Figure 1, a healthy, large maize crop grown over January may require a daily application rate of 11.3mm/day (8.5 mm/day x 1.2 ÷ 0.9).

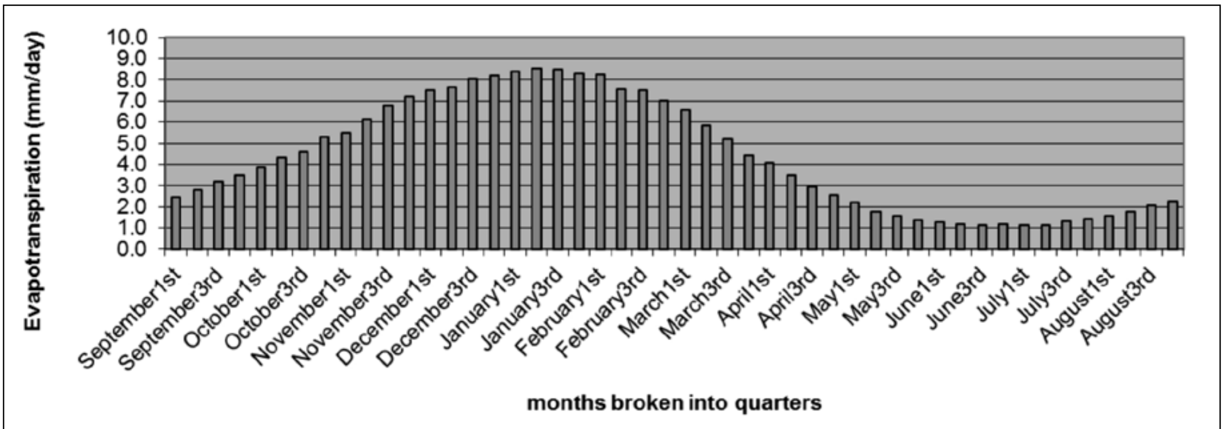

Figure 1. Average daily evapotranspiration (mm/day) over the year in Echuca.

Irrigating on night and/or weekend rate electricity is quite common but it will limit watering to 91 hours a week or an average of 13 hours a day. Using the above example, the design system capacity would have to be capable of applying 21mm/day to cover not irrigating during the day. Building a system to deliver this desired application rate will require a higher capital cost.

Understand the changing costs of running the system, compared to the value of the crop

The pie charts in Figure 2 show the cost of irrigating a winter crop (left hand side) or maize (right hand side), including electricity, labour, water cost, interest payment and depreciation. Note this does not include the actual crop costs which could be another $100/ha on top of a normal dryland winter crop or $1,200/ha for a maize crop. The water, power and labour demands are higher for the maize crop because it requires more water than the winter crop, however the interest and depreciation cost remain the same.

Assumptions

- Maize crop requires 8.3ML/ha.
- Winter crop requires 3ML/ha.
- Irrigation efficiency with centre pivot of 90%.
- Labour $35/hr.
- Water $100/ML (temporary market).
- Centre pivot set up cost of $3,000/ha (30ha).
- Interest rate of 6% and the cost of the system is depreciated over 20 years.
- Pressure at the pump for centre pivot is 35m head.
- Electricity is $0.23/kwatt/hr.

The values in Figure 2 vary for each irrigator. For instance, pumping from a deep bore compared to a river diversion will have a different cost. Some values change throughout the year such as the water price. If the electricity price increased from $0.23/kwatt/hr to $0.30/kwatt/hr the running cost would increase by $30/ha and $85/ha for the wheat and maize crop, respectively.

Ensure the machine is working as it is meant to.

Ensure the machine is working properly to maximise yields and keep cost down. Test pressures to make sure they are not too high or too low. Pressures that are too high are simply wasting energy while low pressures will lead to poor water distribution affecting performance.

Undertake uniformity tests to check correct and even application. The results of a uniformity check can be seen in Figure 3. This centre pivot was set to apply 12mm, however a uniformity check indicated it was only applying 9.2mm with a poor coefficient of uniformity (CU) of 80%. The pressure at the end of the pivot was 7PSI while it should have been 20PSI; 5PSI above the regulated pressure.

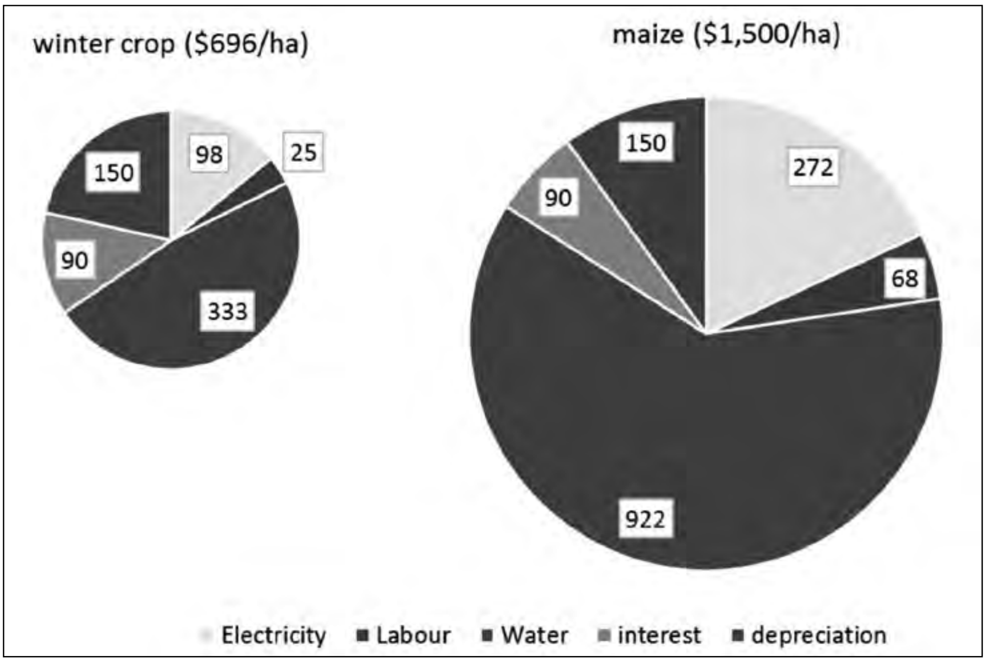

Figure 2. Typical annual cost breakdown of a 30 ha centre pivot ($/ha) irrigating a winter crop (left hand side) or a maize crop (right hand side). Electricity cost is $98/ha and $272/ha, respectively and the following costs are labour, water, interest and depreciation in a clockwise direction.

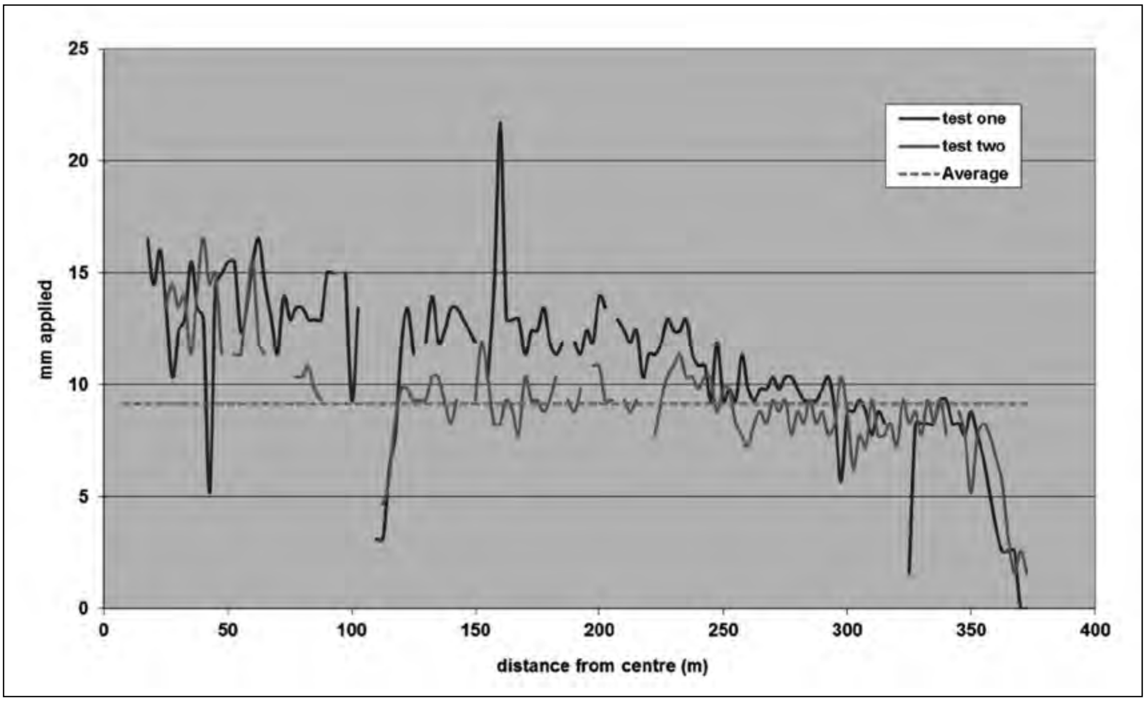

Figure 3. Example of a poor performing centre pivot with a coefficient uniformity of 80% applying 9.2mm (despite being set to apply 12mm).

A poor CU can have one of two consequences or a combination of the two:

1. Extra water is applied to compensate for the poor CU, resulting in higher pumping and water cost, or
2. Insufficient watering occurs incurring a yield penalty.

Extra water applied to a wheat crop to compensate for a CU of 80% compared to 90% will increase the cost by an extra $54/ha for a winter crop and $152/ha for a maize crop.

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Taking the guesswork out of irrigation scheduling

Nick O'Halloran and Robert O'Connor.

Agriculture Victoria.

Keywords

- irrigation scheduling, soil moisture monitoring, evapotranspiration.

Take home messages

- Accurate irrigation scheduling is important for maximising crop yield and water productivity.
- The use of soil moisture and evapotranspiration monitoring takes the guesswork out of irrigation scheduling and helps assess irrigation performance.
- Evapotranspiration data, both past and forecasted, is freely available.
- Agriculture Victoria provides evapotranspiration data in a free weekly email service and on the Irrigating Agriculture website.

Background – irrigation scheduling

Rising water costs has driven interest in systems to improve irrigation scheduling and increase water productivity. Irrigation system upgrades, both in supply and on-farm, have also resulted in better water control and have enabled farmers to take advantage of irrigation scheduling tools.

Irrigation scheduling tools such as soil moisture and evapotranspiration monitoring help take the guesswork out of irrigating. Many farmers find them particularly useful on the shoulder periods of the irrigation season to determine when to start irrigating in spring and when to stop irrigating in autumn. These tools are also very valuable in the peak of summer when crop water demands are highest and growth rates are more sensitive to delayed irrigations.

Irrigation scheduling tools can help farmers to irrigate at a similar soil water deficit (soil dryness). If done well, crop losses from waterlogging and drought stress are minimised, and irrigation systems will operate more consistently. For example, with border check systems water cut-off times will be more consistent with similar runoff. This improves application efficiency, particularly if using timer based automation systems.

Irrigation scheduling tools can provide a record of irrigation events and how much water was applied. This is useful for benchmarking performance and making informed decisions about how to change irrigation scheduling practices.

No single irrigation scheduling system should be used in isolation. Combining objective irrigation scheduling tools such as soil moisture and evapotranspiration monitoring with more traditional methods of digging in the paddock or using a penetrometer to test soil hardness will give greater confidence all round.

Visual crop symptoms should not be used for irrigation scheduling. If your crop is wilting or visually water stressed, crop growth will already be compromised and yield lost.

Evapotranspiration

Evapotranspiration is calculated from weather data (sunlight, wind, humidity and temperature) and is a reliable estimate of daily crop water requirements in millimetres per day (mm/day). By summing daily evapotranspiration and subtracting rainfall, when to irrigate next can be calculated. Past and forecast evapotranspiration data is freely available from a range of sources. Some of these sources provide user-friendly tools that take the hassle out of doing the calculations required to use evapotranspiration data.

When farming on the Riverine Plains, estimates of evapotranspiration are relatively consistent over large distances, so the use of evapotranspiration data from your nearest Bureau of Meteorology weather station is recommended. However, rainfall is much more variable over small distances, so it is better to use rainfall data collected from your own property when scheduling the next irrigation.

Evapotranspiration calculated from weather data gives an estimate of crop water requirements for a 'standard crop' or 'reference crop', so this is called reference evapotranspiration (ETo). Your crop is unlikely to be identical to the reference crop, and therefore, ETo is multiplied by a crop coefficient (Kc) to calculate daily water use of your crop. The crop coefficient will vary depending on crop type and stage of development (Figure 1). The internet based tool IrriSAT uses weekly satellite images to estimate the crop coefficient for your crop and automatically does all the necessary calculations.

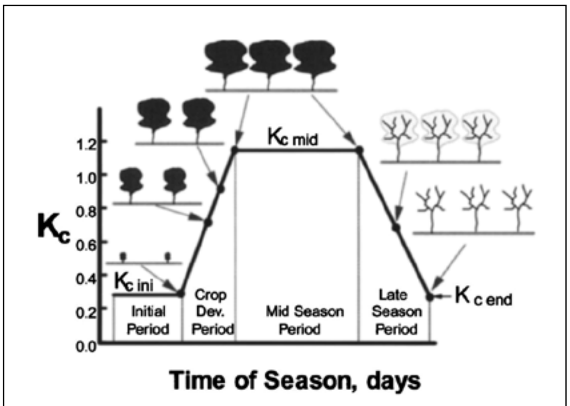

Figure 1. Generalised diagram of how crop coefficient (Kc) changes with crop development (Allen et al, 2005).

Free sources of evapotranspiration data include:

- Bureau of Meteorology - http://www.bom.gov.au/watl/eto/
- SILO (Queensland Government) - https://www.longpaddock.qld.gov.au/silo/datadrill/
- irriGATEWAY (CSIRO) - http://weather.csiro.au/?aws_id=8&view=summary
- The YIELD App - https://www.theyield.com/products/free-growers-app
- irriSAT App - https://irrisat-cloud.appspot.com/
- For weekly email services email:
  - Northern Victoria – robert.oconnor@ecodev.vic.gov.au
  - North East Victoria – dennis.watson@ecodev.vic.gov.au
- Weekly ETo updates for Northern Victoria and other valuable irrigation information can be viewed online at http://extensionaus.com.au/irrigatingag/

Soil moisture monitoring

The two main types of commercially available soil moisture sensors are: suction based and volumetric based systems.

Suction based sensors measure how tight water is held in the soil. The measurement relates directly to how hard the plant needs to work to extract water and is therefore consistent across different soil types.

Volumetric soil moisture systems measure the total amount of water in the soil. To estimate how much of this water is 'readily available' to plants, the soil type needs to be known. In practice, volumetric moisture monitoring tools can be used to guide when to irrigate, but also how much water to apply.

Real-time monitoring of soil moisture data is possible with automatic data logging and transmission to your office or mobile device. Logged data provides a record of your irrigation practices, which can be used to assess your irrigation performance. Alternatively, lower cost manual-read options are available. There are numerous companies that will install soil moisture sensors and manage the data, with varying fee structures and total costs.

Complementary benefits of soil moisture and evapotranspiration monitoring

Soil moisture and evapotranspiration monitoring complement each other. To use evapotranspiration data for irrigation scheduling knowledge of how much water is available in the soil is also necessary. This varies depending on soil type and the crop type grown. Soil moisture monitoring can help by telling us what is happening in the ground; what depth the crop is drawing water from, how deep rain and irrigation water is penetrating, how dry the soil gets between irrigation events and how much water is available to the crop. However, soil moisture sensors only measure a small patch of soil at a single point in the paddock. Evapotranspiration tells us about the potential water use of the crop across the entire paddock, while soil moisture monitoring can confirm what is actually happening in the paddock. Installing soil moisture sensors in a representative location in the paddock is important.

Useful resources

- https://extensionaus.com.au/irrigatingag/
- http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/irrigation
- http://agriculture.vic.gov.au/__data/assets/pdf_file/0007/376567/Soil-Moisture-Monitoring-fact-sheet-Dec-2017.pdf
- http://agriculture.vic.gov.au/__data/assets/pdf_file/0019/402625/What-is-evapotranspiration-and-how-do-I-use-it-to-schedule-irrigations-Tech-Note.pdf
- http://www.dairyingfortomorrow.com.au/tackling-specific-issues/water/smarter-irrigation-for-profit/
- https://grdc.com.au/__data/assets/pdf_file/0019/170344/irrigated-wheat-best-practice-guidelines-publication-2016.pdf
- https://grdc.com.au/__data/assets/pdf_file/0037/292789/Irrigated-wheat-in-southern-cropping-systems.pdf

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Notes:

The value of water and the options if the temporary price rockets

Rob Rendell.

