Irrigation Research & Extension Committee

FARMERS' NEWSLETTER

NO. 200 — SPRING 2018

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Front page left: Collection of rice tillers at harvest for yield component analysis. PHOTO: Brian Dunn.

Front page right: Planting of cotton. PHOTO: Cotton Seed Distributors Ltd

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ISSN 0467 - 5282

WELCOME TO THE 200th FARMERS' NEWSLETTER

Rob Houghton
Chairman IREC
Irrigator, Gogeldrie

QUICK TAKE

- IREC continues to work with major commodity groups, universities and research organisations where ever possible to identify technology that will improve efficiencies right across our farming systems.
- There is plenty happening at the IREC Field Station at Whitton, with a fully automated recirculation system being implemented for the coming irrigation season; as well as preparations for a second cotton crop, that will provide income for IREC.
- IREC has changed its committee structure, the 'representative' committee spends more time delving into detailed research issues that affect our members; and an executive committee of four (including the chairman) deals with capital-raising, partnerships and administration of IREC.

Highly variable weather from one season to the next seems to be a topic that never goes away! Spring of 2016 was too wet for optimal planting and just 24 months later it appears we are facing a very dry spring.

CHANGING seasons are a continual challenge to all primary producers. The industries and communities that rely on the business and produce from our farms are equally impacted when our water resource fails to meet expectation.

In these difficult times it is important for all of us to remain positive, talk to neighbours, family and others in the community to realise everyone is dealing with the same issues and better times are just around the corner.

It is also a reminder that research, development, extension and demonstration of new and innovative irrigation practice will help our businesses cope with the inevitable changing climate.

IREC is working in partnership with our major commodity groups, universities and research organisations where ever possible to identify technology that will improve efficiencies right across our farming systems.

Field station

We will be managing the IREC Field Station at Whitton again this year, which gives us the opportunity to turn the profit of our second-year cotton crop into finance for IREC's operations into the future. It has been overwhelming to see the commitment to IREC's research and extension activities by the businesses that have contributed to this year's cotton crop.

There is plenty happening at the field station at the moment. A fully-automated recirculation system is being implemented for the coming irrigation season and work is under way to remove the subsurface drip tube from 15 ha, which will be converted to a fully-automated 'pipe through the bank' system. Coupled with automation on the bankless block, automated storage and the Murrumbidgee Irrigation automated supply, the new development will provide a great comparison between layouts and automated systems. I would like to thank all individuals and organisations for their ongoing support of the field station. The next article provides more detail on developments at the field station.

In mid-May we held a very successful 'post-picking' machinery field day. It was well supported by machinery dealers and many farmers. I would like to thank the machinery dealers for working around the clock to have machinery on site at short notice for the field day. This will become an annual event.

IREC structure

The IREC has been looking at its structure over the past twelve months, with the view of changing things to better reflect how we fit into today's changing research and extension space.

To get better value out of our current 'representative' committee, it was decided to the committee should spend less meeting time on fundraising and administrative issues and get back to using this forum to delve into detailed research issues that affect our members.

To this end it is proposed to create an executive committee of four (including the chairman) to deal with the capital

A large membership base is vital for IREC to play its role in irrigated agriculture in the future. Through its members, IREC can identify relevant key areas for targeted research, extend findings to the farming community and encourage quick uptake of new technology. PHOTO: Rob Gill.

raising, partnerships and administration of IREC. This committee will meet every month reporting back to the broader committee, which will still meet four times a year. The new executive committee will closely resemble current representative membership.

These changes involve changes to IREC's constitution, along with other requirements to make our constitution relevant for current day practice. These amendments were forwarded to members for consideration, and then presented and passed unanimously at the AGM in August.

200 large area editions of the Farmers' Newsletter

This edition is the 200th since the *Farmers' Newsletter* was split into large area and horticultural editions. The *Farmers' Newsletter* has been an important means of extending information to irrigators in southern New South Wales for many decades; and in that time, the publication has taken many forms.

In 2016, IREC made the decision to go digital with publication and delivery. Starting with this edition, there will be further tweaks to the digital format, hopefully for easier reading on tablets and computers. We welcome your feedback on these changes.

In this 'information age', information arrives in many and varied ways. To that end, IREC will be doing a lot more cross-promotion of the articles that our valued contributors provide to the *Farmers' Newsletter*.

The future

The future of irrigated agriculture has never looked more exciting. IREC has great support from its major commodity organisations, Murrumbidgee Irrigation, Coleambally Irrigation Co-operative Limited and Deakin University to investigate and extend new technologies.

For IREC to play its role in irrigated agriculture in the future, it is vital to have a large membership base. This is important to help identify relevant key areas for targeted research and to extend findings to a broad sector of the farming community, to encourage quick uptake of the most recent advancements. Together we can deliver the huge 'promise' that technology has to offer.

To this end, please make sure your IREC membership is current. You can do this via the IREC website or simply contact the IREC office and speak with Hayley. Now is a good time to join up, to get the best bang for your buck!

I hope you enjoy this edition of the *Farmers' Newsletter*, and the current season improves soon.

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UPDATE ON THE IREC FIELD STATION

Iva Quarisa
Executive Officer, IREC

PHOTO: The IREC Field Station at Whitton has developed into a valuable asset for irrigators of the Murrumbidgee Valley and beyond, showcasing research trials and new irrigation layouts and technologies.

QUICK TAKE

- Since 2015, the IREC Field Station has hosted hundreds of visitors who have come to learn more about irrigation automation and irrigation layouts, and to see equipment and machinery in use.
- A cotton crop grown at the field station in 2017–18 provided the basis for a number of trials focused on cotton production, as well as providing a significant source of income for the ongoing operation of IREC.
- The success of the field station is due to the generous support of individuals, businesses, supply companies and research and development corporations — all with a common goal of a more productive, profitable and sustainable irrigation industry in the region.

The IREC Field Station at Whitton is a great asset for the region's irrigators, as it provides an ideal site and location to undertake research and showcase new and emerging technologies and irrigation layouts.

IREC is very pleased that it has been able to grow its first cotton crop at the Whitton field station this past summer. The cotton will be the main source of income for IREC, so a lot was riding on sound yields. Like many summer croppers in our region, picking was completed much earlier than anticipated and we keenly await ginning results to know exact yields.

Pulling crowds at the field station

The field station has hosted hundreds of visitors over the past three years, who have come to learn more about irrigation automation and irrigation layouts, and to see equipment and machinery in use.

The Machinery Demonstration Day held in May 2018 not only gave farmers an opportunity to see a wide variety of machinery in action but also allowed hands-on operation of the tractors, sprayers, spreaders and implements present. There was a wide range of machinery on display, from self-propelled sprayers, primary and secondary cultivators and a few 'one pass' implements that worked well in difficult conditions. For many, this made the decision to make a sizeable investment in expensive machinery a little easier.

The major IREC field day held in January 2018 enabled people to learn more about the various research projects and view the trials taking place at the field station. You can read all about the projects in the Edition 199 of the *Farmers' Newsletter*. We thank all the researchers who ran trials at the field station in the 2017–18 season and previous seasons, and we look forward to future collaboration in coming seasons.

Collaborative cotton growing

Growing the cotton crop this season was a magnificent combined effort by a number of dedicated people and businesses. While Rob Houghton took on responsibility for the crop this season on a contract basis, he went well beyond what was required, and we thank him for all his hard work and dedication to IREC.

As Rob stated in the Chairman's foreword of the last edition of the *Farmers' Newsletter*, IREC had overwhelming support from many people and businesses to enable IREC grow to its first crop of cotton and in order for the crop to be as profitable as possible.

Thanks must go to Bernie Walsh for volunteering his time and labour, as well as arranging some free diesel from Lowes Petroleum.

A huge thanks to Emma Ayliffe from Summit Ag who provided free agronomic advice for the crop.

In addition to advice, Emma coordinated many of the research trials at the field station and arranged many of the in-kind contributions from different businesses. These included EM surveying from PCT, herbicide and insecticide supplied by Nufarm and Sipcam, first growers discount from Monsanto and at-cost fertiliser from Incitec Pivot. Elders provided product storage and coordinated sourcing and product delivery.

Kieran O'Keeffe from CottonInfo has also gone above and beyond, running trials, providing guidance and facilitating

The cotton crop picked at the IREC Field Station in 2018 was the first for IREC. Proceeds of the crop will underpin ongoing operation of the field station and IREC's activities in the region.

the contribution from Back Paddock for free petiole testing.

AgGuard insured our cotton; Southern Cotton picked it, including the awkward trial runs, and will be ginning it at-cost; Hutcheon & Pearce provided half of the wraps free of charge and John DeWit carried out the spraying.

Truly a combined effort and IREC encourages readers to support *our* supporters wherever they can.