'Fellow' with RM Consulting Group Bendigo.

Keywords

- irrigation, value of water, temporary water price.

Take home messages

- NSW General Security (GS) allocations determine water prices.
- It is what you do in the low water price years that counts.
- Determine your buy, sit and sell water price which is unique to your system.
- Short term decisions based on finishing what you have started, seasonal decisions based upon gross margin comparison with selling/buying water, and strategic decisions about infrastructure development and water ownership are based on longer term farm financial performance.

Background

Water is a key input to irrigated cropping systems and the availability and cost varies from year to year and within years. Irrigation farmers are required to make decisions around water purchases/sales on a temporary and permanent basis. Coupled with these decisions are decisions around investment in irrigation infrastructure. The following information is provided to assist farmers to make better decisions.

Available water

Table 1 summarises the available water and the price for different southern Murray Darling Basin climate scenarios, water allocation and use and price – post 2006.

The 'actual' refers to what happened in those particular years, whereas the 'projected' refers to what would happen if those years were

Table 1. Available water (GL) and the price ($/ML) for different southern Murray Darling Basin climate scenarios, water allocation and use and price – post 2006.

Climate Scenario	Allocation level	Frequency (last 12 yrs)	Total water allocated Actual–Projected (GL)*		Price -($/ML) Actual - Projected		Comment
Very Wet 10/11, 11/12, 12/13	Victorian Low security water available, 100% NSW GS	3	6,200	5,300	20-50	50	Carryover increased
Wet 13/14,16/17	90% NSW General Security	2	5,400	5,000	65	70	Rice expands
Average 14/15,17/18	55% NSW General Security	2	4,300	4,000	125	130	Rice sits on allocation
Dry 09/10,15/16	30% NSW General Security	2	3,500	3,300	150-208	210	Small rice crop as it sells to dairy/cotton
Drought 06/07, 07/08, 08/09	1 0% NSW GS, 80% NSW HS, and 50% Vic/SA high security	3	2,100	1,700	300-680	600	Horticulture minimises and cotton/dairy sell mostly, rice fails

repeated today given the smaller size of the consumptive pool.

Industry use of water has changed

Horticulture (excluding almonds) has continued to slowly increase its water use over the last 50 years from 600GL in 1970 to around 800GL in 2015/16 (Figure 1) and is likely to continue to slowly increase to 900GL in the foreseeable future.

The next drought may limit perennial horticultural growth as horticultural demand is likely to be capped by the total water available on the market.

Almond's water use has increased from almost nothing in 1999/00 to over 400GL in 2015/16 and is predicted to increase to over 600GL in the foreseeable future.

Since 2010, cotton has continued to replace rice in the Murrumbidgee region. Cotton currently uses 450GL and is expected to increase to up to 700GL in the foreseeable future.

Since peaking in the early 2000s, dairy has reduced its production and water use. This is shown in Figure 1 for the Goulburn Murray Irrigation District (GMID). Dairy is now estimated to use 1,000GL in the southern basin but is expected to reduce to 900GL on average in the foreseeable future.

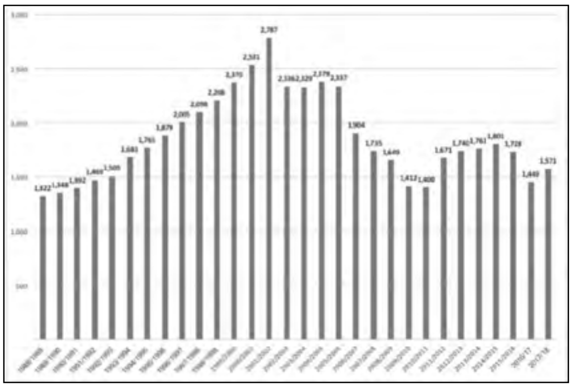

Figure 1. Dairy production in the GMID (ML).

Rice production increased dramatically prior to 1999/00 reaching over 1.4 million tonnes in 2001. However, in recent times production has halved and now varies according to the climate scenario and allocations. This ranges from 0.2 million tonnes to 1 million tonnes (Figure 1). Rice water use now averages 650GL but ranges from 250GL to 1000GL per year.

Regional winners and loser

Some industries continue to expand and others decline as the water availability has reduced with the Basin Plan and irrigator's behaviour has changed. Similarly, some regions have also expanded and others have declined.

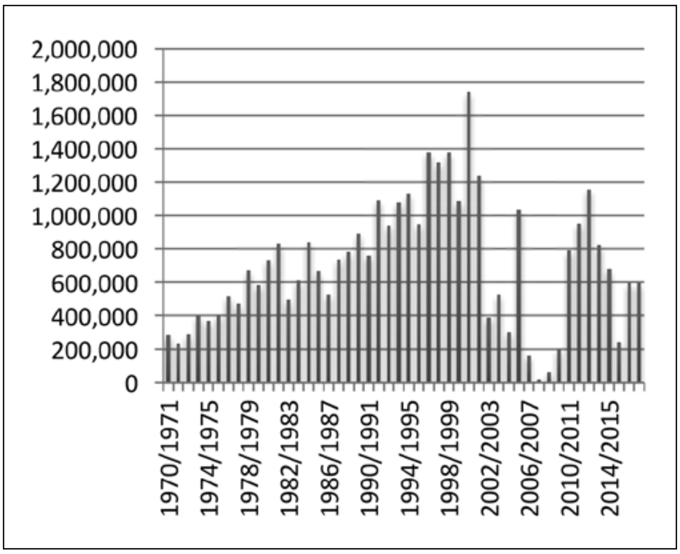

Figure 2. Southern Murray Darling Basin (sMDB) rice production over time (tonnes).

Table 2. The new projected equilibrium (GL) in the sMDB based on current entitlements and no more recovery.					
Sector	Drought (06/07)	Dry (15/16)	Average (14/15)	Med-wet (16/17)	Wet (12/13)
Mixed grazing	121	286	316	416	474
Rice	72	241	631	943	1,143
Cotton	241	676	676	721	721
Other crops	145	406	541	554	554
Dairy	435	811	901	970	1,067
Horticulture	1,400	1,442	1,442	1,386	1,286
Carryover to next year				554	554
Total (incl. carryover and 500GL of groundwater)	2,414	3,863	4,507	5,545	5,800

In general terms since 1999/00 when water use across the basin was at its peak, it is observed that:

- SA Riverland region has maintained its overall water use.
- Victorian/NSW Mallee region has expanded its water use significantly.
- NSW Murrumbidgee has maintained its High Security (HS) water use but decreased its GS water use. BUT the decrease in water use has been offset by the expansion of cotton which uses less water per ha.
- NSW Murray Irrigation has significantly reduced its water use as the rice industry has declined.
- Victorian GMID area has significantly reduced its water use resulting in a large decline in the dairy industry. With 417GL of the buyback and farm efficiency HS entitlements coming directly from the GMID, and additional indirect back trade of water out of the GMID to other regions where water has been recovered, this has resulted in a 500GL reduction in water use in the GMID. This is almost half of the total reduction (1,169GL) in the sMDB consumptive pool in an average year.
- Over the last twenty years the GMID has had a net decline of 1,000GL/y (almost 50%), with half of this due to the Basin Plan and the other 500GL due to water trade, climate, carryover, new reserve policies and earlier water recovery initiatives such as the Living Murray.

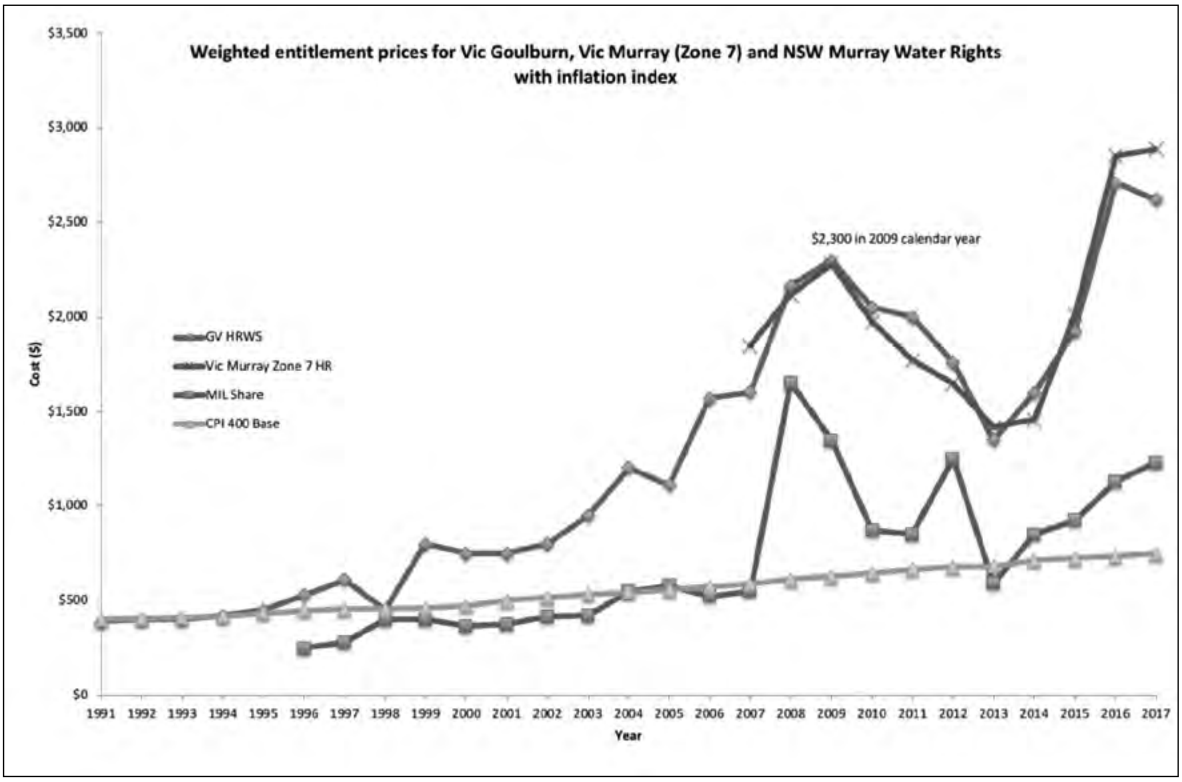

Figure 3. Weighted entitlement prices for Vic Goulburn, Vic Murray (Zone 7) and NSW Murray Water Rights with inflation index.

The future estimated water use by industry in sMDB

Water price

The price of entitlements over time is shown in Figure 3.

The relationship between the level of allocation and the temporary price in the water market continues to hold with considerable accuracy and is shown in Figure 4 and Figure 5.

The value for 2018 appears to be slightly cheaper than the standard curve would indicate. However, 2018 had a very high level of carryover across the sMDB (at ~ 2,000GL) which effectively provided a greater allocation, i.e. it shifts the effective point to the right on the graph, closer to the standard fit.

The temporary price is shown in Figure 6. From this it can be seen that over the last six years the temporary price has been relatively consistent between regions and has ranged from $120 +/-$100 per ML.

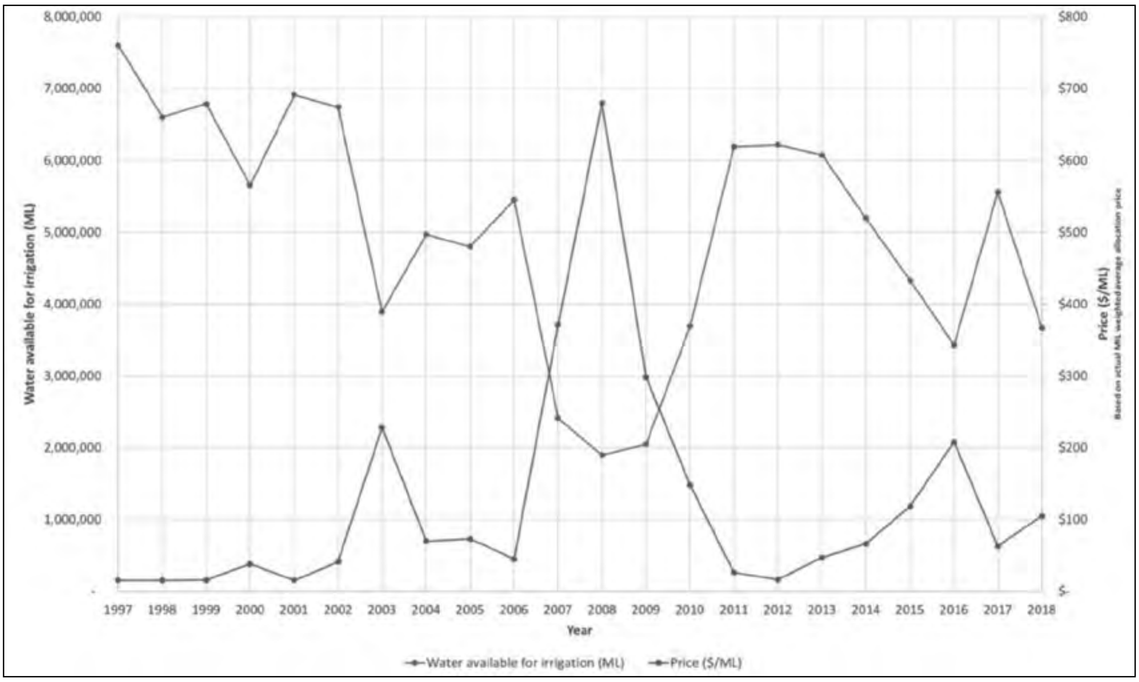

Figure 4. Water allocation and average price.

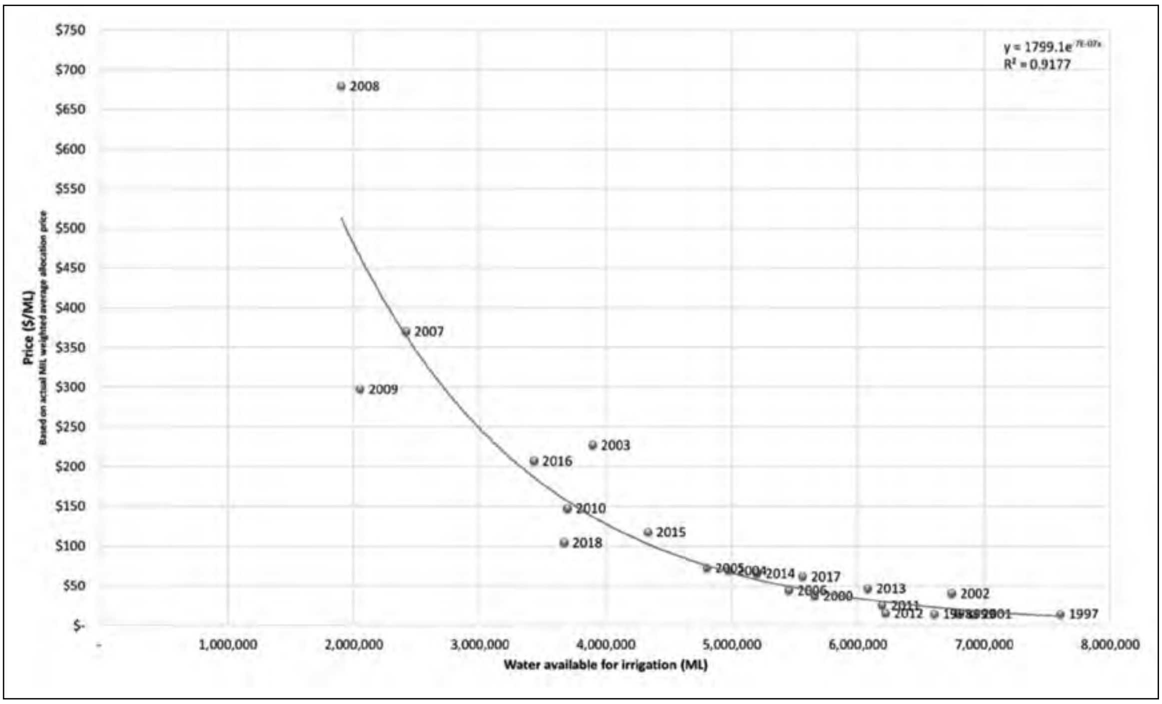

Figure 5. Correlation between water allocation and average price: 1997-2018.

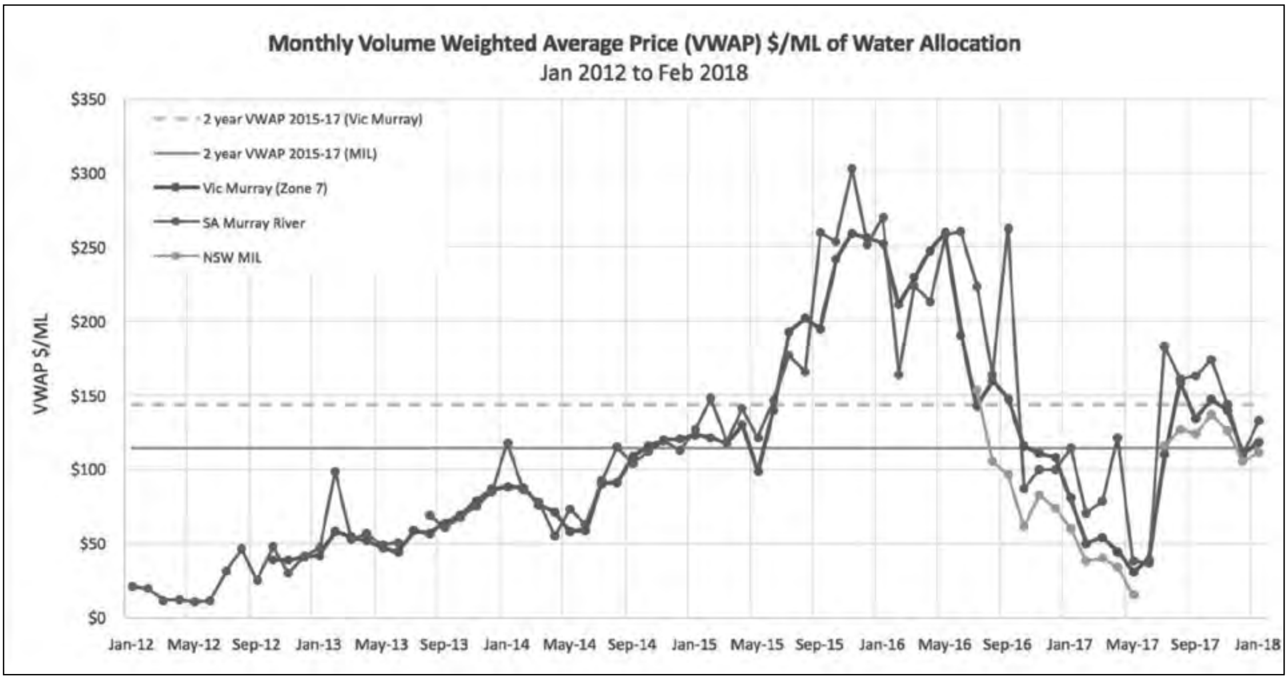

Figure 6. Monthly volume weighted average price (WAP) $/ML of water allocation (2012 – 2018).

Industry Data

The number of farmers, the area irrigated and water applied in 2015/16 season is shown in Table 3.

In 2015/16 croppers generally used what water they owned but did not purchase much as the average price was around $200/ML.

Table 3 shows a lot about the region and where croppers fit in.

There are 5,000 irrigated businesses in the regions of which about ¼ irrigate crops excluding cotton and rice. In the NSW Murray and northern Victoria region there are 900 croppers using on average less than 300ML of water per year in 2015/16. The cotton growers use 10 times that amount per grower and the rice growers use over 1,000ML per year per business in a low production year.

Some things to think about

i. **What is your buy, sit and sell price for water?**

   Everyone has a different set of numbers – do you know yours?

ii. **Good times make or break your business**

   In other words, low water prices enable you to produce lots and determine your profitability. It is not what you do when water is expensive – did you buy water last year and make 'hay' when the sun shone?

Table 3. The number of farmers, the area irrigated and water applied in 2015/16 season.

Commodity Description	Number Of Businesses	Area Watered (ha)	Volume Applied (ML)	Application Rate (ML/ha)	Volume per Business (ML/Business)
Victoria : Goulburn Broken & North Central /CMA					
Total number of agricultural businesses irrigating, including dairy, horticulture and grazing	2,748				
Total crops	*479*	*53,789*	*101,490*	*1.9*	*212*
Cotton	1	96	766	8.0	766
Rice	1	182	231	1.3	231
New South Wales : Murray /CMA					
Total number of agricultural businesses irrigating, including dairy, horticulture and grazing	1,086				
Total crops	*472*	*91,814*	*145,554*	*1.6*	*308*
Cotton	10	1,131	8,383	7.4	820
Rice	79	6,608	77,262	11.7	982
New South Wales : Murrumbidgee /CMA					
Total number of agricultural businesses irrigating, including dairy, horticulture and grazing	1,124				
Total crops	*365*	*83,761*	*220,784*	*2.6*	*605*
Cotton	97	34,352	320,271	9.3	3,303
Rice	194	17,450	221,318	12.7	1,140
Total of 3 regions					
Total number of agricultural businesses irrigating, including dairy, horticulture and grazing	4,959	-	-	-	-
Total crops	*1,317*	*229,364*	*467,828*	*2.0*	*355*
Cotton	108	35,579	329,420	9.3	3,045
Rice	274	24,241	298,810	12.3	1,091

iii. $/ML of gross income is the main measure

Keep it simple – there are all sorts of complicated ways of measuring performance but the simplest is $?/ML gross income

iv. Allocation water as % of income

Think of allocation water cost as a % of gross income i.e. water at $200/ML and maize at 16t/ha and 6ML/ha and $300/t means water is 25% of income – what is your limit?

v. Be careful of irrigation development

Owning water is an appreciating asset whereas developing irrigation infrastructure depreciates – which has made more money; owning water or irrigation development?

vi. Irrigation development must be used.

Once you develop for irrigation – that money spent is GONE from the balance sheet– so can you make it produce?

vii. Croppers compete with other industries

Do you know their gross income$/ML? i.e. know thy enemy

viii. Short term price

There are short term (immediate, marginal return) decisions i.e. do I finish the crop – this usually means you can afford to pay a lot more for water. Do I buy now or do I buy later?

ix. There are seasonal decisions

Each year the price is different and depending upon the likely average price for the year impacts what and how much crop you will plant. This needs an understanding of gross margins and ensuring you maximise total water use. If you own water the gross margin is always much better than if you have to buy

x. There are longer term decisions

Over the long term there are strategic decisions around do I stay farming, do I expand land, purchase water or undertake infrastructure development. All of these require a good knowledge of cost of operating (tax returns and some simple data of water use are all you need) and your profit. Also need to factor in purchasing entitlement or temporary pricing. The table provided (Table 7) gives a good basis for these numbers.

xi. Should you own permanent or buy temporary

Probably both but those who own have done well have owned water???

xii. Carryover

Always participate in carryover if the price of water is less than your 'buy' price. The more water you use at a profitable price the more you make.

xiii. Farm efficiency grants

These have been provided as a subsidy which has typically meant instead of having for example 12 years to pay back the development, the payback period is reduced to five years. The big benefit is that it reduces labour which enables farm expansion (replace the water) or enables a longer life for older farmers.

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References

"Update on GMID water availability scenarios and Irrigated Production across the Southern connected Basin" Prepared by RMCG for Goulburn Broken CMA - 6 JUNE 2018

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Notes

Notes

What's the likelihood of Goulburn, Murray and Murrumbidgee River inflows in 2018?

Dale Grey.

Agriculture Victoria, Bendigo.

Keywords

- climate, inflows, spring irrigation, weather forecasts.

Take home messages

- The season is delicately poised, no El Nino, but the prediction of a late one is forming.
- Plenty of random things need to happen before one could form.
- The Indian Ocean isn't playing unfair like it often does before an El Nino forms.
- Stronger pressure needs to decrease, or the effect could be similar to either phenomena.

Introduction

The last time I spoke at the Moama GRDC Grains Research Update was July 2015 and a full blown El Nino was occurring. 2015 turned out to be a challenging spring however, in 2018 things are very different. Many models are predicting an El Nino for this spring and the odd model is forecasting it even earlier, during late winter. Looking at all but one climate indicator, nothing seems to be within a 'bull's roar' of looking like an El Nino. Yet, despite this, rainfall in many areas has been less than average so far. So, what has got the models so fired up this year? It's all to do with the undersea heat that has developed in the eastern Equatorial Pacific as a result of a strong burst of reversed trade winds in February. This strong west wind near Papua New Guinea sent warm water under the Pacific and on its way over to the South American coast. Such a beginning is essential for the start of an El Nino, but it fortunately doesn't guarantee one.

Looking at some recent undersea cross section data from1982 to current date, the years where undersea temperatures were warm at this time of the year have been extracted and followed onto spring to see what eventuated (Table 1).

Strong warming that developed early and lasted through the season like what happened during 1997, 2009, and 2015 are fortunately not as common as other years. More common are the warming that starts in the winter and develops in the spring, such as what happened during 1982, 1991, 2002, and 2006. There is also a smattering of years that show promise for the development of an El Nino but this does not eventuate, such as what happened during 2001, 2004, 2012 and 2014. What is clear about all of these years is that the rainfall has been variable in all of them. The odd strong, long-lived event like 2009 had a reasonable rainfall outcome. The late spring developers are often drier, but have often been joined by a positive Indian Ocean Dipole (+IOD) in winter which has resulted in very dry seasons. Likewise, some of the failed El Ninos have been dry due to the +IOD popping up. At this stage of the year the Indian Ocean looks like it is behaving itself, with models highly variable as to its likely course for the season.

So, what of this year? Well apart from the warm Pacific undersea, we have, as yet, no El Nino indicators and little evidence of the desire by the Pacific Ocean for one. The Southern Oscillating Index (SOI), trade winds and cloud patterns at the dateline are all not interested at this stage. Even if they started tomorrow it's unlikely that an El Nino would be seen for many months. And yet things aren't as wet as we would like. The reason for this has been the domination of higher pressure over South East (SE) Australia for May and June.

Table 1. Years during which undersea temperatures were warm during July and the resulting spring.		
	Winter Equatorial Pacific to depth	Spring Equatorial Pacific to depth
1982	Weak warming at depth (dry)	Very warm and an El Nino Sept-Dec (dry)
1986	Weak warming at depth (wetter)	Weak warming and weak short lived El Nino Oct-Dec (wetter)
1987	Moderate warming at depth and El Nino from May-Aug (wetter)	Warming decreased but weak El Nino till Nov (drier)
1991	Moderate/weak warming at depth (wetter)	Strong warming and El Nino in Oct-Dec (drier)
1994	Weak warming at depth (drier)	Moderate warming for El Nino in Oct-Dec (drier)
1997	Strong warming at depth and El Nino June-Aug (drier)	Strong warming at depth and El Nino Sep-Dec (average)
2001	Moderate warming in Jul (average)	Warming decayed to neutral Aug-Dec (average)
2002	Strong warming at depth (drier)	Strong warming at depth and El Nino Aug-Dec (drier)
2004	Moderate warming in Jul (average)	Weak to no El Nino (average)
2006	Moderate/weak warming at depth (drier)	Strong warming and El Nino in Oct-Dec (drier)
2009	Strong warming to depth El Nino in Jun-Jul then decayed (average)	Strong warming to depth El Nino in Oct-Dec (average)
2012	Moderate/weak warming at depth (drier)	Warming decayed to neutral Aug-Dec (drier)
2014	Moderate/weak warming at depth (drier)	Warming decayed to neutral Aug-Dec (drier)
2015	Strong warming at depth and El Nino June-Aug (drier)	Strong warming at depth and El Nino Sep-Dec (drier Vic, wetter NSW)

Sometimes the +IOD and/or El Nino can cause this and other times it's a frustrating part of natural variability. The finger marks of climate change are also all over such an increase in pressure and this has been on an increasing trend in SE Australia for the last 110 years.

Figure 1, 2 and 3 show historic tercile (thirds) river flow outcomes for the Goulburn, Murray and Murrumbidgee catchments in various years. High pressure during winter has strong effects at drying out the catchment, but not in every year. As does the effect of high pressure during winter on spring

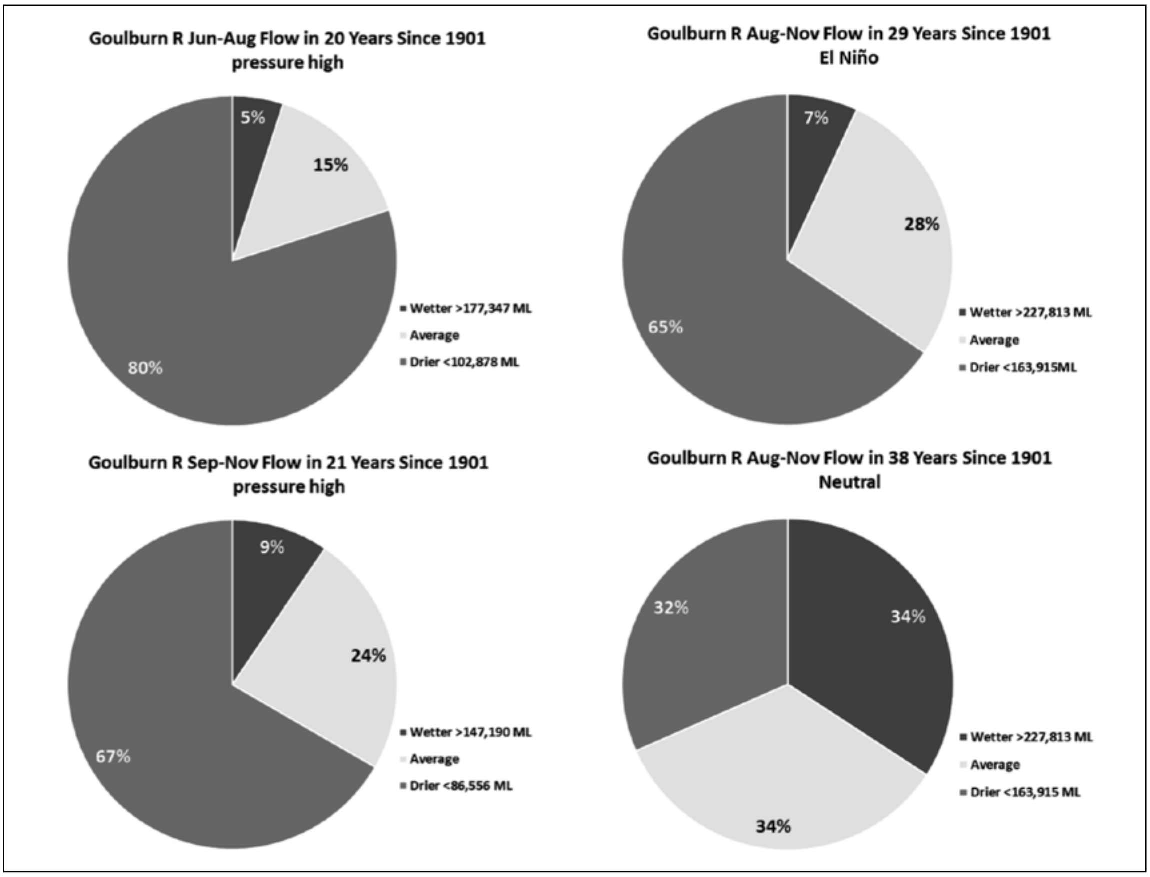

Figure 1. Goulburn River flows since 1901 when the season has experienced high pressure, El Nino or it has been a 'neutral' year.

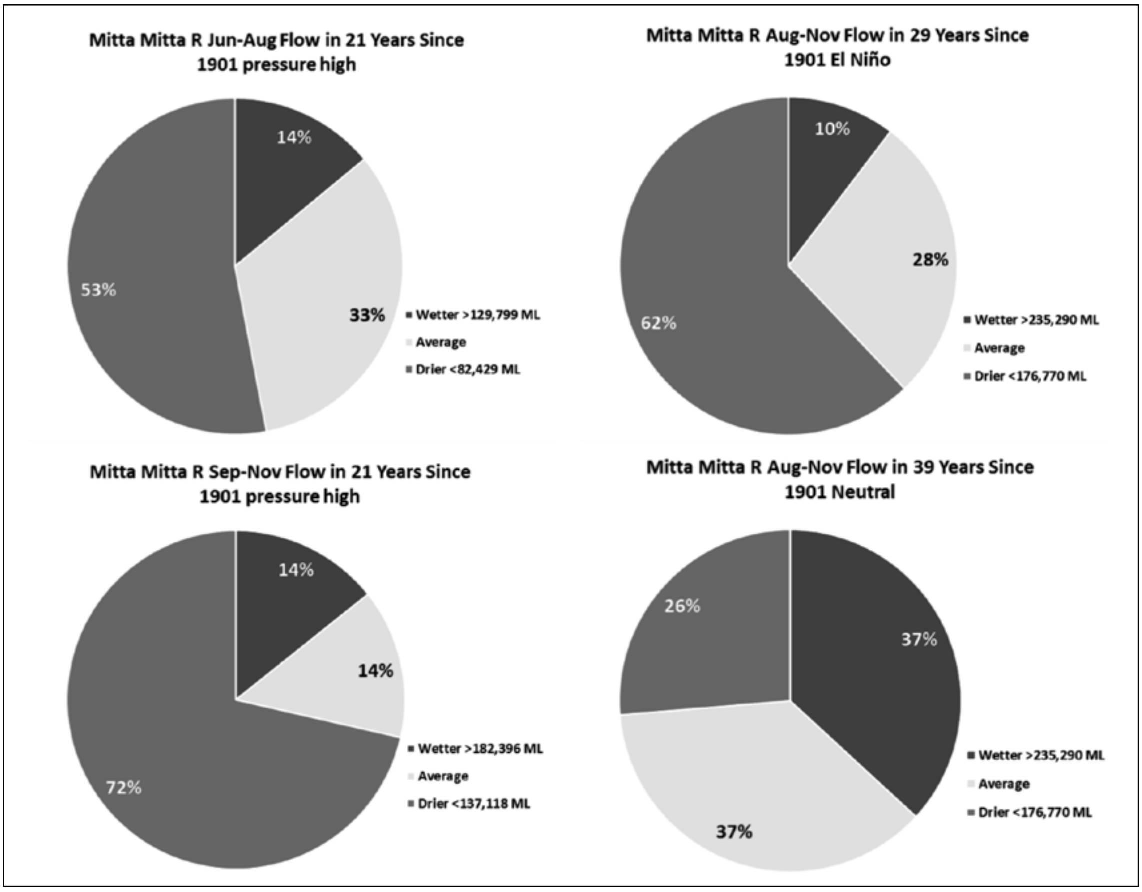

Figure 2. Mitta Mitta River flows since 1901 when the season has experienced high pressure, El Nino or it has been a 'neutral' year.