Automation and redevelopment

In the midst of the cotton-growing mayhem, Rob also worked on two other projects at the field station—automation of the recirculation system/recycle pump and redevelopment of a further 15 ha of land.

The recirculation project is funded predominantly by the Cotton Research and Development Corporation, with generous contributions of time and product from Dallas Stott and Andrew Bell from Bidgee Automation.

The Grains Research and Development Corporation is funding the automated 'pipe through the bank' redevelopment, which will continue in earnest once the subsurface drip tube has been removed.

Thanks must go to former NSW DPI Research Agronomist Steve Buster, who has now moved into the private sector with Summit Ag and RivCott Gin. Steve coordinated with Kygome from Echuca for the use of the three row drip tape lifter. Steve also ran the growth regulant trial at the field station last season and provided valuable research advice.

A very special mention must go to Mike Naylor who dedicated many hours of his time to provide IREC with the best irrigation design for different layouts and recycle system, as well as the installation of structures, all free of charge.

Just a reminder that the automated irrigation layout was only made possible through funding from Cotton Research and Development Corporation, Riverina Local Land Services and Cotton Seed Distributors with discounts on equipment from Rubicon and Padman Stops.

Murrumbidgee Irrigation also provided support at the field station with a 70 ML allocation of water for a three-year period. This is in addition to the support Murrumbidgee Irrigation offers IREC through providing office space and access to amenities, and promoting IREC membership to its customers. We are very grateful for this ongoing support.

Subsurface drip tube being removed at the IREC Field Station to make way for the redevelopment project of an automated 'pipe through the bank' layout.

Industry-wide effort for industry-wide benefit

The IREC Field Station was set up to become a showcase operation, and this has required a significant financial investment, as well as support and collaboration from a wide range of businesses and individuals. Together we are striving to improve the productivity, profitability and sustainability of irrigation farmers.

We hope you take the opportunity to visit the field station and see the rewards of all the hard work that has been going out there over the past few years.

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WATER PRODUCTS—WHICH ONE TO CHOOSE?

Michael Ryan
Riverina Agriconsultants

PHOTO: Irrigators need a range of water products to manage the balance sheet, cash flow and risk. It is important to understand the impact of each type of water on the whole of the business.

QUICK TAKE

- There are several water products available, including owning or leasing entitlements and purchasing an allocation.
- Each product has pros and cons: owning an entitlement is capital intensive and reliability of allocations vary, however temporary markets are volatile.
- Every business is unique so consider which products best suit your cashflow, balance sheet and appetite for risk.
- Understand key business drivers and cut off prices that underpin purchase decisions.

Irrigators have a range of options for accessing water. There is no single best option and so it is important to consider which product/s best suit your business.

BROADLY, the options are owning (or leasing) a water entitlement but there are several types of entitlement, with varying allocations year-to-year. There is also the option to buy an allocation, which is a deliverable volume of water. The types of water entitlements available in the Murrumbidgee Valley, as at 1 July 2017, are summarised in Table 1.

Table 1: Murrumbidgee Valley water entitlements

Water source	Total ML	$/ML	Allocation reliability	Capital invested per allocated ML
High security	360,297	5,000	95%	$5,263
General security	1,891,895	2,200	60%	$3,667
Supplementary	198,780	600	40%	$1,500
Groundwater (Lower Murrumbidgee)	267,500	2,475	100%	$2,475

Note: prices as at May 2018

General security entitlements are good value compared with high security entitlements but have significant allocation risk. Over 20 years general security allocations have averaged 59%.

Comparison of entitlement types

General security entitlements are good value compared with high security but have significant allocation risk. Seasonal conditions result in high variation of annual allocation announcements. Over the last 20 years general security allocations have averaged 59%, ranging from 13% to 100%.

Up to 30% of unused general security allocations can be carried over from one water year to the next. As this water is already allocated there is no allocation risk (unless the dam spills). Carry over allows irrigators to manage their own allocation risk to some extent.

Entitlements can be leased, with the lessee usually wearing the allocation risk. Typical lease rates are 5% of capital value. Allocated water can be purchased as a temporary transfer, for use in the current water year or as forward water for use in the next water year.

When considering and planning water, remember that rainfall is an important water source — 400 mm of rainfall per annum is 4 ML/ha.

The advantages and disadvantages of different types of water entitlement are presented in Table 2.

Table 2. A comparison of the pros and cons of different sources and water

Water source	Pros	Cons
High security	Reliable allocation Capital growth	High capital cost No carry over Fixed costs
General security	Lower capital cost per allocated ML Capital growth	Capital cost Variable allocations Fixed costs
Supplementary	Lower capital cost	Episodic events Timing cannot be controlled and is often announced when demand is low Need on-farm storage to best use
Groundwater	Reliable allocation Capital growth Can pump and/or carryover 200% in any year	Expensive infrastructure High energy costs Infrastructure is a depreciating asset Extraction limits (annual and daily) Limited suitable bore locations
Lease	No capital investment Operational expense	No capital gain Allocation risk Value subject to allocation
Temporary purchase and forward water	No capital investment Buying deliverable water Operational expense	No capital gain Volatile market

In addition to water purchase costs, riparian irrigators have energy and infrastructure renewal costs.

Considering the options

If general security entitlement is purchased at $2200/ML, for example, then the interest cost (at 5% p.a.) is $110/ML. If there is a 50% allocation the interest cost will be $220/ML. If high security entitlement is purchased at $5000/ML, for example, at 95% allocation the interest cost (at 5% p.a.) will be $263/ML. Water purchase costs in the irrigation areas include charges for delivery entitlements.

Riparian irrigators will have energy and infrastructure renewal costs.

Leasing general security entitlements at 5% of the capital value is the same cost as the interest cost (if buying) with the same allocation risk. Leasing high security entitlements at 5% of the capital value resolves allocation risk but increases the cost per ML.

Entitlement holders with spare carry over space will sell "carry over capacity" late in the water season for $25–35/ML.

Temporary surface water was listed for sale in mid-August 2018 at $390/ML. There are a few crops that justify the purchase of water at this price and still generate a worthy return.

At the same time, groundwater was listed for sale at $150/ML (Zone 3). When pumping costs are taken into account worthy returns at this price from some crops are possible.

Purchasing entitlements (as set out in Table 1) usually requires finance. Increasing debt increases business risk, so purchasing entitlements requires a strong balance sheet. Entitlements provide a return on capital and have shown strong capital growth in recent years.

Groundwater is highly reliable but the true cost of groundwater also includes energy and depreciation costs.

A new irrigation bore costs $200,000–300,000 (or more) to install and has an expected lifespan of 25 years.

So a $250,000 bore, over 25 years is a capital cost of $10,000 per annum (plus interest), which is $20/ML based on pumping 500 ML per annum. Subject to pumping depth and type of energy, pumping costs (including repairs and maintenance) are about $75/ML. Government charges are about $5/ML. Total cost of a new irrigation bore is $20 + $75 +$5 = $100/ML.

What is the best option?

There is no simple answer, you need a range of water sources to manage your balance sheet, cashflow and risk. It is important to understand the impact of each option on the whole of the business, don't just rely on a simple gross margin. Think and act long.

For those reliant on temporary purchases it is important to understand volatility of the market and have access to funds to buy water when the market dips. You need to know your cut off price, which could be rice at $125/ML, cotton returning $500/bale at $150/ML, and cotton returning $600/bale at $200/ML.

Many possibilities, same principles

There are numerous combinations of how growers can set up their water portfolio, depending on historic access to water, capital development of their operation, risk aversion, location and available water sources.

Following are six real life examples of how irrigators may secure and manage different water sources for their irrigation business.

Grower 1 started with general security water only and used 30% carryover. Purchased high security entitlements, constructed on farm storage and installed a bore. Supplements with temporary purchases and carry forward water.

Grower 2 has general security water only and uses 30% carryover. Supplements with temporary purchases and carry forward water.

Grower 3 has high security and general security water and uses carryover. Installed a bore to reduce exposure to general security allocation volatility.

Grower 4 has high security and general security water plus on farm storage and uses 30% carryover. Supplements with temporary purchases and carry forward water.

A range of water products are needed to manage the balance sheet, cashflow and risk, with each option having its own impact on the farm business.

Grower 5 has groundwater and supplementary water and uses carryover. Supplements with temporary purchases to manage bore extraction limits during peak crop demand. Five year plan is to construct water storage to better utilise supplementary entitlements.

Grower 6 has groundwater entitlements, uses carryover and supplements with temporary purchases to manage extraction limits during peak crop demand.

Common to all six growers is the use of carryover and reliance on a range of water sources, including temporary purchases. The key driver of success in management a water portfolio will be how well ***access to water is managed or optimised***.