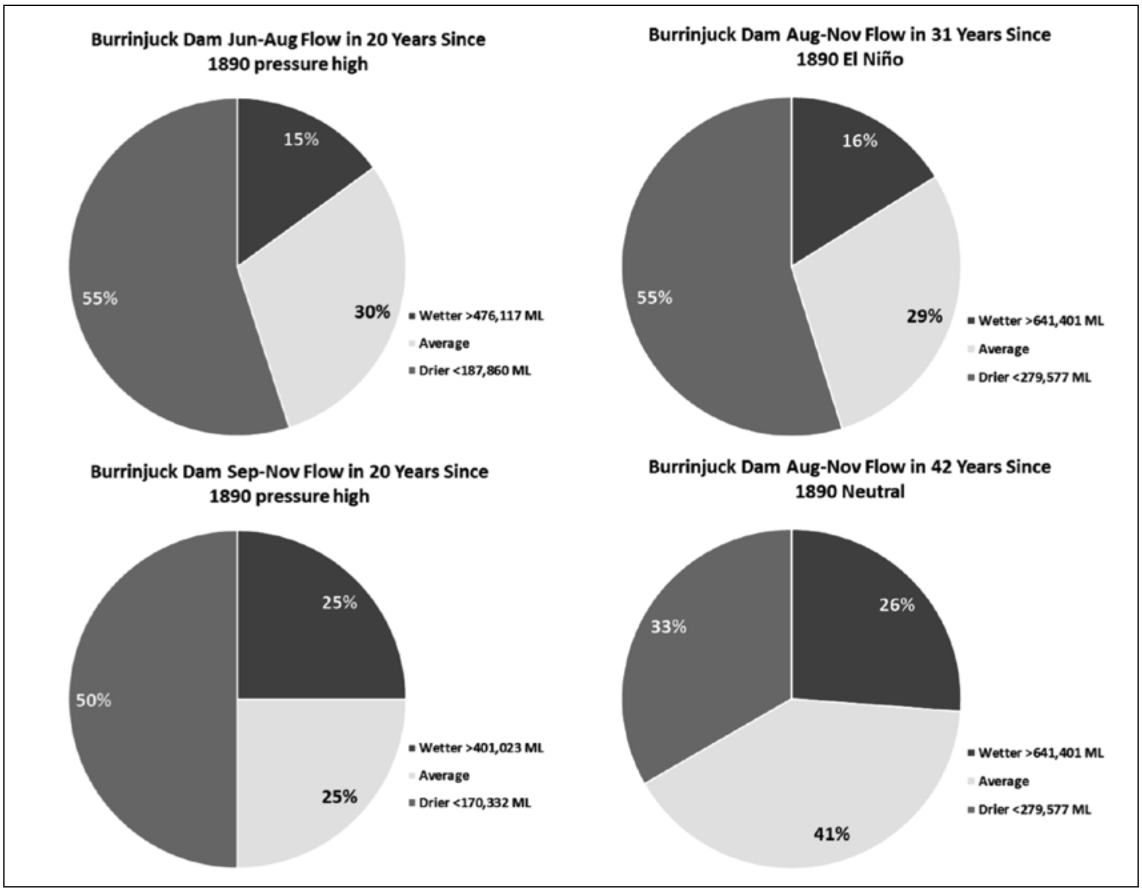

Figure 3. Burrinjuck Dam intake since 1901 when the season has experienced high pressure, El Nino or it has been a 'neutral' year.

flow rates; there's a memory in the system that lasts due to the slow charging of the catchment. El Nino has the classic drying (but not always) effect, quite like higher pressure. Figure 1, 2 and 3 also indicate the effect of the so called 'neutral years' where the Pacific and Indian Ocean do nothing. Historically river flow has been close to climatology in those years, i.e. an equal third of the time the outcome has been drier, average or wetter. It's for the same reason that model predictions for average rainfall are actually the same as 'neutral'. Occasionally models have a stronger probability of average being the outcome, but in my years of monitoring models, this has been uncommon.

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Using irriSAT for irrigation decisions

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From pretty pictures to decision making - how to make use of your yield maps

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Keywords

- yield maps, harvest data, variations.

Take home messages

- Data correction.
- Analyse.
- Investigate/interrogate.

Introduction

Most modern harvesters as part of their standard, come with yield mapping capabilities. A yield map can be a very valuable layer of information when it comes to assessing crop performance and paddock variability.

To enable a yield map to be used as an accurate layer of information, the raw data needs to be assessed and all data points which have inconsistencies need to be removed.

The processing of a yield map involves identifying and removing all data points which are not consistent with the area that they are in. These inconsistent data points are a result of normal harvest operations where the normal throughput of grain in the harvest operation is impeded, for example; head land turns, edge effects when opening paddocks up, partial header front passes, etc.

Once inconsistencies have been removed, the yield map is a reliable layer of information of what was recorded in the paddock at harvest and the yield map can then be calibrated to actual yield.

Most precision ag software programs will allow post calibration using actual tonnage, and therefore, production of an accurate yield map.

Yield maps are best viewed as raw data points when analysing to pick up subtle differences from pass to pass.

A contour map can be produced at the end of the process for easier viewing.

From this point a legend can be manipulated and produced to define an accurate map of information.

Most programs produce a legend as a standard spread in yield increments and this can show a large range of variance within the yield map. Manipulation of a legend can assist in identifying finer variability of a focused area, i.e. making the map tell a story.

Identifying and ground truthing the points of variation is the key to understanding the factors behind the variabilities and whether actions are then required.

Variabilities can come in several different forms; some that can be acted on (nutrition, pest control, irrigation, wild life, soil type, previous rotations, etc) and some that are climatic (frost, hail, heat stress, drought water logging, wind, etc).

A corrected yield map can then be used as a base to produce the following maps:

- Nutrient removal map.
- Gross margin map.

- Water use efficiency map.
- Assist in the creation of a variable rate map.
- Can also be used to verify applied nitrogen efficiency.

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Grazing canola – agronomic and feed considerations

Rob Fisher[1] and Damian Jones[2].

[1]Agronomic Results; [2]Irrigated Cropping Council.

Keywords

- winter canola, grazing, irrigation.

Take home messages

- At current livestock prices, gross margin returns in excess of $2000/ha have been achieved with irrigated grain and grazed canola.
- A better understanding of the agronomy of winter canola and how it fits into the livestock program has been established and are critical to success.
- Further work needs to be undertaken on the issues which are currently barriers to adoption.

Background

Winter canola is increasing in popularity as a dual purpose crop – offering grazing opportunities followed by grain production. The 'winter' habit is due to the requirement from the crop of a period of cold (vernalisation) to initiate flowering. Access to rrrigation provides growers with the opportunity to sow early to provide biomass for grazing and then lock the crop up (i.e. remove livestock) for grain production. Unfortunately, the vernalisation requirement sees the currently available winter canola varieties flower later than the 'grain' types which is an issue for the Northern Victoria/Southern NSW irrigation regions as delayed flowering increases the risk of high temperature stress during flowering and grain fill, leading to poorer grain yields.

Some irrigators have tested winter canola crops and preliminary results suggest that rather than a true grain and graze crop, a significant portion of the gross margin returns are from the grazing value of the crop and the grain crop could be regarded as a bonus rather than the driver of profitability. This paper summarises a number of irrigators' experiences and poses questions for further adoption of winter canola in the irrigation region.

Method

Several growers across the western Murray Valley provided summaries of their agronomic practices, productivity and thoughts on their experience of growing irrigated winter canola (Table 1). Additional data was obtained from trials conducted by the Irrigated Cropping Council.

Results and discussion

Table 1 summarises the irrigators agronomic practices, productivity and experiences.

Paddock selection

It's important to match paddock size with the number of sheep to stop preferential grazing given a biomass of approximately 2t/ha.

Select a paddock that is preferably well drained with minimal weed seedbank (especially no broadleaf problems) and good soil structure that produces a fine seedbed. It is recommended that gypsum is applied at approximately 2.5t/ha, both as a source of sulphur and to aid plant establishment.

Variety selection

The 2018 Victorian Winter Crop Summary lists three long season winter canola varieties – SF

Table 1. Irrigator's data at a glance

Theme	Irrigator's information	Comments
Varieties	Edimaxx CL, Hyola® 970, Hyola® 971	
Sowing Date	Late February to mid-March	
Sowing Rate	2 – 5kg/ha	Aiming to achieve at least 40 plants/m^2, so rates varied with expected establishment given soil type, preparation and flood or overhead irrigation
Starter fertiliser	Approximately 100kg DAP/ha plus variable use of pre-sowing N fertilisers	Key is to supply adequate P. N rates have varied (20 – 55 kg N/ha) depending on soil N levels
Autumn water use	1 – 2.5ML/ha	This is seasonally dependant on rainfall and time of sowing
Grazing - starting date	Approx. 8-10 weeks after sowing	
Feed on offer	1.5 – 2.6t DM/ha	Earlier sowing tends to have higher DM
Grazing - end or lock up	Mid-June- Mid July	Set stocked paddocks are usually out of feed by this stage
Typical stocking rate	25-35 lambs/ha	
Supplemental feeding	Straw, hay and grain	Straw will be required. Hay and grain may not be necessary
Topdressing at lock up	75 – 100kg N/ha	
Spring water use	1.25 – 2.5ML/ha	
Flowering period	Mid-September to early October	
Windrowing/direct heading	Late October windrowing. Direct harvest can be delayed until late December.	Extended growth period depending on rainfall can result in green contamination. Large stem diameter can create issues.
Grain Yield	1.25 – 2.0t/ha	
Oil content	39 – 44%	

Brazzil (conventional), SF Edimax CL and Hyola® 970CL (the latter both Clearfield® varieties). The herbicide tolerant varieties (SF Edimax CL and Hyola® 970CL) offer greater opportunity to control in-crop weeds, particularly where Group A resistance problems already occur. In the authors' opinion, because of the extra season length and opening up of the canopy after grazing that is offered by the CL varieties that they should be the only varieties that are grown. Additionally, it would be a difficult task to achieve effective weed control with the conventional canola herbicide options.

The two Clearfield varieties are hybrids, meaning that any retained seed will not be true to type.

If contemplating summer sowing, a Clearfield® variety is essential.

Sowing rate

Sowing rates should be sufficient to establish at least 40 plants/m^2. The actual rate is reflected in the irrigators' data where those using overhead irrigation are using rates around 2kg/ha and up to 5kg/ha where watered up (Table 1). ICC trial data suggests that there is no extra dry matter produced from higher sowing rates but the individual plants are smaller which may be of benefit at windrowing/ harvest. Some loss of plant numbers can also be expected by grazing.

Sowing date

The irrigators surveyed for this paper all sowed in late February to early March. The general feeling was to wait for the drop in temperature that signals the start of pasture irrigation. This timing has a few other benefits; cooler temperatures allow the soil to stay moist for a longer period during germination and weeds such as ryegrass also start germinating which allows for an early kill. Generally, a knock down herbicide is required even if weed numbers seem small. Experienced operators on good layouts can successfully water the crop up, or alternatively sowing into moisture is fine, but attention must be paid to the correct sowing depth. Sowing at this date results in rapid growth and the crop is ready for grazing in approximately 8 to 10 weeks. This sowing date has seen the required autumn irrigation vary from 1.0 to 2.5ML/ha.

Winter canola growers in the southwest of Victoria are sowing in the preceding spring and are achieving good summer plant survival. Limited attempts have been made to do this in the irrigation zone and possibly this is because this system may not be as successful in the north as in the south. Lower success rate is due to less summer rain in the north compared with the south, and therefore, the crop would most likely have to be irrigated over the summer and produce little growth. The upside would be the existence of established plants that rapidly respond to irrigation in the autumn, and therefore, early production of feed. Where this system may have a place is where a summer rainfall event is large enough to allow germination and establishment of the canola to occur.

Fertiliser

The phosphorus (P) requirement of the crop needs to be applied at sowing, typically 100 to 120kg DAP or MAP/ha. Nitrogen (urea or sulphate of ammonia) has been used where the paddock N levels are low to encourage early growth. The danger is too much N early which results in high nitrate levels in the plant and subsequent health issues for the grazing stock, particularly young or pregnant stock.

Once stock are removed, the crop is top-dressed with 150 to 200kg urea/ha depending on the initial soil nitrate levels and the target yield.

Herbicides

If the crop is sown prior to autumn, it is highly likely that summer weeds will be an issue and the Clearfield® system offers the best opportunity for weed management. However, this does present an issue for subsequent weed control as applying a second Clearfield herbicide application is not permitted according to label recommendations. Care also needs to be taken to adhere to the labelled crop growth stage at application and the grazing withhold period for products registered for use in Clearfield canola production systems.

Group A herbicides are an option, but application only adds to the development of resistance in cropping paddocks. They should only be used early in the crop's development if grasses pose a competition risk to the canola. Some weeds present in the crop may be an advantage when stock are introduced as it gives the stock something to graze on that they are familiar with and allows the rumen to gradually adapt to the canola.

Generally, trifluralin cannot be used if watering up by flood irrigation, but can reduce grass problems under a pivot or lateral irrigation system.

Current best management systems employ an early autumn sowing, then use the Clearfield® system plus a grass selective, plus clopyralid after grazing.

Grazing

Sheep can be introduced when there is at least 1.5t DM/ha; i.e. when the crop is approximately 250mm in height.

The irrigators surveyed generally have introduced sheep approximately 8 to 10 weeks after sowing, with dry matter on offer being between 1.5 and 2.6t/ha, with the higher amounts being from earlier sowings. Sheep have been set-stocked, with the removal of stock determined by the lack of feed, generally around mid to late June. Stocking rates have been as high as 35 cross-bred lambs/ha, while others have started with ewes and lambs (40 head/ha) and tapered the stocking rate off as the lambs have matured and have been drafted off to market.

All irrigators report that they have used the same common-sense approach when introducing stock to any new feed; i.e. introduce the sheep when they are not hungry and slowly introduce them into the canola over a few days. Post this, they reported no palatability or health issues.

An advantage of having winter canola for grazing is that it takes the pressure off the pasture paddocks, allowing them to get away and have sufficient feed available once the canola is finished.

Theoretically, sheep could graze later in the season via rotational grazing, as the plant will not start to bolt until late August. This late grazing could potentially compromise grain yield as the crop must have time to recover biomass before flowering. But if the principal reason for growing winter canola is in the feed value, then reduced grain yield may not be such an issue.

Feed quality and supplemental feeding

Average feed quality data is presented in Table 2. This data is from six test results taken prior to sheep entering the paddock.

Table 2. Average feed quality (Dry matter basis).

Feed Component	Average	Range
Digestibility DOMD %	81.3	75-84
Metabolisable Energy MJ/kg	13.5	12.2-14.6
Crude Protein %	22.7	15-31
Acid Detergent Fibre %	16.6	11-22
Neutral Detergent Fibre %	26.6	24-32
Fat %	4.2	4-5
Ash %	8.5	6-13
Nitrate ppm	750	53-2200

While most results are in the upper range of what is regarded as quality feed, two components do stand out as potential issues. The level of neutral detergent fibre in many cases is lower than the recommended 30% (from 'A producer's guide to production feeding for lamb growth', MLA) which can be addressed by having a source of roughage available such as hay or straw. The nitrate level can be relatively high depending on soil N and applied fertiliser. The highest level was from canola planted into an old lucerne paddock with 100kg MAP/ha and 150kg Stimulus/ha, adding up to 55kg N/ha applied at sowing. The resulting nitrate level just prior to grazing of the crop was 2200ppm. According to information supplied by FeedTest, nitrate levels less than 1500ppm are regarded as safe, nitrate levels between 1500ppm and 4500ppm prompt a warning – 'CAUTION: Problems have occurred at this level. Mix, dilute, limit feed forages in this level'. This can also be addressed by having straw or hay on offer in the paddock. The set-stocking approach does make for challenging early N management as you want to make sure enough N is present to ensure high growth rates but not too much that creates nitrate issues, with little ability to change the N status in-crop unless stock are removed for at least 2 to 3 weeks post topdressing.