Understand your cut off price

Understanding your cut off price for water purchases is fundamental as the margin erodes as the price goes up. An average sized business can spend $250,000 to $500,000 on temporary water purchases. Therefore prudent business management is important to provide working returns on this investment.

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THE 2018 COTTON SEASON REVIEW

Kieran O'Keeffe
Regional Extension Officer, Southern NSW
CottonInfo team

PHOTO: An end of season survey of cotton growers provided valuable information for review and benchmarking of the 2017–18 cotton growing season. CREDIT: Cotton Seed Distributors Ltd

QUICK TAKE

- During the 2017–18 growing season, the southern cotton growing region experienced fewer cold shocks and more hot shocks than average.
- Yields were above average for the season, with most farms averaging 11–12 bales/ha. This is above the long-term average of 10.8 bales/ha.
- Good to average yields combined with exceptional lint and cotton seed prices saw average gross margin per hectare (GM/ha) returns of $2460.
- Estimated water use ranged from 8 to 13 ML/ha, with the average across the survey data set being 10 ML/ha.

At the end of each cotton season growers and advisors are asked to complete a confidential survey for CottonInfo. The survey has been conducted for the last five years, and each season provides valuable trends and reminders on best practice.

MOST growers experienced a reasonable start to the 2017–18 season, i.e. during late September and the first two weeks of October. In the southern growing region, cold shocks (temperatures less than 11 °C) were below average for the year (Figure 1) and hot shocks (temperatures above 35 °C) were well above average (Figure 2).

Some large storms in late November and early December impacted crops in some regions and early season *Alternaria* leaf spot set some crops back. It was a very dry and warm finish to the season, which helped ripen crops and provided excellent picking conditions.

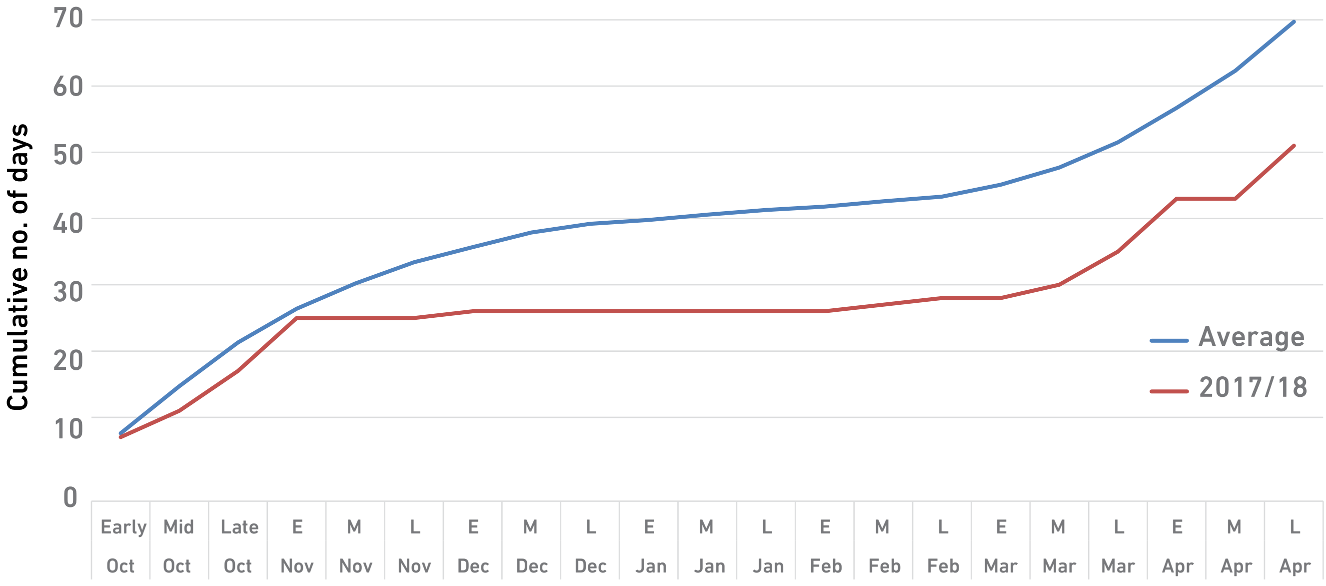

Figure 1. Minimum temperatures were below average throughout the 2017–18 season, and there were almost no cold shocks, compared with average, particularly at the start of the season.

Most growers experienced a reasonable start to the 2017–18 season, with cold shocks below average.

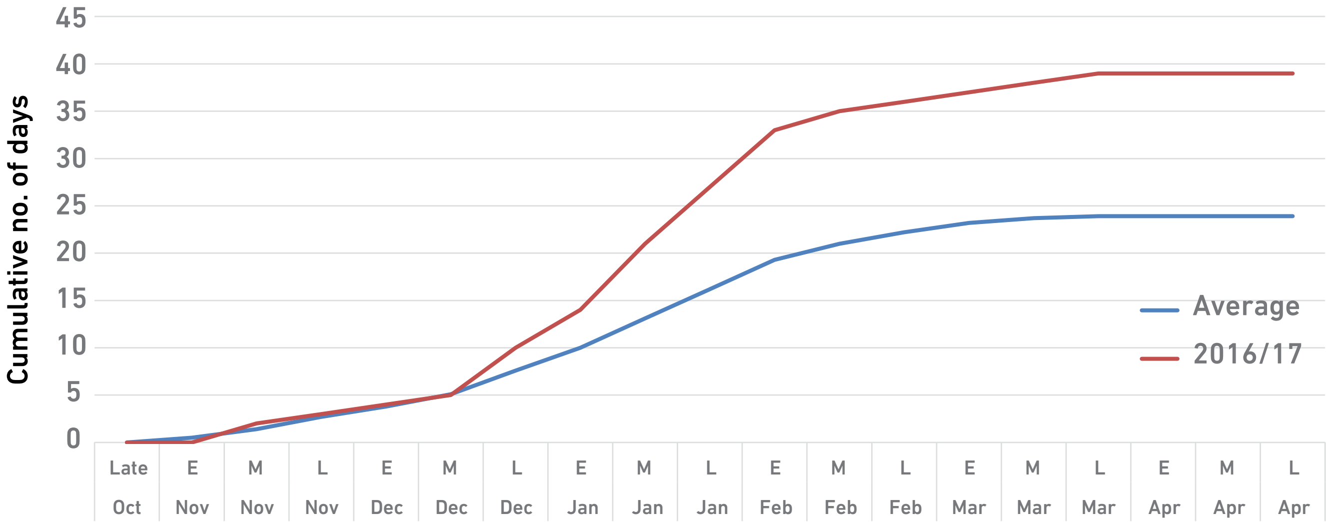

Figure 2. Maximum temperatures were above average throughout most of the 2017–18 season, and there was a large increase in hot shocks, compared with average, from February onwards.

Above average yields in 2018

The survey covered more than 40,000 ha, with the highest yielding field at 16.2 bales/ha. A lot of growers had at least one field that went over 12 bales/ha.

The true indication of the season performance, however, was shown by overall farm average yields (Figure 3), which ranged from 10 to 14 bales/ha with most in the 11–12 bales/ha range. The survey average was 11.76 bales/ha, with the final southern NSW average likely to be around 11.2 bales/ha. This is above the long-term average of 10.8 bales/ha. At the time of writing, ginning was still underway and this average is only an estimate of overall yield taken from the survey sample of 25 crops.

In comparison, 2017 was a lower yielding season with farm averages at 9.25 bales/ha, while 2016 was an exceptional year for yield with farm averages of 12 bales/ha.

The 2017–18 season was an above average year for yields and prices. The good to average yields combined with exceptional lint and cotton seed prices saw average gross margin per hectare (GM/ha) returns of $2460 (Table 1).

The average gross margin per megalitre (GM/ML) return reported in 2018 was $322 [not in Table 1] but there was a big range of $477 to $220 due to different contracted prices and actual water use.

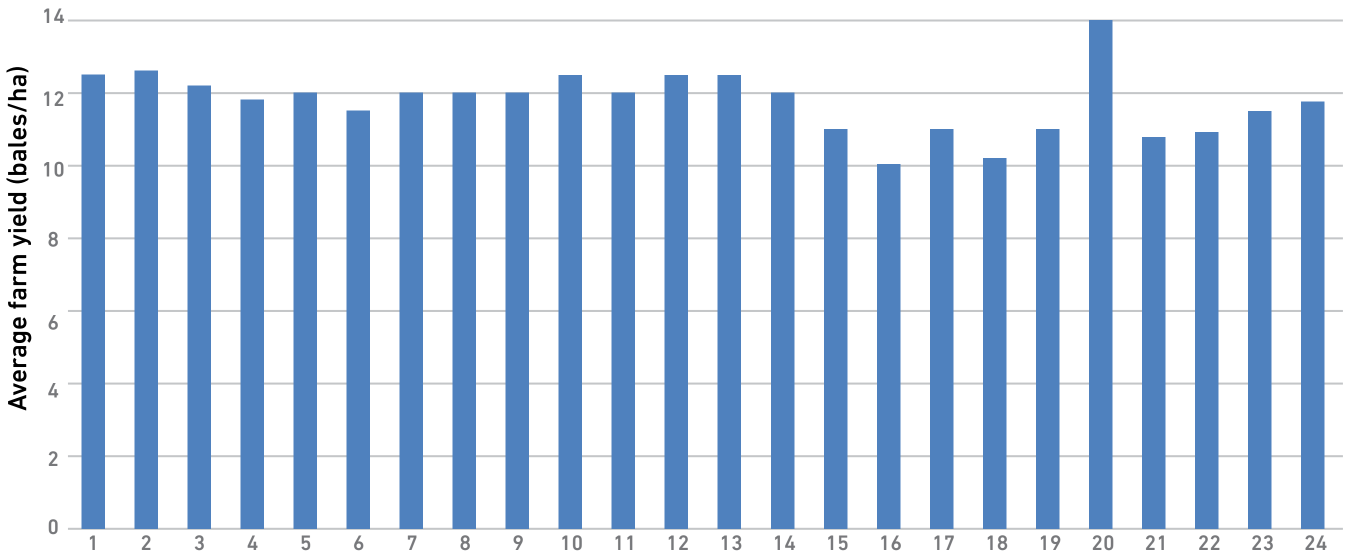

Figure 3. Average farm yield (bales/ha) for 24 survey respondents from southern NSW, in the 2017–18 cotton survey.

Table 1. Averaged income, costs and gross margin for three growing seasons

	Income/ha	Variable costs/ha	GM/ha	GM/ML
2016	$7200	$3895	$3305	$330
2017	$5458	$3404	$2058	$205
2018	$6310	$3850	$2460	$246

Average water use in 2018

The survey data showed a lot of variation between farms with water use estimated from 8 to 13 ML/ha (Table 2). The calculated figures in Table 1 were based on the average water use across the data set of 10 ML/ha.

Another good benchmark on performance is bales produced per megalitre of water applied. Results for the top ten crops in the survey are shown in Table 2. The five-year average is 1.4 bales/ML but it will vary depending on the season from 1.1 to 1.6 bales/ML.

The success of the 2017–18 cotton season was attributed to attention to detail during the planting operation and excellent irrigation management. PHOTO: Cotton Seed Distributors Ltd.

Table 2. Top ten yielding crops in southern NSW, in the 2017–18 cotton survey

Crop	Yield (bales/ha)	Irrigation system	Estimated ML applied	Bales/ML
1	16.2	Bankless 1m hills	9.0	1.8
2	15.7	Bankless 90 cm beds	9.0	1.7
3	15.4	Siphons, 1:2000 1m hills	8.0	1.9
4	15.3	Siphons 1:1500 1m hills	11.2	1.4
5	15.2	Siphons 1m hills	11.0	1.4
6	15.1	Siphons 1: 1800 90 cm beds	11.0	1.4
7	14.5	Siphons 90 cm beds	11.0	1.3
8	14.2	Pipes through the bank, 1m beds	9.5	1.5
9	14.2	Siphons 1m hills	12.5	1.1
10	14.0	Bankless beds	13.0	1.1
Average	15.0		10.4	1.4

Keys to success in 2018

When asked to comment on why this season's crop was a success, there were two consistent themes in growers' responses:

- attention to detail during the planting operation
- excellent irrigation management, i.e. water on and off bays quickly, accurate timing during peak demand and well-maintained layouts.

Siphon layouts were the dominant cotton layout, with 57% of the area surveyed using this technology. Bankless channel layouts made up 31% of the survey area and this is increasing each year. The area under 'pipe through the bank' is also increasing.

Fibre quality was reported as being exceptional, with most growers reporting no discounts and some premiums for colour grades.

When asked what their biggest challenge was to remain profitable, the response, predictably, was around water. Water availability and water affordability were mentioned by over 80% of the respondents. Disease build up, with black root rot specifically mentioned, came in second.

This article is only a snapshot of the survey results. The full report is available on request.

Success in 2017–18 was attributed to attention to detail at planting and excellent irrigation management.

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CottonInfo is a joint initiative of CRDC CSD Cotton Australia

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SAVE WATER AND USE NITROGEN BETTER WITH IMPROVED WATER MANAGEMENT

Kieran O'Keeffe[1] and Janelle Montgomery[2]
[1]Regional Extension Officer, CottonInfo, Southern NSW
[2]Regional Extension Officer, CottonInfo Gwydir

PHOTO: A series of trials in cotton crops across all growing regions investigated the relationship between irrigation management and nitrogen fertiliser efficiency.

QUICK TAKE

- **Correct placement of pre-plant nitrogen fertiliser in cotton crops can minimise nitrogen losses in the first two irrigations.**
- **Three-quarters of the irrigation events measured in replicated trials had an application efficiency of less than 80%, therefore there is significant room for improvement in irrigation management.**
- **Increased irrigation flow rates can result in excess tailwaters if siphons are not pulled at the correct time; and this can significantly reduce the efficiency of an irrigation event.**

Trials across the cotton growing valleys in 2017–18 aimed to quantify the runoff component of the nitrogen loss pathway, and to highlight the relationship between irrigation and nitrogen management.

BOOSTING the nitrogen use efficiency and water use efficiency of cotton farms are key objectives of the Australian cotton industry. Research by Jon Baird (2016) and Ben McDonald (2017) identified up to 10% fertiliser nitrogen losses in the first two irrigations, and these were influenced by pre-season fertiliser placement, deep drainage and runoff.

Measurements and monitoring

Trials were conducted in each cotton valley by CottonInfo's team of regional extension officers during the 2017–18 season were set up with two irrigation treatments (single siphons and double siphons) and four replicates of each treatment.

Soil cores were taken to measure soil nitrogen at the start of the season and again after the second irrigation. Cores were taken from the head ditch and the tail drain ends of the field, and split in two, based on depth: 0–30 cm and 30–60 cm.

The first two irrigations (watering-up/pre-irrigation and the first in-crop irrigation) were monitored to determine how much nitrogen went on in the irrigation water and how much ran off in the tailwater. Water samples were collected, however to determine the amount of nitrogen applied and lost as runoff, we also needed to know the volume of water applied.

The Irrimate suite of tools was used for the irrigation evaluations. A siphon flow meter was used to measure flow rate and total volume of water applied; and advance sensors measured the advance time as the water moved down the length of the field. The data collected was sent to National Centre for Engineering in Agriculture, where Malcolm Gillies and Joe Foley ran it through a model they developed called SISCO. This model simulates the irrigation event based on the data collected in the field. The output of the model included the volume of irrigation water applied, volume of tailwaters, volume of water that infiltrated into the soil profile and the volume of water that was lost as deep drainage (i.e. moved out of the root zone).

This information allowed us to calculate the amount of nitrogen that ran off in the tailwater.

Using SISCO we could also evaluate the performance of the irrigation event and compare the performance of the single siphons and double siphons in terms of:

- **application efficiency**, which relates the amount of water applied in an irrigation to the amount of water available to the crop. A high efficiency means that most of the water applied has been retained in the root zone (not lost as deep drainage or runoff).
- **requirement efficiency**, which describes how well the soil deficit is met. This measure need not be 100%, but anything less means deficit irrigation is occurring, i.e. the profile is not being filled completely along the length of the field.
- **distribution uniformity**, which is a measure of how evenly the water has been applied. The aim is to have distribution uniformity as high as possible.

Flow rate, advance time and total volume of water applied were measured in CottoInfo trials set up to measure nitrogen loss in irrigation runoff.

Nitrogen performance

Soil nitrogen

Interestingly for most of the farms where the trials were conducted, there was much more nitrogen in the soil at the tail drain end of the field compared with the head ditch as shown in Figure 1. In fact, the tail drain often had more than twice the amount of nitrogen compared with the head ditch.

With the pre-season soil test showing such a potential difference between the top and bottom, perhaps this should be considered when developing a nitrogen budget for the field.

In the Darling Downs and Gwydir (Moree) trials, irrigation did not change the relative proportions of nitrogen within the field, a scenario that is ideal for good nitrogen management.