Irrigators surveyed for this paper have had supplemental feeds on offer, ranging from straw to barley grain and oaten hay. At this stage it is likely that the straw is required whereas the grain and hay components are more of an insurance system than a necessity.

Most irrigators surveyed have used mineral supplements of some kind. These supplements may act as a useful buffer when changing from one feed source to another.

Post grazing management

Once sheep are removed, the crop is top-dressed to regenerate plant biomass and subsequent yield. This is achieved with 150 to 200kg urea/ha. This is also the best window for herbicide application.

Spring water use has ranged from 1.25ML/ha to 2.5ML/ha. This water use is typically higher due to the late maturity of the winter canola. On average two flood irrigations in the spring have been necessary.

Flowering date is delayed due to the winter habit and the plant requiring a certain period of cold temperature to change from vegetative to reproductive growth. Consequently, flowering date is not altered significantly by sowing date. This results in the flowering period being delayed when compared to canola crops grown for grain. Irrigators surveyed recorded flowering dates from mid-September to early October. In the 2013 ICC canola variety trial, Hyola 971 began flowering six weeks later than the rest of the trial. This late flowering increases the risk of heat stress during flowering (prematurely ending flowering therefore limiting yield) or grain fill (lower yield through smaller grain).

Windrowing, harvest and yields

Of those surveyed, crops have been both windrowed and direct headed for harvest. In one respondent's opinion, windrowing was essential as he had green material in the sample due to one variety continuing to grow as long as there was moisture. He also had issues with the header cutter bar and stem thickness (referred to as tree trunks) when direct harvesting.

Harvest has been generally in the mid to late December period. Yields ranged from 1.25t/ha (43% oil) to 2.0t/ha (39% oil). It should be noted that these same farmers have grown mid-season irrigated canola varieties on the same areas in other years and achieved yields in the 3.0 to 3.8t/ha range.

Gross margins

Table 4 indicates the gross margin for a grain and graze scenario using a winter canola. One major component that needs to be included in the gross margin is the cost of the livestock that are used for grazing. This will range from a low value (if the lambs would have been produced anyway and the canola is regarded as supplemental feed) to the cost of buying stores at market specifically for grazing. The scenario will vary from grower to grower; and therefore, it's necessary for growers to use their own figures when calculating gross margins. Another aspect not included, and difficult to put a figure on, is the extra pasture growth obtained by having stock on the canola rather than grazing the pasture.

Further issues

Clearly these are early days when it comes to establishing best management practice for grazing of canola and a number of questions still need to be answered:

- Rotational versus set-stocking. Would rotational grazing, allowing recovery periods and opportunities to top-dress between each grazing event, result in higher dry matter grown?
- Varieties need to be more suited for the north of the state and its higher autumn and spring temperatures. Maybe the answer is

Table 3. Gross margin for the production of canola grain only.

CANOLA		3.5	t/ha				
Price	$ 550					$ 1,925	
		number		cost $		cost $/ha	
Pre-sowing	spray	1	operation	15	/ha	15	
	cultivation	1	operation	25	/ha	25	
	water up	1.5	Ml/ha	125	/Ml	187.5	
Sowing	machinery	1	operation	43	/ha	43	
	fertiliser	125	kg/ha	700	/tonne	87.5	
	seed	3	kg/ha	25000	/tonne	75	
Post sowing	herbicide	1	operation	28	/ha	28	
	fungicide	0	sprays	5		0	
	insecticide	0	sprays	15		0	
	topdress	250	kg/ha	600	/tonne	150	
	irrigation	2	Ml/ha	200	/Ml	400	
Harvest	windrow	0	operation	30	/ha	0	
	mow/rake/bale	0	operation	92	/ha	0	
	header	1	operation	70	/ha	70	
			Total Variable Cost			$ 1,081.00	/ha
			Variable Cost - water			$ 493.50	/ha
				Gross Margin		$ 844	/ha
						$ 241	/Ml

Table 4. Gross margin for the production of canola grazing and grain.

CANOLA WINTER							
Grazing		35	lambs/ha				
		42	days				
		280	g/day weight gain				
		$6.70	/kg			$ 2,758	
Canola Grain		2.0					
Price	$ 550					$ 1,100	
						$ 3,858	
		number		cost $		cost $/ha	
Livestock	Lambs	35	head	?	/hd	??	
Pre-sowing	spray	1	operation	15	/ha	15	
	cultivation	1	operation	25	/ha	25	
	water up	1.5	Ml/ha	125	/Ml	187.5	
Sowing	machinery	1	operation	43	/ha	43	
	fertiliser	125	kg/ha	700	/tonne	87.5	
		100	kg/ha	600		60	
	seed	3	kg/ha	25000	/tonne	75	
Post sowing	herbicide	1	operations	28	/ha	28	
	fungicide	0	sprays	5		0	
	insecticide	0	sprays	15		0	
	topdress	200	kg/ha	600	/tonne	120	
	irrigation	2	Ml/ha	200	/Ml	400	
Harvest	windrow	1	operation	45	/ha	45	
	mow/rake/bale	0	operation	92	/ha	0	
	header	1	operation	70	/ha	70	
			Total Variable Cost			$ 1,156	/ha
			Variable Cost - water			$ 569	/ha
				Gross Margin		$ 2,702	/ha
						$ 772	/Ml

a 'Wedgetail' type canola variety that has a reduced cold temperature requirement, and therefore, flowers earlier.

- Other herbicide tolerance options, but not triazine tolerant (TT) as the vigour and yield penalty of these varieties, along with the herbicides options for watering up aren't a good fit. However, a Roundup Ready variety of appropriate season length and a two spray option could help.

Conclusion

At current livestock prices, financial returns are possible based on the grazing value of the canola alone, and grain is the secondary commodity but still important.

Start early but not too early, aim for the autumn temperature drop off point.

If an opportunity to establish plants before autumn arises, then seriously consider it.

A true graze and grain variety for the Murray Valley is not quite here yet.

Use best management grazing practices when shifting from one feed source to another.

Useful resources

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/07/winter-canola-for-grazing-and-grain-production

How pasture characteristics influence sheep production. NSW DPI Primefact 530

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Herbicide resistance update – North East Victoria and southern NSW

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GRDC project codes: UCS00020, UA00158

Keywords

- random weed surveys, multiple tactics, resistance testing.

Take home messages

- Herbicide resistance in ryegrass, wild oats, brome and sowthistle has been confirmed in southern NSW and northern Victorian random weed surveys.
- A multiple tactic approach is required to combat resistance including seed set control and seed capture techniques.
- Resistance testing identifies effective herbicide opportunities.
- Over relying on Group J and K herbicides for ryegrass control increases selection for resistance.

Resistance to pre-emergent herbicides.

Shifts in resistance of major weed species have been monitored since 2005 across southern Australia via random weed surveys. These surveys are funded by GRDC and have been conducted annually since 2005 by the University of Adelaide, Charles Sturt University and the University of Western Australia. The methodology involves collecting weed seeds from paddocks chosen randomly at pre-determined distances prior to harvest. Weed seeds are tested in pot trials the following growing season. In northern Victoria and southern NSW, annual ryegrass resistance to in-crop selective post-emergence Group A and B herbicides continues to increase (Table 1). However, resistance to Group D and J herbicides was lower than in most other survey regions in NSW, Victoria and SA. The use of diverse cropping rotations and strategies such as hay production and grazing are contributing factors.

Table 1. Incidence of herbicide resistance in southern NSW* and northern Victoria# in annual ryegrass identified in GRDC random weed surveys. Paddocks were scored as resistant if the seeds collected exhibited >10%-20% survival in a pot test conducted the following season.
*Data courtesy of John Broster, CSU; #Data courtesy of P. Boutsalis, University of Adelaide.

Herbicide	S-NSW	N-Vic	N-Vic	N-Vic
group	2013 & 2016	2006	2011	2016
A ‘fop’	79	40	55	72
A ‘den’	20	34	31	60
A ‘dim’	20	5	8	4
B ‘SU’	78	43	71	74
B ‘Imi’	56	-	29	51
D	21	2	0	0
J	0	-	-	2
K	0	-	-	0
M	0	-	-	3

Resistance has also been confirmed in other weed species in northern Victoria and southern NSW such as wild oats and sowthistle (Table 2). In wild oats resistance is restricted to the Group A herbicides and in sowthistle to the Group B herbicides. No resistance in wild radish or brome has been detected in the random weed surveys, even though resistance has been confirmed by commercial testing.

Table 2. Incidence of herbicide resistance in northern Victoria and southern NSW identified in GRDC-funded random weed surveys. Results determined by pot trials the following autumn.

Species	Herbicide	S-NSW	N-Victoria
Wild Oats	Group A Fop	36%	9%
	Group A Dim	0%	0%
	Axial®/Achieve®	18%	0%
	Sulfonylurea	0%	0%
	Group J	0%	0%
Brome	A/B/M	-	0%
Wild Radish	B/C/F/I/M	0%	-
Sowthistle	Sulfonylurea	51%	72%
	Imidazolinone	0%	63%

- no weeds detected in that survey.

Wild oats

Resistance in wild oats remains relatively low in southern Australia compared to northern NSW. However, due to limited alternative herbicide options, resistance to Group A herbicides can restrict cropping options. Differences in efficacy between Group A herbicides in controlling Group A resistant wild oats occur. Resistance to the Fops herbicides used in cereal crops can often be controlled with Fops only used in broadleaf crops. Additionally, differences in efficacy between Fops, Dims and Axial® can occur in Group A resistant wild oats. Resistance testing can help identify the effectiveness of individual Group A herbicides. Although Group B herbicides were effective in both survey regions, resistance to sulfonylureas and sulfonamides has been detected in other regions. Relying on one mode of action increases the chance of resistance.

Brome

Brome is a competitive species with limited control options in cereals particularly since its peak germination occurs after sowing (low temperature vernalisation requirement) and after the seed has been buried (dark requirement). Pre-emergent herbicides therefore, provide limited brome control. The most effective herbicides for brome control are the imidazolinone herbicides in Clearfield® crops and Group A Fop herbicides in broadleaf crops. Various Group B sulfonylurea and sulfonamide herbicides are only registered in wheat. Further increases in resistance in brome is therefore a concern due to the limited herbicides available.

Sowthistle

Once a weed of predominantly northern zones, sowthistle has spread to most cropping regions. It germinates all year-round if moisture is present and is quite drought tolerant as plants mature. A single plant can produce over 10,000 seeds that can germinate immediately under favourable growing conditions. The high incidence of resistance to Group B herbicides including imidazolinones complicates control in Clearfield® crops also. Additionally, biotypes resistant to glyphosate and Group I herbicides have been identified in nearby regions.

Resistance to pre-emergence herbicides

No resistance to Group K herbicides and limited resistance to Group D and J pre-emergence herbicides has been detected in southern NSW and northern Victoria. In other survey regions, such as the Wimmera and most SA cropping regions where continuous cropping is more common, the incidence of resistance to these pre-emergent herbicides is significantly greater.

Resistance occurs when individuals survive post herbicide application and set seed. Many tactics exist to control weeds and reduce the onset of herbicide resistance. These tactics include use of knockdown herbicides, pre-emergence herbicides (new mode of action pre-emergence herbicides are in development), selective post-emergence herbicides, seed set control and weed seed destruction. Increased adoption of these strategies will reduce herbicide resistance. During random weed surveys, the density of ryegrass and other species encountered was generally low. Seed is collected from these plants and tested for resistance in pot trials. In some cases, the plants present at the end of the season are the ones that drive resistance further. If the density of weeds late in the season is low, late season tactics can be overlooked. However, the adoption of late seed-set control or weed seed destruction techniques can eliminate surviving herbicide resistant individuals and reduce herbicide resistance. A comprehensive list of these techniques can be found at the following site: (https://www.youtube.com/redirect?q=https%3A%2F%2Fahri.uwa.edu.au%2Fspoiled-rotten-the-sequel%2F&v=oAG-

FaF2gwt8&redir_token=CXZsfGQuBByWyJ6DUgO-jt_DodGh8MTUzMDU3NTI3M0AxNTMwNDg4OD-cz&event=video_description)

Benefits of herbicide resistance testing

Establishing a baseline of herbicide resistance can help maximise weed control. What the random weed surveys highlight is that there are many opportunities to use older chemistry effectively where resistance is not present. This can result in a significant cost saving. In the latest surveys in northern Victoria and southern NSW, resistance to Axial® was detected in 60% and 20% of the ryegrass populations collected, respectively. Therefore, in 40% and 80% of cases, respectively, Axial® would be effective. Directed resistance testing can identify opportunities to use effective herbicides. This involves growers sending seed prior to harvest, or plants growing in the paddock during the growing season to enable a herbicide resistance Quick-Test to be conducted (www.plantscienceconsulting.com.au).

Some growers find it convenient to assume they have resistance to the older chemistry without ever having it tested. Our testing has shown there are often differences within a single mode of action group. For example, ryegrass resistant to chlorsulfuron is not always resistant to Hussar®. Similarly, ryegrass resistant to haloxyfop is not always resistant to Axial®. Wild oats can be resistant to Axial® and Achieve® but not haloxyfop. There are also cases where ryegrass has been identified as resistant to sulfonylurea herbicides and cross-resistant to imidazolinone herbicides without prior exposure to the latter chemical group. Less resistance exists to the newer products, such as Arcade®, Sakura, Boxer Gold® and Butisan®. Not only are these products often more expensive, but weed populations are unnecessarily being exposed to strong selection pressure. Resistance to Group J herbicides has already been confirmed in ryegrass biotypes with resistance to other chemistries under investigation.

Herbicide resistance testing can identify situations when a herbicide failure was not due to resistance. Some of these factors can be rectified, such as improving spray techniques. Ensuring optimum coverage and sowing speed is essential to maximise placement of pre-emergence herbicide in the close proximity to weed seeds. To maximise coverage and herbicide performance, it is important to spray during ideal weather conditions with the correct nozzles, speed, water volume, water quality and herbicide quality. With literally thousands of herbicide products available today (for example for glyphosate alone there are approximately 500 registered products) certain cheaper formulations can also result in reduced control. Herbicide efficacy can also be reduced under certain adverse environmental conditions (for example, drought, frost and temperature extremes) that cause weeds to stress. Processes such as uptake, translocation and metabolism of herbicides can be disrupted thereby reducing weed efficacy.

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Notes

Irrigated pulse trials

Damian Jones.

Irrigated Cropping Council.

ΦExtra technical comment by Protech Consulting Pty Ltd

GRDC project code: ICF00011

Keywords

- irrigation, pulses, layout.

Take home messages

- Drainage was the key to a successful trial.
- In 2017, pre-irrigation alone provided sufficient moisture to grow the crop successfully.
- In2017, the addition of spring irrigations did not translate to improved yield or grain quality.
- In 2017 there was low disease pressure.
- Irrigated lentils and chickpeas could be quite profitable, assuming that the 2017 harvest prices are maintained.

Background

Growing irrigated chickpeas and lentils has potential financial rewards but their reputation for susceptibility to waterlogging and disease may make them a risky proposition. However, advances in irrigation technology and infrastructure may have reduced some of that risk. The Irrigated Cropping Council is attempting to test their performance with trials that have a combination of irrigation technologies, irrigation and fungicide strategies and variety evaluation.

Method

Trials consisting of four varieties of lentils and four varieties of chickpeas were sown at three locations – ICC Trial Block Kerang, (border check), Dhuragoon (near Moulamein, NSW, overhead spray) and Appin (subsurface drip 'on the flat'). All sites were grey clays (vertosols) and each site had a combination of irrigation and fungicide strategies. Growing season rainfall at trial sites was 220mm (Figure 1).

Overlaid on each site were two fungicide strategies – strategic (applied only when disease pressure is expected to be high such as pre-irrigation or a rainfall event) or regular application every three weeks.

Results and discussion

Border-check trial

The border-check trial was sown on 16 May following pre-irrigation (1.8ML/ha) on 8 April 2017. Terbyne Xtreme (1.0kg/ha) + Glyphosate (1.5 L/ha) + Goal (75 ml/ha) was used as a pre-emergent treatment. Thirty millimetres of rain fell shortly afterwards but did not affect establishment.