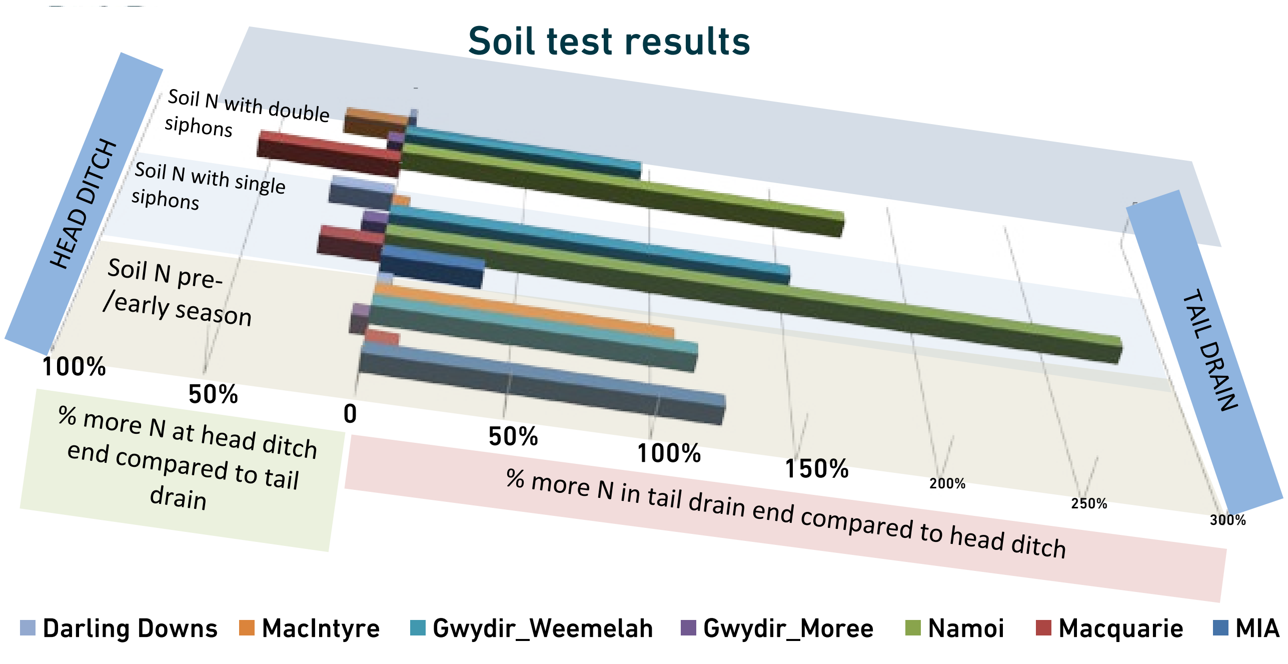

Figure 1. Distribution of soil nitrogen in the field following the equivalent of two irrigations

Irrimate flow meter used in the trials. Flow rates and other data collected allowed volume of runoff, infiltration and deep drainage to be calculated.

Nitrogen losses in tailwater

Tailwater samples were taken from a single furrow in each treatment. They were analysed for total nitrogen and nitrogen concentration. In all cases except one site there was only a small amount of nitrogen in the tailwater for these events. There was up to 7 kg N/ha in the tailwater in the single siphon treatment compared with up to 13 kg N/ha in the double siphon treatment (Figure 2). This indicates that the placement of pre-plant nitrogen was well managed by the growers, being below furrow level in the bed or hill.

Double siphons resulted in greater losses of nitrogen and this was related to the higher volumes of tailwater produced. Optimising the irrigation events reduced the amount of nitrogen lost in the tailwaters.

The nitrogen in the tailwater can be lost to the atmosphere within 24 hours so the water should be applied to other fields immediately and not held in storages.

Irrigation performance

Application efficiency

The application efficiency of each individual irrigation event measured in the trial is presented in Figure 3.

An application efficiency of 80% should be considered as a standard for minimum performance.

Three-quarters of the irrigation events measured had an application efficiency of less than 80%, indicating significant room for improvement in irrigation management. It should be noted that an application efficiency of greater than 90% is achievable under furrow irrigation.

The SISCO computer model identifies the required flow rates of water and the cut off times (when siphons are pulled) to match the soil's infiltration characteristics. Using the model results in improved irrigation performance through maximising application efficiency and uniformity of distribution, which in turn reduces runoff and deep drainage, thereby reducing nitrogen losses.

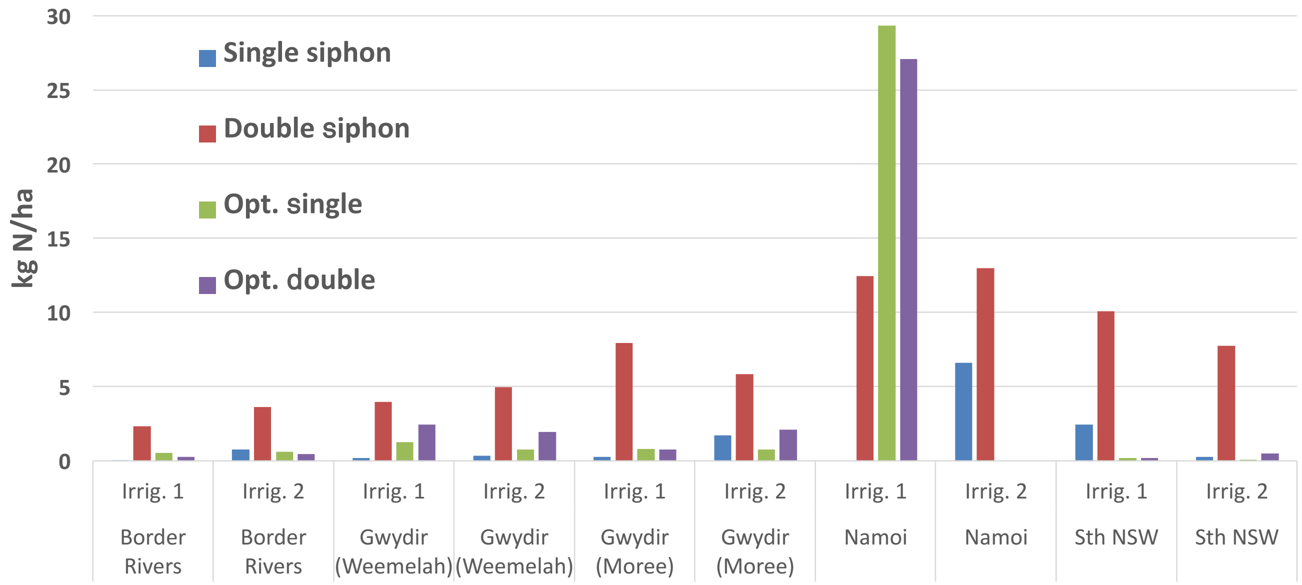

Figure 2. Quantity of nitrogen in tailwaters (kilograms of nitrogen per hectare) for individual irrigation events

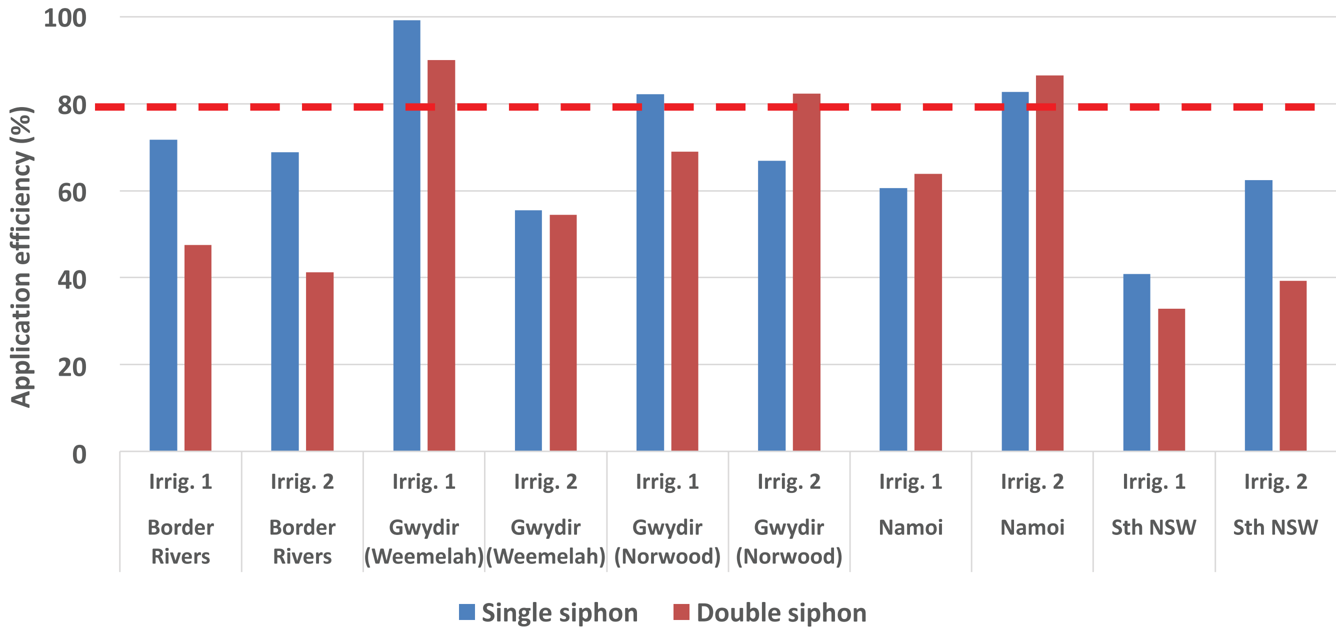

Figure 3. Application efficiency of individual irrigation events for single and double siphon treatments

Optimising irrigation performance of the irrigation events improved application efficiency, as shown in Figure 4.

Requirement efficiency

Requirement efficiency shows how well the soil deficit has been met, i.e. how well the soil profile has been filled. This measure does not have to be 100% but if it is not, deficit irrigation is occurring, i.e. we are not filling the profile completely along the length of the field.

Across the trials, 60% of the irrigation events had a requirement efficiency of 100% (Figure 5). This was due to the irrigation time being too long, causing siphons to continue to run once water reached the tail drain and the profile to keep filling.

It is important to consider application efficiency and requirement efficiency together. For the irrigation events measured in the trials, a high requirement efficiency often resulted in lower application efficiency.

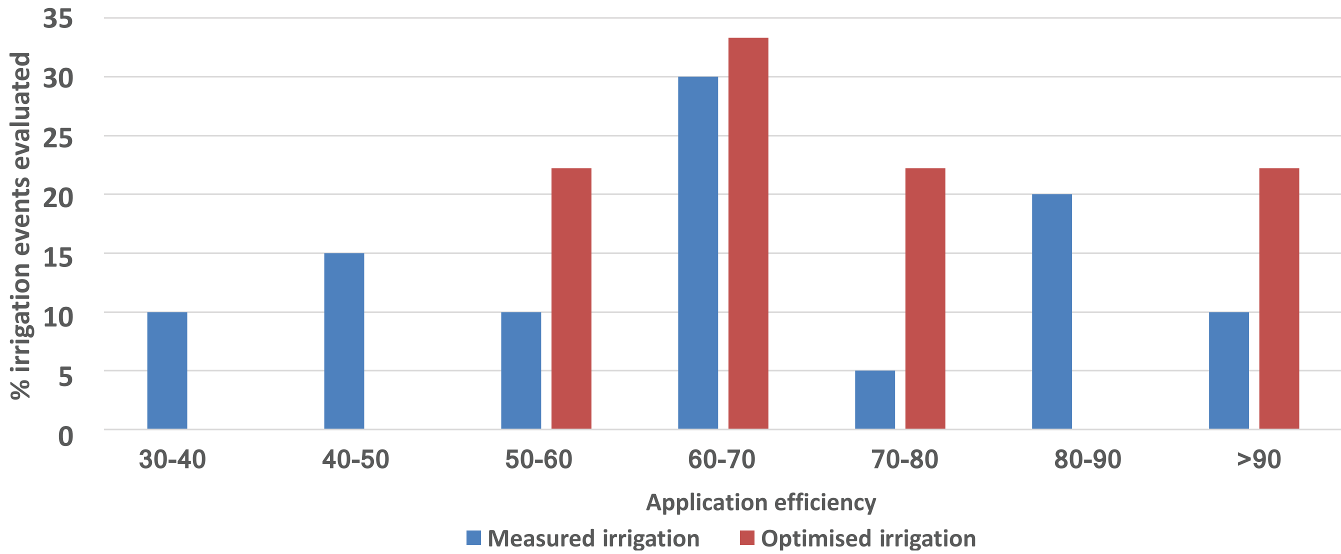

Figure 4. Application efficiency of measured and optimised irrigation events

Information collected by a Norwood irrigation advance meter, together with other irrigation data and soil nitrogen tests after two irrigations, enabled nitrogen loss in tailwater to be determined.

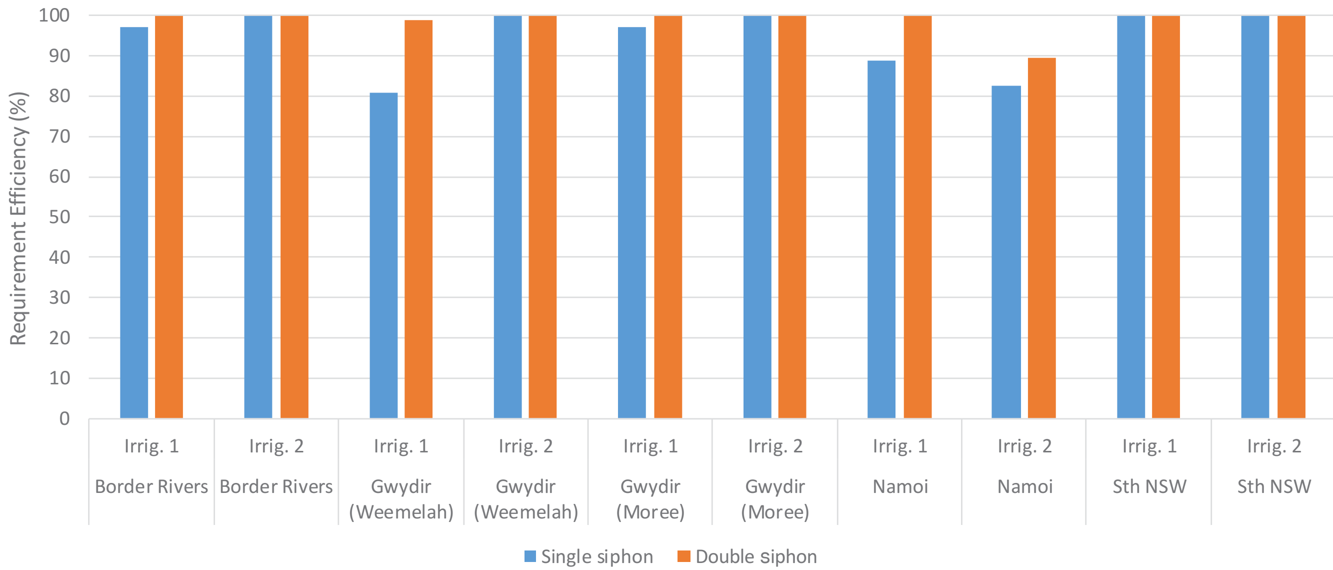

Figure 5. Requirement efficiency of individual irrigation events for single and double siphon treatments

Distribution uniformity

With each irrigation event, the goal is to have distribution uniformity as high as possible. In the trials, distribution uniformity was high with half of the events having a distribution uniformity greater than 90% (Figure 6)

A high uniformity does not guarantee efficient irrigation. To achieve such uniform applications, often more water is applied than is necessary.

Water savings

One benefit of optimising flow rates and cut off times for irrigation is the potential for water savings.

As the double siphons were generally run for far too long, resulting in excess tail water, the single siphons often saved considerable amounts of water, in this trial.

If irrigators increase flow rates, excess tailwaters can result if siphons are not pulled at the correct time. This can significantly reduce the efficiency of an irrigation.

On average the single siphons saved 0.24 ML/ha per irrigation compared with double siphons. To put this saving into perspective: 0.24 ML/ha x 6 irrigation events across the season = 1.44 ML/ha. Multiply this by a typical cotton area, e.g. 500 ha, then 720 ML of water could be saved over the season on a 500 ha farm. That's enough water to grow another 72 ha of cotton.

By optimising the irrigation event with double siphons, the water saving between the measured and optimised events was 0.4 ML/ha/irrigation. To put into perspective: 0.4 ML/ha x 6 irrigation events across the season = 2.4 ML/ha. Multiply this by a typical cotton area, e.g. 500 ha, then 1200 ML of water could be saved over the season on a 500 ha farm. That is enough water for another 120 ha cotton.