The fungicide program started on 21 July, with 1.5 kg/ha Mancozeb applied to all plots.

The '3 week' treatments then occurred on 11 August, 31 August, 13 September, 29 September and 10 October using Chlorothalonil at 1.5L/ha – a total of six fungicide applications for the season.

The 'strategic' treatment was sprayed on 21 July, 31 August (onset of rain), 13 September (irrigation) and 10 October (onset of rain).

No disease was detected in any plots during the season.

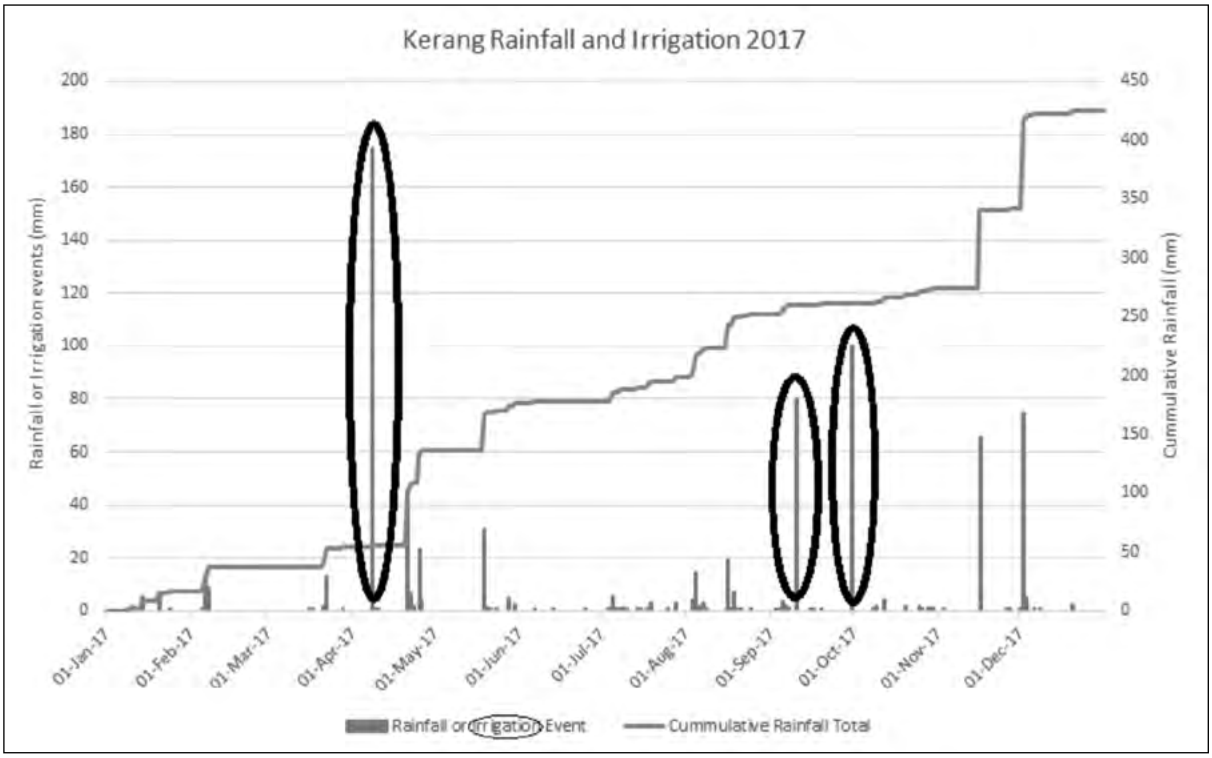

Figure 1. Rainfall and irrigation (latter circled) at the trial sites during 2017.

Table 1. Irrigated pulse trial irrigation infrastructure and strategy.

	Irrigation Strategy		
Layout	Pre-irrigation Only	Pre-irrigation + spring to flowering	Full Irrigation
Border check (1:800 fall)	✓	✓	✓
Overhead Sprays		✓	✓
Subsurface drip		✓	✓

Table 2. Varieties tested, target population (plants/m^2) and sowing rate (kg/ha) at each site.

	Variety	Target pop'n	Sowing Rate
Lentils	PBA Bolt⍉	120	66
	PBA Jumbo2⍉	120	82
	PBA Giant⍉	100	94
	PBA Hurricane XT⍉	120	53
Kabuli Chickpeas	Genesis™ 090	35	159
	Almaz⍉	35	206
Desi Chickpeas	Boundary⍉	45	135
	Slasher⍉	45	194

The first spring irrigation (0.8ML/ha) occurred on 13 September in response to soil moisture probe data. At this stage, the first flowers were starting to appear on the lentils and chickpeas. The second spring irrigation (1.0ML/ha) occurred on 30 September.

The 'pre-irrigation only' treatment appeared quite dry in mid-September, with cracks starting to open up. However, the plants remained quite green until well into October.

After the first spring irrigation, which took nine hours at 6ML/day, there appeared to be little waterlogging damage to the plots.

The second spring irrigation ('Full Irrigation' treatment, 1.0 ML/ha) took six hours and resulted in some areas of yellowing plants, but the overall impression was that there was minimal damage.

Plots in the 'pre-irrigation only' trial began to hay off in late October, while the irrigated trials remained green.

Table 3. Border check grain yields (t/ha) for chickpea and lentil with different irrigation strategy.

Chickpeas	Full Irrigation	To Flowering	Pre-irrigation only
Almazⓓ	3.20	3.72	3.45
Boundaryⓓ	3.82	3.12	3.05
Gen™ 090	3.19	3.37	3.46
Slasherⓓ	3.45	3.58	3.49
p (variety)	0.327		
p (irrigation)	0.686		
Lsd	Not Significant		
cv%	10.2		
Lentils	**Full Irrigation**	**To Flowering**	**Pre-irrigation only**
Boltⓓ	3.42	3.88	3.39
Giantⓓ	2.41	2.60	2.76
Hurricane XTⓓ	3.72	3.57	3.92
Jumbo2ⓓ	3.48	3.19	3.24
p (variety)	<0.001		
p (irrigation)	0.893		
Lsd (variety)	0.615		
Lsd (irrigation)	Not significant		
cv%	16.2		

Table 4. Average seed size (g/100 seeds) for chickpea and lentil with different irrigation strategy.

Chickpeas	Almazⓓ	Boundaryⓓ	Gen™ 090	Slasherⓓ
Pre only	41.4	18.2	30.2	29.4
To flowering	38.4	18.1	30.3	30.6
Full Spring	36.0	17.5	29.0	29.8
Lentils	**Boltⓓ**	**Giantⓓ**	**HurricaneXTⓓ**	**Jumbo2ⓓ**
Pre only	4.3	6.5	3.2	4.4
To Flowering	4.2	6.5	3.3	4.3
Full spring	4.2	6.3	3.3	4.3

Table 5. Gross margins for irrigated pulses on a pre-irrigation only or one spring irrigation strategy.

Pulse	Type	Spring Irrigation ML/ha	Ave Yld t/ha	$/ha	$/ML
Chickpea	Kabuli	0	3.36	1957	1087
Chickpea	Kabuli	0.8	3.43	1933	743
Chickpea	Desi	0	3.07	1168	649
Chickpea	Desi	0.8	3.35	1258	484
Lentil	Red	0	3.53	1349	750
Lentil	Red	0.8	3.59	1304	501
Lentil	Green	0	2.76	1188	660
Lentil	Green	0.8	2.60	1004	386

Harvest occurred on 14 December 2017.

Results

Yield and grain quality

Yield data and grain quality for chickpeas and lentils is presented in Table 3. The fungicide strategy made no difference to either chickpea (p = 0.43) or lentil (p = 0.34) yields.

Seed size

Fungicide strategy made no significant difference to seed size (Table 4).

Gross margin

Table 5 summarises the gross margins for the irrigated pulses using the assumptions:

- Prices: Kabuli $800/t, Desi $600/t, Red Lentils $550/t, Green Lentils $650/t
- Water cost $100/ML
- Autumn pre-irrigation used 1.8 ML/ha
- Four fungicide applications

An excel-based Gross Margin calculator is available from ICC if you wish to calculate the gross margins of the irrigated pulses using your own scenario.

What does it mean?

Results indicate that irrigation was not detrimental to the performance of the pulses, however yield was not significantly improved by any spring irrigation. Bear in mind the soil profile was almost full at the end of August 2017. If this moisture reserve had not been in place, a yield response to spring irrigation may have been seen.

Seed size was not negatively affected by lack of spring irrigation, and in many cases, lack of irrigation resulted in small improvements in seed size.

2017 was a low disease pressure season which most likely contributed to the observation of little benefit from the more frequent fungicide strategy.

Gross margins (GM) can rapidly change with variations in price and yield. A GM calculator, be it a simple spreadsheet or a more comprehensive example like the Correct Crop Sequencing Decision Support Tool (https://www.dpi.nsw.gov.au/agriculture/budgets/costs/cost-calculators/correct-crop-sequencing-decision-support-tool) which can 'price in' commodity or water price fluctuations, can help irrigators test the viability of growing any irrigated crop.

Overhead sprays

An overhead spray trial similar to that conducted at the Trial Block (i.e. border-check trial) was sown on 1 June. Sowing was delayed due to the site being too wet following pre-irrigation (approximately 0.7ML/ha) and rain in mid-May.

Initial grass control was poor from using 500ml/ha clethodim on 21 July. Following confirmation of the poor result, a second attempt was made on 18 August using butroxydim at 180g/ha. Only partial control was achieved and the trial suffered from high ryegrass numbers.

The fungicide program started on 21 July 2017, with 1.5kg/ha Mancozeb applied to all plots.

The '3 week' treatments then occurred on 9 August, 31 August, 19 September, 29 September and 10 October using Chlorothalonil at 1.5L/ha – a total of six fungicide applications for the season.

The 'strategic' treatment commenced on 21 July, with further applications on 31 August (onset of rain), 29 September (irrigation) and 10 October (onset of rain) – a total of four applications.

No disease was detected in any plots during the season.

Irrigation began in late August and the last 'to flowering' irrigation occurred on 29 September, with spring irrigation totally approximately 1.0ML/ha. The 'Full' treatment received an extra two irrigations or approximately 0.8ML/ha.

Areas of poor drainage became apparent in early September, with yellowing of the plants and reduced vigour.

The trial was harvested 15 December.

Results

Yield

Results indicated that the irrigation strategy did not affect the yield of either chickpea (p = 0.83) or lentil (p = 0.31).

Table 6 incorporates data from both the 'up to flowering' and 'full' irrigation treatments. Fungicide strategy did not have any effect on yields. Caution needs to be taken when making any conclusions from this data as yield data was highlyvariable (high cv% value).

Seed size

Neither irrigation nor fungicide strategy made any difference to seed size (Table 7).

What does it mean?

In summary, the results indicate that drainage is king. Despite smaller and more frequent irrigations, plant damage (yellowing and poor vigour) and death was much higher when compared to the border check trial due to the flat nature of the site.

Ryegrass competition was a factor in the poorer and variable plot yields.

2017 was a low disease pressure season which most likely contributed to the observation of little benefit from the more frequent fungicide strategy.

Sub-surface drip irrigation

The sub-surface drip irrigation trial was sown on 17 May 2017 following pre-irrigation (approximately 1.5ML/ha).

Terbyne Xtreme (1.0kg/ha) + Trifluralin (1.0L/haΦ) + Glyphosate (1.5L/ha) was used pre-sowing.

ΦRate listed is below the minimum label rate of 1.25L/ha. In commercial situations, label recommendations must be adhered to.

Establishment was below expectations at the site due to 30mm of rain that fell shortly after sowing, which resulted in waterlogged conditions, and then predation by mice. The chickpeas were especially targeted by the mice, which resulted in one replicate of the trial being resown on 19 June.

The fungicide program started on 20 July, with 1.5kg/ha Mancozeb applied to all plots.

The '3 week treatments then occurred on 11 August, 1 September, 22 September and 10 October using Chlorothalonil at 1.5L/ha – a total of five fungicide applications for the season.

The 'strategic' treatment was sprayed on 21 July, 1 September (onset of rain) and 10 October (onset of rain) for a total of three applications.

No disease was detected in any plots during the season.

The first spring irrigation occurred on 22 September, with the first flowers starting to appear. The soil became quite wet and although no water broke out on the surface the soil remained quite wet for several days.

After the first spring irrigation (approximately 1.0ML/ha), individual plants began to yellow and progressively die. The green lentils appeared

Table 6. Overhead grain yields (t/ha) from the fungicide strategies

Chickpeas	3 week	Strategic
Almaz⦻	1.87	1.62
Boundary⦻	2.43	2.07
Gen™ 090	2.14	1.74
Slasher⦻	1.92	1.74
p (variety)	0.172	
p (fungicide)	0.083	
Lsd	Not Significant	
cv%	23	
Lentils	3 week	Strategic
Bolt⦻	2.40	2.18
Giant⦻	1.90	1.62
Hurricane XT⦻	2.64	1.85
Jumbo2⦻	1.98	2.00
p (variety)	0.260	
p (fungicide)	0.141	
Lsd	Not significant	
cv%	27	

Table 7. Average seed size (g/100 seeds) for chickpea and lentil varieties.

Chickpeas	Almaz⦻	Boundary⦻	Gen™ 090	Slasher⦻
g/100 seeds	36.3	16.6	29.0	28.3
Lentils	Bolt⦻	Giant⦻	Hurricane XT⦻	Jumbo2⦻
g/100 seeds	4.2	6.6	3.4	4.7

Table 8. Grain yields (t/ha) and seed size (g/100 seeds) for chickpea and lentil varieties.		
Chickpeas	Grain yield	Seed size
Almaz⊕	1.43	29.9
Boundary⊕	1.17	15.7
Gen™ 090	1.41	24.7
Slasher⊕	1.26	24.1
p	0.81	<0.001
Lsd	Not Significant	2.584
cv%	33	6.6
Lentils	Grain Yield	Seed size
Bolt⊕	2.17	4.2
Giant⊕	-	-
Hurricane XT⊕	2.10	3.4
Jumbo2⊕	2.30	4.6
p	0.86	0.002
Lsd	Not significant	0.387
cv%	24	4.8

to be most susceptible to the irrigation induced waterlogging. Plots with low establishment appeared to fare worse.

Harvest occurred on 6 December.

Results

The following results presented in Table 8 should be viewed with caution as the data was quite variable. Plots ranged from very few plants to reasonably well vegetated plots with random bare patches. Data from all irrigation and fungicide treatments has been consolidated into one data set.

Yield and seed size

What does it mean?

In summary, the results indicate that drainage is king. The trial was sown onto 'the flat' rather than on beds. Prolonged waterlogging post-sowing and post-spring irrigation, saw poorer establishment and increased plant damage compared with the other trials. Poorly established plots appeared to suffer from higher plant death in spring which may be due to the lack of plants (i.e. poor establishment) and the subsequent low water use, which extended the period of waterlogging. Raised beds would have improved drainage and plant establishment, survival and vigour, and consequently crop yields.

The beneficial value of the fungicide treatments was compromised by the variable establishment of the plots.

Irrigation seemed to be detrimental, particularly to the green lentil variety, GiantA, with very few plots harvestable.

Conclusion

Drainage is king. Even though irrigation volumes were smaller and/or application duration was shorter in the overhead and subsurface drip systems, the key for success was drainage post irrigation or rainfall event. The flat layouts of the overhead and subsurface drip irrigation did not facilitate drainage and subsequently the pulses suffered waterlogging, resulting in poorer growth and plant survival.

If drainage is adequate, either by slope, soil texture or beds, then there is potential for chickpeas and lentils to be a profitable irrigated pulse crop.

The results from 2017 suggest spring irrigation at any stage did not improve yield or grain size. 2017 experienced well-above average rainfall in August, resulting in an almost full soil moisture profile coming into September. Without this soil moisture buffer, a different result may have been achieved from the 'pre-irrigation only' treatments.

Disease management will be crucial to achieving high yields.

Useful resources

Correct Crop Sequencing Decision Support Tool https://www.dpi.nsw.gov.au/agriculture/budgets/costs/cost-calculators/correct-crop-sequencing-decision-support-tool

ICC Trial Summary 2017

On Farm Trials website (www.farmtrials.com.au)

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Notes

Poor performance of preinoculated pasture seed

John Fowler.

Murray Local Land Services, Deniliquin..

Keywords

- rhizobia, inoculation

Take home messages

- The rhizobia strain in root nodules can now be identified by DNA test.
- A survey of 20 irrigated pastures in the NSW Murray Valley indicated an 80% failure rate of preinoculation.
- The main problem appears to be storing seed too long after preinoculating.
- 'Old' seed needs an additional inoculation treatment.