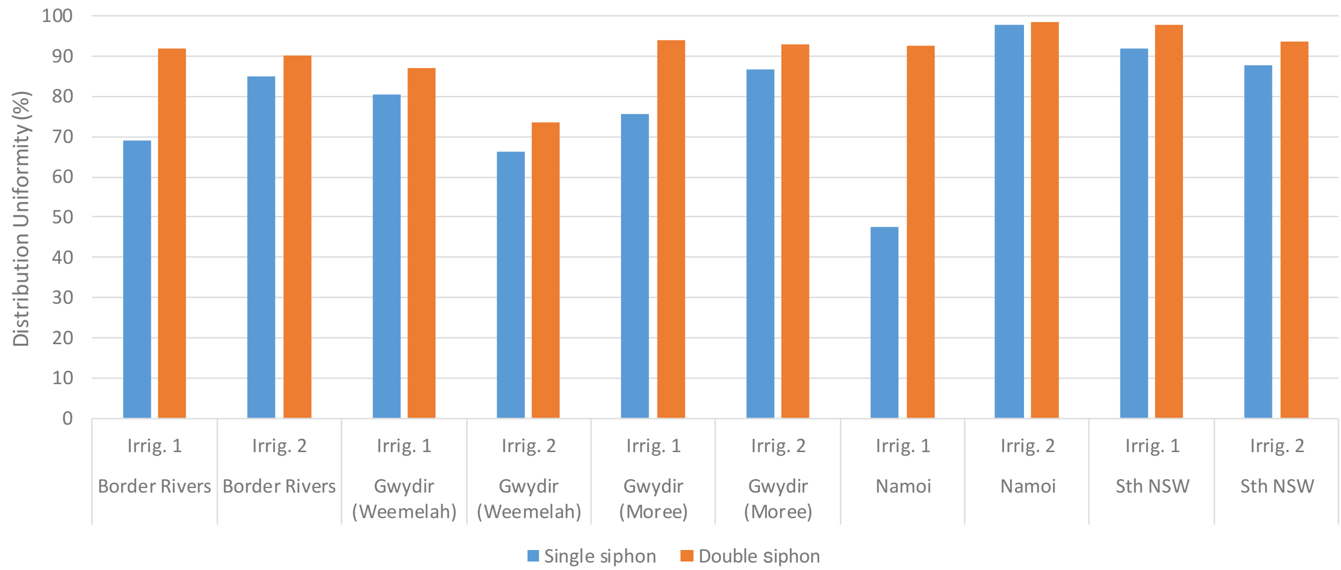

Figure 6. Distribution uniformity of individual irrigation events for single and double siphon treatments

Acknowledgements

Growers and consultants who provided trial sites and assistance.

CottonInfo Regional Extension Officers, Amanda Thomas, Geoff Hunter, Sally Dickinson and Annabel Twine

John Smith (former NSW DPI Irrigation Agronomist) for collating the soil sample results

Joseph Foley & Malcolm Gillies, NCEA, USQ for conducting the irrigation evaluations

CRDC for funding the trials

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DETERMINING BEST PRACTICE FOR CURRENT AND NEW RICE VARIETIES

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NSW Department of Primary Industries, Yanco

PHOTO: Collection of rice plant samples at harvest to determine plant growth and yield in response to different management practices. The results of the trial provide best management information for current and new rice varieties.

This article is based on an article first published in the 2018 Rice R&D Update: Improving the productivity, profitability and sustainability of the Australian rice industry.

QUICK TAKE

- This project provides growers with agronomic information on how best to manage current and new rice varieties.
- Improved management maximises grain yield and water productivity and improves the consistency of achieving both.
- The project identifies how rice varieties respond across seasons and regions to different sowing methods, water management practices, nitrogen rates and application timings.
- The impact of all these factors on crop growth and development, grain yield and grain quality is measured to determine best management practice.

Each season, experiments are established across the rice growing regions of southern New South Wales with current and near to release rice varieties to determine effects of agronomic management.

THESE experiments are often located in growers' commercial fields and include aerial, dry broadcast, conventional drill and drill with delayed permanent water (DPW) growing methods. The experiments conducted in the 2017–18 season and their treatments are listed in Table 1. The Jerilderie Drill, Yanco DPW and the Leeton water management (WM) experiments all had split sowing dates so that the reproductive periods of the varieties and treatments aligned so true comparisons could be achieved.

The experiments are continually monitored and sampled throughout the season to determine key growth stages with panicle initiation (PI), microspore, flowering and maturity (22% grain moisture) determined for each variety. Plant establishment is counted and physical samples collected at PI and maturity so crop growth and all components that contribute to yield can be determined. Water depth and water and air temperature are also recorded at each site so their impact can be accounted for.

Grain quality samples are collected from many of the experiments as each variety reaches maturity. This allows the evaluation of sowing, water management and nitrogen treatments for their impact on grain quality. Three short grain experiments were conducted this season that investigated the impact of three plant densities and ten nitrogen rate by timing treatments on grain quality of the sushi varieties (Opus, Koshihikari and YRK5).

Hand sowing an aerial sown variety x nitrogen experiment in trials to determine best practices for management of current and new rice varieties

Table 1. Details of rice variety by nitrogen experiments conducted in the 2017—18 season

Location	Sowing method	Varieties	Nitrogen rates (kg N/ha)
Mayrung	Aerial	Reiziq, Sherpa, Doongara, Opus, Koshihikari, Illabong	0, 90, 150, 90-60
Coleambally	Dry broadcast	Reiziq, Sherpa, Doongara, Viand, Langi, Topaz	0, 120, 180, 120-60
Wakool	Drill	Reiziq, Sherpa, Opus, Koshihikari, Illabong, YDP	0, 60, 120, 60-60
Jerilderie	Drill	Reiziq, Opus, Koshihikari, Viand, YRK5, YDP	0, 90, 150, 90-60
Jerilderie	Drill density	Koshihikari, Opus, YRK5, Viand – 3 densities	10 treatments
Yanco	DPW	Reiziq, Opus, Doongara, Koshihikari, Viand, YRK5, YDP	0, 60, 120
Yanco	Fully aerobic	Reiziq, Sherpa, Opus, Doongara, Langi, Topaz, Koshihikari, Viand, YRK5 & YDP	60 mid till + 60 PI
Leeton WM	Aerial, drill, DPW	Reiziq & Sherpa	0, 120, 180, 240

NB Several Australian rice varieties are granted Plant Breeders Rights by IP Australia. This publication acknowledges PBR for Opus⊕, Reiziq⊕, Sherpa⊕, Topaz⊕ and Viand⊕.

Implication of results

The results obtained from each season's experiments are combined with results from previous seasons to update and improve variety recommendations. Seedling vigour, plant number, PI date, PI nitrogen uptake, flowering and maturity dates, grain yield, floret sterility, plant height, lodging scores (Table 2) and other measurements are used to update the "Rice Variety Guide" each season and develop individual variety growing guides for current and new varieties. Information is also presented to growers and agronomists at field days and pre-season meetings.

The data collected on plant growth stage is also being combined with temperature data to develop more accurate models for predicting PI date for aerial, dry broadcast, Drill and DPW sowing methods. The development of models to predict flowering and maturity (22% grain moisture) dates is also planned and will use this data. This data is also the basis for sowing date recommendations, which have been modified considerably over the last three seasons.

Table 2. Rice variety yield, maturity, seedling vigour, height and lodging score characteristics

Variety	Yield potential % of Reiziq	Maturity days different to flower than Reiziq	Seedling vigour 1 = weak 5 = strong	Height (cm)	Lodging score (the higher number, the more prone to lodging)
Reiziq	100	Standard	4	80	1
Sherpa	105	-3	3	83	1
Opus	100	+2	3	81	2
Langi	95	-2	3	86	2
Topaz	85	+1	1	81	1
Illlabong	105	+4	2	86	2
Doongara	95	+1	3	75	1
Koshihakari	80	+4	3	91	6
Viand	95	-9	4	85	3
YRK5	85	-9	4	93	6

Aerial photo of the water management experiment at Leeton Field Station.

Revised sowing dates

Rice sowing dates have undergone some minor refinement again this season. Three seasons of data has provided us with the confidence to push the start of the sowing windows back by five days for many varieties when aerial and drill sowing (Table 3). It is important to note that sowing too early can be as bad as sowing too late with increased risk of the crop being affected by cold temperatures at microspore. Early sowing can also have a negative impact on whole grain yield with grain filling and dry down occurring during warmer temperatures. Therefore it is important that the new sowing date guidelines are followed.

Table 3. Recommended sowing/first flush dates for rice varieties, regions and sowing methods

Variety	MIA/CIA Ideal sow/first flush time			Murray Valley Ideal sow/first flush time		
	Aerial/Dry broadcast	Drill	DPW	Aerial/Dry broadcast	Drill	DPW
Reiziq, Opus, Topaz, Doongara	25 Oct–5 Nov	20–31 Oct	10–25 Oct	20 Oct–5 Nov	15–25 Oct	5–20 Oct
Sherpa, Langi	25 Oct–10 Nov	20 Oct–5 Nov	10–30 Oct	20 Oct–5 Nov	15–30 Oct	5–25 Oct
Koshihikari, Illabong	–	–	–	20–30 Oct#	10–25 Oct	1–20 Oct
Viand	10–30 Nov	5–25 Nov	1–20 Nov	5–30 Nov	1–20 Nov	25 Oct–10 Nov
YRK5	–	–	–	–	1–20 Nov	25 Oct–10 Nov

Do not aerial sow or dry broadcast Koshihikari or YRK5 as this will increase lodging potential

Collection of 30 tiller samples at harvest for yield component analysis.