Background

Annual pastures, primarily subterranean clover, were common on irrigated mixed farming properties in the NSW Murray Valley throughout the second half of the 20th century. These pastures however did not survive the millennium drought and were basically absent from the region by 2009. With the return of reasonable water allocations in 2010, some landholders began to re-establish annual pastures into their system. The majority of these new pastures were originally sown with preinoculated seed.

The rhizobia strain present in all Group C inoculants since 2005 is code named WSM1325. This replaced the former Group C inoculant rhizobia strain (code name WSM409) due to its superior performance. All annual clover pastures sown since 2005 should therefore be nodulated with the current Group C strain (WSM1325).

A survey was conducted in spring 2017 of 20 irrigated annual pastures in the Berrigan, Finley, Deniliquin and Bunnaloo areas. This was a small part of a wider survey conducted on dryland pastures in the eastern half of the Murray Local Land Services region and in the Riverina Local Land Services region.

The survey included extensive background information on the age of the pasture, inoculation method used, herbicide usage, insecticide usage and fertiliser practices. At each site a soil test was taken and the pasture was sampled to determine nodulation health and the rhizobia strain(s) present in the root nodules. This paper will only report on the findings of the rhizobia strain testing.

Method

At each site, four pasture sods were dug up and the soil washed from the roots. The nodulation was assessed against a standard chart and an average 'score' was determined. The roots were cut, padded dry and sent to the MALID ID laboratory in Perth to determine the rhizobia strain present.

Pastures established since 2005, which were originally sown with preinoculated seed, were analysed to determine the success of this inoculation technique. The test could determine if the rhizobia present was the current Group C strain or one of the old Group C strains or another strain altogether.

Results and discussion

The results of the paddocks sown with preinoculated seed are shown in Table 1.

Table 1. Rhizobia strain present in the root nodules of the sampled plants. Samples taken from paddocks sown with preinoculated seed.

Rhizobia strain present	Proportion of roots
Current Group C	18%
Old Group C	45%
Other strains	37%

The results showed that that preinoculated seed failed in over 80% of cases in our surveyed paddocks (Table 1) which was an extremely disappointing result. It should be noted however that only 20 pastures were sampled and a larger sample would be needed to more accurately indicate the success rate of the technique.

This result, while disappointing, was not unexpected. The GRDC report 'Inoculating Legumes: A Practical Guide', published in 2012, reports on surveys of inoculant quality (rhizobial numbers) of preinoculated seed sampled at the point of sale. This report indicated that only 32% of preinoculated subterranean clover seed had adequate viable rhizobia at point of sale (i.e. a 68% failure rate). It also reported that no seed had adequate rhizobia numbers 50 days after preinoculation.

If seed purchased is then stored on-farm for some weeks before sowing, the number of viable rhizobia would further decline. Therefore, our results of an 82% failure rate in the field are not inconsistent with the survey that showed a 68% failure rate at the point of sale.

It appears that the main problem is that landholders are not ensuring that they sow the seed within six weeks of the date of preinoculation.

Irrigated pastures present an additional challenge to successful inoculation because the seed is commonly sown into dry soil and the seed may sit there for several days before it is irrigated. This means that seed inoculated on-farm at point of sowing with peat based inoculum will also be ineffective as this rhizobia will only survive in adequate numbers for a day when in dry conditions.

Irrigators attempting to inoculate any bare or out-of-date preinoculated seed need to consider how to do so effectively. Sowing peat inoculated seed will only be effective if it is sown into moist soil. If sowing into dry soil which will later be irrigated, a more suitable inoculation method, such as a clay based granule, needs to be used.

Conclusion

The use of preinoculated seed for establishing subterranean clover pastures has become widespread. In fact, most of the newly released varieties are not available as bare seed. While it is a very convenient method to use, it has not proven itself to be a very successful method.

The success of the technique relies on the use of freshly preinoculated seed. Growers are advised not to rely on preinoculation if the seed is sown more than six weeks after the inoculation date (which is usually written on the bag or the seed label). Older seed should have an additional inoculum source, such as being sown with a clay based granule.

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Notes

Efficient use of nitrogen fertiliser in Riverina irrigated cropping – could mid-row banding help?

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GRDC project code: 9175353

Keywords

- nitrogen fertiliser, banding, irrigation, cropping, Riverina.

Take home messages

- Placing fertiliser into a concentrated mid-row band at sowing can offer a low risk alternative for meeting crop nitrogen (N) requirements.
- Losses via volatilisation, leaching and denitrification will potentially be minimised as urea will be preserved in the ammonium form which is not vulnerable to these losses.
- A large proportion of the mid-row banded N was preserved as ammonium until 91 days after sowing (DAS), successfully preserving N through the waterlogging event, even though almost all nitrate was denitrified.
- When waterlogged, mid-row banded N achieved similar grain yield, grain N and apparent nitrogen recovery efficiency (ANRE) as topdressing after the waterlogging event, but less than a particularly efficient topdressing that occurred before the water-logging event. When dry, the treatment effect was the same.

Background

Irrigated winter crops in the Riverina need a substantial nitrogen (N) supply for high, water productive yields. A 5t/ha wheat crop needs a supply of 240kg N/ha. For continuous cropping systems, often more than 150kg N/ha of that must come from fertiliser nitrogen (N).

In wet winters the saturated soil profile of a pre-watered or rice stubble crop increases the risk of prolonged periods of waterlogging in winter from relatively modest rainfall events. When N is in the nitrate form it can quickly be leached below the root zone or denitrified as nitrous oxide gas, resulting in a large loss of fertiliser N (Zerulla et al., 2001). Denitrification is particularly a risk on clay soils in the Riverina, where soil internal drainage rates are low. As such, waterlogging will be a strong focus of this trial.

Placing fertiliser into a concentrated mid-row band at sowing can offer a low risk alternative for meeting the crops N requirements. Much of the N can be preserved in the ammonium form, as nitrification is inhibited when ammonium concentration reaches 3000ppm or when the soil pH >8 (Wetselaar et al., 1973). Angus et al. (2014) found that high concentrations of banded N were toxic to microbes responsible for nitrification. Brar (2013) recorded that banding also resulted in a corresponding increase in soil pH, further inhibiting nitrification. As a result, banding should provide a slow-release of N throughout the growing season. Losses via volatilisation, leaching and denitrification will potentially be minimised as urea will be preserved in the ammonium form which is not vulnerable to these losses. In addition, roots have been shown to enclose the band of fertiliser, making them well-placed to intercept mobile nitrate once it becomes available (Wetselaar et al., 1972; Angus et al., 2014; Sandral et al., 2017).

Method

The trial was conducted in a rice bay that was cropped with a 5t/ha barley crop in 2016, but not pre-watered. Wheat (var. Mace(b)) was sown on the 16 of May at 85kg/ha to a depth of 3 to 5cm, with 150kg/ha MAP + 1.0% Zinc. A Bettinson disc drill was used with 18cm row spacings. Every third row was blocked to seed and MAP, and only urea was placed in this row (at about 7cm depth) for the 104N mid-row banding (MRB) and 150N MRB treatments. No fertiliser was placed in the mid-row band for the other treatments.

The early topdressing treatment was applied at GS31 on the 28 July, immediately prior to the waterlogging treatments were applied on the 29 July. The late topdressing treatment was applied between GS32-33 on the 16 of August prior to a small rainfall event.

The site was not pre-watered. Levees were constructed after sowing, to exclude water from the 'Dry' plots during the winter waterlogging event. Waterlogged treatments were irrigated for 10 days. Two spring irrigations occurred on the 19 September and 20 October to set up the crop for the nominated yield potential of 5t/ha.

A split plot design was used, with waterlogging treatments in the main plots and N treatments in the sub-plots. There were four replicates. Each plot was approximately 40m long and 8m wide.

Results

Yields of all treatments were modest, driven primarily by a small number of grains per head. This is not surprising, as neither the dry nor wet irrigation treatments had ideal conditions. The dry treatment suffered from substantial water stress before the first irrigation on 19 September as the paddock was not pre-irrigated. The wet treatment was exposed to 10 days' inundation beginning 29 July.

A large proportion of the mid-row banded N was preserved as ammonium through the waterlogging event, even though almost all nitrate was denitrified (Figure 1). About half of the initial concentration was still present at 91 days after sowing (DAS) after the waterlogging event, but only 5 to 8% of the mid-row banded N was available on 3 October, 131 DAS, so the bulk of it was exhausted by flowering in late-September, when the number of grains per head was set.

The mid-row ammonium concentration reduced a similar amount from before to after the waterlogging event, for both the water-logged and unwater-logged treatment, suggesting that little or no ammonium was lost due to waterlogging.

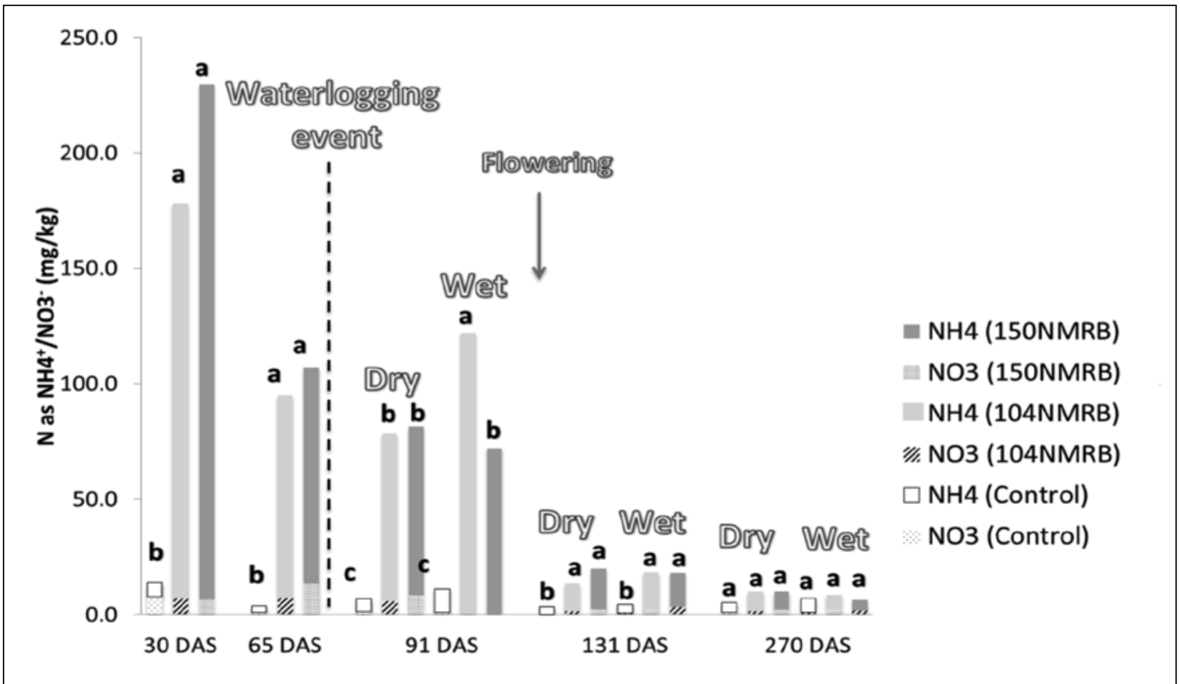

Figure 1. The concentration of N in the sampled mid-row band, present as either NH4+ or NO3- (mg/kg) at four different times of sampling, for two mid-row banded N treatments (104N MRB and 150N MRB), for two waterlogging treatments after the imposition of the water-logging event, Moulamein 2017. Columns with the same letter within each time of measurement were not significantly different (P<0.05).

Both MRB treatments had similar apparent nitrogen recovery efficiency (ANRE) to late topdressed treatments (NTL), of 18 to 21% but less than early topdressed (NTE) treatments when waterlogged. In a non-waterlogged environment MRB treatments had an ANRE of 19 to 31% which reflects previously reported efficiencies of 21 to 28% in an Australian high rainfall environment (Angus et al.,2014) and 24 to 31% in south-east China (Chen, 2016). The topdressed treatments had an ANRE of 30 to 41% which is above the reported rates of 20% in Australia and 27 to 30% in China. The trial topdressing figures are more similar to the global estimate of 33 to 34% reported by Ladha et al. (2005) and Raun & Johnson (1999). Waterlogging significantly reduced treatment efficiencies, resulting in an ANRE of 18 to 22% for MRB treatments and 21 to 36% for topdressed treatments.

The waterlogging event both reduced chlorophyll content of plants (CCCI) and a normalised measure of the canopy chlorophyll and biomass (NDRE) and also eliminated all N treatment effects (comparing CCCI 2 wet with dry and NDRE 2 wet with dry, immediately after the waterlogging event). They were all the same immediately after the waterlogging event (CCCI 2 and NDRE 2). The topdressed N treatments recovered better after the waterlogging event than the mid-row banded N treatments (comparing ΔCCCI and ΔNDRE, which is the change from measurement 2 to measurement 3).

It appears that both topdressed treatments were particularly efficient, as ANRE was relatively high. With reference to the high ANRE of the NTE treatment, we suspect that topdressed N was preserved as ammonium during the subsequent waterlogging and hence was not lost via denitrification.

Conclusions

Mid row banding preserved much of the N as ammonium until 91 DAS, successfully preserving the N from a waterlogging event. Only 5 to 8% of the mid-row N was in the mid-row by 131 DAS, just after flowering. When waterlogged, mid-row banded N achieved similar grain yield, grain N and ANRE as topdressing after the waterlogging event, but less than an efficient topdressing before the water-logging event. When dry, the treatment effect was the same.

Wheat with mid-row banded N showed less recovery after the water-logging event, and had fewer grains per head than either of the topdressed treatments. Hence, the N supply from MRB N to flowering and beyond appeared less than that of topdressed N.

Mid-row banding of N showed an acceptable response in both waterlogged and non-waterlogged conditions, but similar or less than the highly effective N topdressing treatments.

Table 1. The grain yield (mt/ha), grain N (kg/ha), ANRE (%), yield components, CCCI and NDRE and change in CCCI and NDRE (ΔCCCI and ΔNDRE) after the waterlogging event, for five different N treatments (15N, 150NTE, 150NTL, 104NMRB and 150NMRB) and two irrigation treatments (dry and wet), Moulamein 2017.

	15N	150NTE	150NTL	104NMRB	150NMRB
Grain Yield	1.66c	3.91a	3.35ab	2.89b	3.068b
Grain N	25.98c	78.28a	62.02b	49.39b	50.93b
ANRE (%) Dry		41.3a	30.3b	31.1b	19.0c
Wet		36.1a	20.7b	21.5b	18.1b
Heads/m^2	407.5c	619.8a	537.6b	592.4ab	530.8b
Grains/hd	10.03b	17.58a	17.00a	12.70b	14.49ab
1000 GW	43.40a	39.41c	40.40bc	42.62ab	42.78a
CCCI 2 (dry)	0.559a	0.596a	0.566a	0.590a	0.598a
CCCI 2 (wet)	0.513a	0.519a	0.519a	0.526a	0.520a
CCCI 3 (wet)	0.546c	0.641a	0.606b	0.595b	0.580b
ΔCCCI (wet)	0.033d	0.122a	0.085b	0.069c	0.060c
NDRE 2 (dry)	0.266c	0.323a	0.275b	0.334a	0.309a
NDRE 2 (wet)	0.254a	0.285a	0.265a	0.293a	0.275a
NDRE 3 (wet)	0.363c	0.510a	0.464b	0.448b	0.429b
ΔNDRE (wet)	0.109c	0.225a	0.199a	0.155b	0.154b

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Notes

THE 2017-2019 GRDC NORTHERN REGIONAL PANEL

FEBRUARY 2018

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHAIR - JOHN MINOGUE

John Minogue runs a mixed broadacre farming business and an agricultural consultancy, Agriculture and General Consulting, at Barmedman in south-west NSW. John is chair of the district council of the NSW Farmers' Association, sits on the grains committee of NSW Farmers' Assn and is a winner of the Central West Conservation Farmer of the Year award. His vast agricultural experience in central west NSW has given him a valuable insight into the long-term grains industry challenges.

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DEPUTY CHAIR - ARTHUR GEARON

Arthur is a grain, cotton and beef producer near Chinchilla, Queensland. He has a business degree from the Queensland University of Technology in international business and management and has completed the Australian Institute of Company Directors course. He is a previous vice-president of AgForce Grains and has an extensive industry network throughout Queensland. Arthur believes technology and the ability to apply it across industry will be the key driver for economic growth in the grains industry.

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ROGER BOLTE

Roger Bolte is a fourth-generation farmer from the West Wyalong area in NSW, operating a 6500 ha winter cropping program with his wife and family focussing on cereals, legumes and hay. During his 35-years in the industry, Roger has been involved in R&D in various capacities and has had the opportunity to travel abroad and observe a variety of farming systems. He believes that R&D and education are the cornerstones of the industry and feels privileged to be afforded the opportunity to share his experiences.

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ROY HAMILTON

Roy Hamilton operates a 4400 ha mixed family farming enterprise near Rand in NSW's Riverina. He was an early adopter of minimum till practices and direct drill and press wheel technology and is currently migrating to CTF. The majority of the property is cropped while the remainder runs ewes and trade lambs. He has held roles on the south east NSW Regional Advisory Committee, the GRDC's southern region Regional Cropping Solutions Network and was a founding committee member of the Riverine Plains farming systems group.

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DR TONY HAMILTON

Tony is a grower from Forbes, NSW and managing director of an integrated cropping and livestock business. He is a director of the Rural Industries Research and Development Corporation. He has worked as an agricultural consultant in WA and southern NSW. With a Bachelor of Agricultural Science and a PhD in agronomy, Tony advocates agricultural RD&E and evidence based agriculture.

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ANDREW MCFADYEN

Andrew is a grower and private agricultural consultant near Lake Cargelligo NSW with more than 17 years agronomy and practical farm management experience. He is an active member of the grains industry with former roles on the Central East Research Advisory Committee, NSW Farmers Coolah branch and has served on the GRDC northern panel since 2015. He is also a board member and the chair of Grain Orana Alliance.

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PETER MCKENZIE

Peter operates a private agronomy consulting business based in Quirindi NSW. Prior to this he was facilitator/agronomist for AgVance Farming group, a communications conduit between industry and growers. He is a passionate supporter of research and has been active in extending weed management research information to industry, particularly in central west NSW, is a former director of Conservation Farmers Inc., a former member of the North East Regional Advisory Committee and a participant in Northern Growers Alliance local research group on the Liverpool Plains.

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GRAHAM SPACKMAN

Graham has been Managing Director of a private agricultural consultancy at Emerald, Queensland, for the past 28 years, providing advice on the agronomy and management of summer and winter, dryland and irrigated crops in grain and mixed farming systems. He has extensive involvement in RD&E having participated in two decades of GRDC and DPI-funded farming systems research, particularly in weed management, soil fertility and adaption of agronomic practices in CQ farming systems. Graham was a member of the CQ Research Advisory Committee for over 10 years and Chairman for five years.

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BRUCE WATSON

Bruce and his family operate a 3400 ha family grain growing business near Parkes NSW, which produces a mixture of dryland winter cereals, pulses and oilseeds as well as summer dryland cereals, pulses and cotton grown on a 12m zero till CTF platform with full stubble retention. Bruce holds a Bachelor of Agricultural Economics from the University of Sydney and previously worked with PricewaterhouseCoopers in its Transfer Pricing practice. He is an active member of the grains industry and was awarded a Nuffield Scholarship in 2009.

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DR JO WHITE

Dr Jo White is an experienced researcher with over 15 years' experience in agricultural research programs based at the Department of Agriculture and Fisheries in Queensland (DAFQ) and the University of Southern Queensland (USQ), including 10 years' experience in the field of plant pathology of broad acre summer crops. Jo has a keen interest in developing and delivering on-ground practical research solutions to growers which improve productivity and profitability of their farms and is now working as a private consultant based in Queensland.

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LUCY BROAD

Lucy Broad is the General Manager of the Grains Research and Development Corporation's (GRDC) Grower Communication and Extension business group. Lucy holds a Bachelor of Science in Agriculture, majoring in agronomy, and prior to working at the GRDC spent the last 13 years as Director and then Managing Director of Cox Inall Communications and Cox Inall Change, Australia's largest and leading public relations agency working in the Agribusiness and Natural Resource Management arena. Her entire career has been in communications, first with the Australian Broadcasting Corporation and then overseeing communications and behaviour change strategies for clients across the agriculture, natural resource management, government and not-for-profit sectors.

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NORTHERN REGION GROWER SOLUTIONS GROUP AND REGIONAL CROPPING SOLUTIONS NETWORK

FEBRUARY 2018

The Northern Region of the Grains Research and Development Corporation (GRDC) encompasses some of the most diverse cropping environments in Australia, ranging from temperate to tropical climates – it has the greatest diversity of crop and farming systems of the three GRDC regions.

Implemented, to provide structured grower engagement, the GRDC Grower Solutions Group projects and the RCSN project have become an important component of GRDC's investment process in the northern region. The Northern Region Grower Solutions Group and the RCSN have the function of identifying and, in the case of Grower Solutions Groups managing short-term projects that address ideas and opportunities raised at a local level which can be researched demonstrated and outcomes extended for immediate adoption by farmers in their own paddocks.

GROWER SOLUTIONS GROUP AND REGIONAL CROPPING SOLUTIONS NETWORK CONTACT DETAILS:

NORTHERN GROWER ALLIANCE (NGA)

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Northern Grower Alliance (NGA) was established in 2005 to provide a regional capacity for industry-driven, applied agronomic grains research. NGA is currently working on a five year Grower Solutions project, fully funded by the GRDC, focussing on cropping areas from the Liverpool Plains to the Darling Downs and from Tamworth and Toowoomba in the east to Walgett, Mungindi and St George in the west. A network of six Local Research Groups, comprised of advisers and growers, raise and prioritise issues of local management concern to set the direction of research or extension activity. Areas of focus range from weed, disease and pest management through to nutrition and farming system issues.

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Grain Orana Alliance (GOA) is a not for profit organisation formed in 2009 to help meet growers research and extension needs in the Central West of NSW to support their enduring profitability. Currently operating under the GRDC Grower Solutions Group - Central NSW project, one of the key priorities is to identify and prioritise R,D and E needs within the region through engagement with local growers and advisers. This grower engagement helps direct both the GRDC investments in research projects and GOA's own successful research programs. GOA's research covers a wide range of relevant topics such as crop nutrition, disease management and weed control. The structure of the project allows for a rapid turnaround in research objectives to return solutions to growers in a timely and cost effective manner whilst applying scientific rigour in the trial work it undertakes. Trials are designed to seek readily adoptable solutions for growers which in turn are extended back through GOA's extensive grower and adviser network.

CENTRAL QUEENSLAND GROWER SOLUTIONS GROUP

ROD COLLINS

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The Central Queensland Grower Solutions project, is a GRDC and DAF Queensland investment in fast-tracking the adoption of relevant R,D & E outcomes to increase grower productivity and profitability across central Queensland. Covering approximately 550,000 ha and representing 450 grain producing businesses, the central Queensland region includes areas from Taroom and Theodore in the south to Mt McLaren and Kilcummin in the north, all of which are serviced by the project staff, located in Biloela and Emerald. Team leader Rod Collins is an experienced facilitator and extension officer with an extensive background in the central Queensland grains industry. He was part of the initial farming systems project team in the region throughout the late 90's and early 2000's which led the successful adoption of ley legumes to limit nutrient decline and wide row configurations in sorghum to improve yield reliability across central Queensland. He has more recently led the development and delivery of the Grains Best Management Practices program.

COASTAL HINTERLAND QUEENSLAND AND NORTH COAST NEW SOUTH WALES GROWER SOLUTIONS GROUP

The Coastal Hinterland Queensland and North Coast New South Wales Grower Solutions project was established to address the development and extension needs of grains in coastal and hinterland farming systems. This project has nodes in the Burdekin managed by Dr Steven Yeates from CSIRO; Grafton managed by Dr Natalie Moore from NSW DPI; Kingaroy managed by Nick Christodolou (QDAF) and Bundaberg managed by Neil Halpin.

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Neil Halpin is a principal farming systems agronomist with the Queensland Department of Agriculture and Fisheries. He has over 30 year's field trail experience in conservation cropping systems, particularly in the sugar-based farming systems of the coastal Burnett. His passion is for the integration of grain legume break crops, reduced tillage, controlled traffic and organic matter retention in coastal farming systems. Maximising the productivity and profitability of grain legumes (peanuts, soybeans and mung beans) is a common theme throughout the various production areas and systems covered by this project.

KINGAROY QUEENSLAND:

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Nick Christodoulou is a principal agronomist with the Department of Agriculture & Fisheries (QDAF) on Qld's Darling Downs and brings over 25 years of field experience in grains, pastures & soil research, with skills in extension application specifically in supporting and implementing practice change. Nick has led the highly successful sustainable western farming systems project in Queensland. Nick was also project leader for Grain & Graze 1 Maranoa-Balonne and DAF leader for Grain & Graze 1 Border Rivers project, project leader for Grain and Graze 2 and was also Project leader for the Western QLD Grower Solutions project. Currently he is the coordinator for the Grower Solutions Southern Burnett program.

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The Burdekin & tropical regional node of the Coastal and Hinterland Growers Solution Project is led by CSIRO research agronomist Dr Stephen Yeates and technical officer Paul McLennan, who are based at the Australian Tropical Science and Innovation Precinct at James Cook University, Townsville. The Burdekin & tropical Grower Solutions node has a committed and expanding advisory group of farmers and agribusiness professionals. Due to the rapid increase in farmers producing mungbean in the region an open door policy has been adopted to advisory group membership to ensure a balance in priorities between experienced and new growers. The node is focused on integrating grain crops into sugar farming systems in the lower Burdekin irrigation area in NQ and more recently contributing to other regions in the semi-arid tropics that are expanding or diversifying into grain cropping. Information and training requests for information and training from the Ord River WA, Gilbert River NQ, Mackay and Ingham areas necessitated this expansion. Recent work has focussed on the introduction of mungbeans in the northern Queensland farming systems in collaboration with the GRDC supported entomologists Liz Williams and Hugh Brier, Col Douglas from the mungbean breeding team, the Australian Mungbean Association and Pulse Australia. Both Stephen and Paul have many decades of experience with crop research and development in tropical Australia.

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The NSW North Coast regional node of the Coastal and Hinterland Grower Solutions Project is led by NSW DPI research agronomist Dr Natalie Moore and technical officer Mr Nathan Ensbey, who are based at the Grafton Primary Industries Institute. The NSW North Coast Grower Solutions node prioritises and addresses issues constraining grain production via an enthusiastic advisory group comprised of leading grain growers, commercial agronomists from across the region and NSW DPI technical staff. In this high rainfall production zone (800-1400mm pa), winter and summer grain production is an important component of farming systems that also includes sugar cane, beef and dairy grazing pastures, and rice. The region extends east of the Great Dividing Range from Taree in the south to the Tweed in the north. Both Natalie and Nathan have many years experience with research and development for coastal farming systems and are also currently involved with the Australian Soybean Breeding Program (GRDC/CSIRO/NSW DPI) and the Summer Pulse Agronomy Initiative (GRDC/NSW DPI).

REGIONAL CROPPING SYSTEMS NETWORK (RCSN) SOUTHERN NSW

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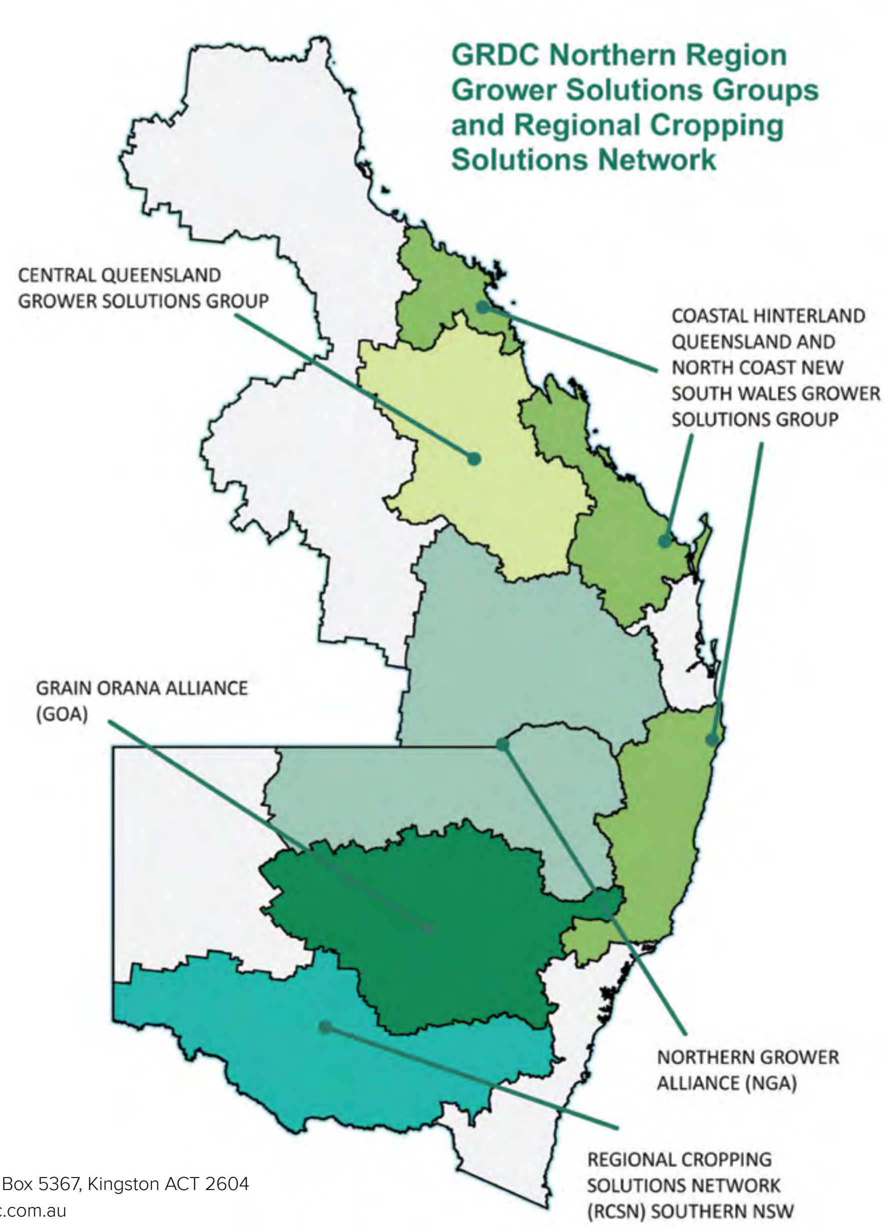
The Southern New South Wales Regional Cropping Solutions Network (RCSN) was established in 2017 to capture production ideas and opportunities identified by growers and advisers in the southern and western regions of New South Wales and ensure they translate into direct GRDC investments in local R, D & E priorities. The SNSW RCSN region covers a diverse area from the southern slopes and tablelands, through the Riverina and MIA, to the Mallee region of western NSW and the South Australian border. The region is diverse in terms of rainfall and climatic zones, encompassing rangelands, low, medium and high rainfall zones, plus irrigation. The SNSW RCSN is facilitated by Chris Minehan. Chris is an experienced farm business consultant and a director of Rural Management Strategies Pty Limited, based in Wagga Wagga, NSW. The process involves a series of Open Forum meetings which provide an opportunity for those involved in the grains industry to bring forward ideas, constraints and opportunities affecting grain grower profitability in their area. These ideas are reviewed by an RCSN committee comprises 12 members, including grain growers, advisers and researchers from across the region that meet twice per year to assist GRDC in understanding and prioritising issues relevant to southern NSW.



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- The local GRDC Grains Research Update planning committee that includes both government and private consultants and GRDC representatives.

- Partnering organisation: ICC

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GRAINS RESEARCH
& DEVELOPMENT
CORPORATION

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

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2018 Moama GRDC Grains Research Update Evaluation

1. Name

ORM has permisssion to follow me up in regards to post event outcomes.

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

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

Your feedback on the presentations

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

3. ICC project learnings – a grower's perspective: ***Stuart Hodge***

Content relevance /10 Presentation quality /10

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

4. A behind the scenes look at the Murray Darling Basin Authority Weekly report: ***Andrew Reynolds***

Content relevance /10 Presentation quality /10

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

5. Irrigation systems and layouts: ***Sam North, Mike Morris, Dennis Watson & Nick O'Halloran***

Content relevance /10 Presentation quality /10

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

6. The value of water and the options if the temporary price rockets: *Rob Rendell*

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

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

7. Seasonal outlook and its impact on spring irrigation: *Dale Grey*

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

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

8. Using irriSAT for irrigation decisions: *Rob Hoogers*

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

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

9. From pretty pictures to decision making – how to make use of your yield maps: *Ian Delmenico*

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

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

10. Grazing canola – agronomic and feed considerations: *Rob Fisher*

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

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

11. Herbicide resistance update: *Peter Boutsalis*

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

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

12. Irrigated pulses – variety review, grower's perspective & inoculation: *Damian Jones, Leigh Vial, and John Fowler*

Content relevance ☐ /10 Presentation quality ☐ /10

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

Your next steps

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

14. What are the first steps you will take?

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

Your feedback on the Update

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

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

16. Overall, how did the Update event meet your expectations?

Very much exceeded	Exceeded	Met	Partially met	Did not meet
❑	❑	❑	❑	❑

Comments

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

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

Thank you for your feedback.