Growing rice with less water

As competition for water becomes an ever-increasing issue, much of our research involves understanding how current and new varieties respond to a reduced period of ponding. Many experiments are conducted on drill and DPW water management each season and in 2017–18 we gave our varieties a preliminary test at being grown in fully aerobic conditions (i.e. no ponding). The severe heat and cold that can occur in our environment during the reproductive period make this practice unviable using current varieties in southern NSW but it is useful to determine which varieties are most durable in this situation.

In 2017–18 an experiment was conducted at Leeton Field Station where Reiziq and Sherpa varieties were grown with replicated water management treatments. Aerial, drill, drill with DWP, and drill with DPW and post-flower flushing (PFF) methods were sown at different times in order to align their reproductive periods and allow a valid comparison.

Grain yield results highlighted how rice grown using DPW has the same yield potential as aerial and drill sown rice (Figure 1) and also its increased nitrogen use efficiency. When permanent water was removed from the crop after flowering and it was regularly flushed (PFF), grain yield was reduced, even though it was never water stressed.

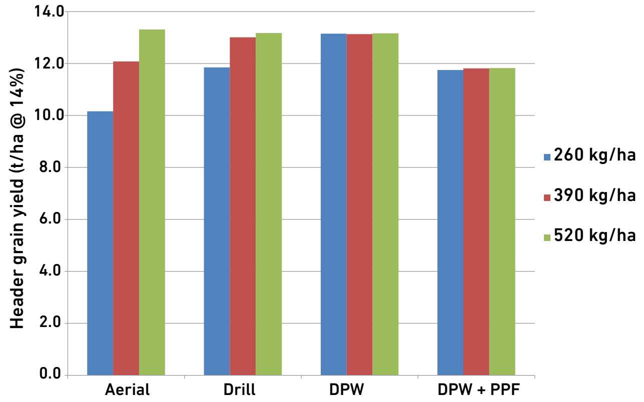

Figure 1. Header grain yield of water management treatments from Leeton experiment, at 260, 390 and 520 kg/ha urea, average of Reiziq and Sherpa varieties (l.s.d. (P<0.05) = 0.95)

Going forward

Research will continue to be conducted in southern NSW rice growing areas testing varieties across water management practices. It is important that water productivity of rice is increased without risking the reliability of achieving high yields and grain quality. In some experiments water use will be measured to quantify water savings and the water productivity (t/ML) that can be achieved. Agronomic management information on current and new varieties will continue to be passed onto growers and agronomists.

Acknowledgements

This research was co-funded by the NSW Department of Primary Industries and AgriFutures (PRJ009790).
We wish to thank the growers who support this research by allowing us to conduct experiments on their properties.

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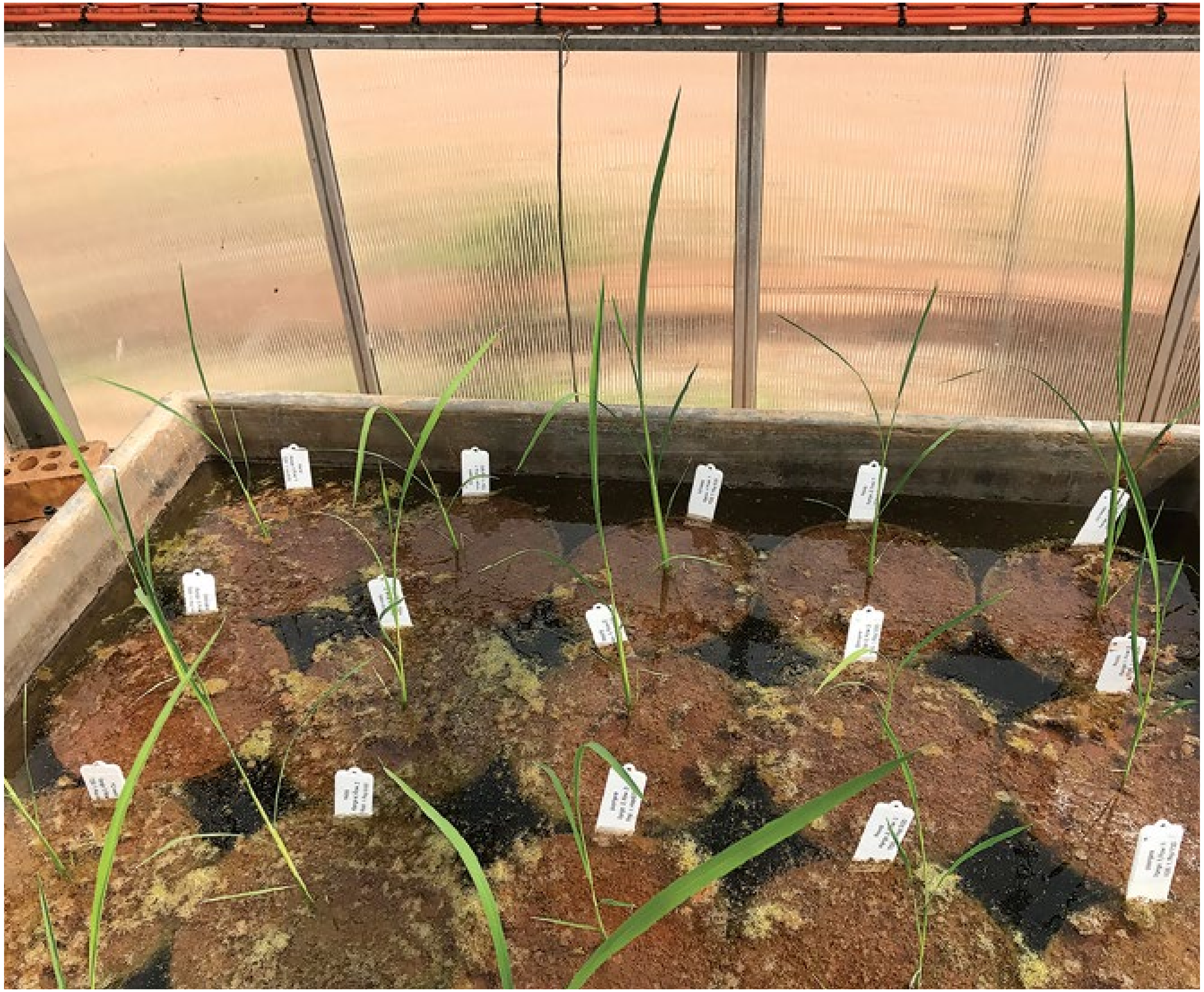
HYBRID RICE FOR AUSTRALIAN FARMERS – HYPE OR HOPE?



Ben Ovenden[1], You Zhang[2], Kylie Elliott[1], Greg Napier[1], Dee Sparkes[1], Liz Dennis[2] and Jim Peacock[2]
[1] NSW Department of Primary Industries, Yanco
[2] University of Technology Sydney, Ultimo

PHOTO: Glasshouse experiments at Yanco Agricultural Institute investigated F1 hybrid rice plants, produced from the Australian rice varieties, Reiziq and Doongara.

QUICK TAKE

- **Hybrid technology could be a way of extracting a large genetic gain from elite Australian germplasm in a short time to rapidly realise the yield and water productivity benefits of hybrid rice.**
- **Experiments at Yanco showed increased yield (and water productivity) from an Australian F1 rice hybrid. Hybrid plants were larger, taller and more vigorous than either parent.**
- **New breeding tools would need to be implemented to develop Australian hybrid rice varieties.**

Hybrid rice is well known to have a significant yield advantage over inbreeding rice varieties. However hybrid rice has historically had a bad reputation for high seed cost and poor grain quality.

FOR these and other reasons hybrid rice varieties have not previously been pursued by the Australian rice breeding program. However, recent technological advances in hybrid breeding have largely overcome these problems and hybrid rice varieties are gaining popularity around the world.

Hybrid rice was developed in China in the 1970s, and is now well established in several major temperate and tropical rice growing areas around the world. Commercial results of hybrid varieties in China and USA over the last 10 years report yield advantages of around 10–20% over equivalent conventional varieties.

Hybrid rice varieties have been rapidly adopted in the southern USA rice growing region with, on average, more than a third of the rice area planted to hybrids. Southern USA hybrid varieties have proved popular with rice growers because of their yield advantage over inbred varieties, competitive growth habit and shorter growth duration. Research has shown there is no difference in the grain quality of southern US hybrid varieties compared to inbred varieties.

Investigating Australian germplasm for hybrid potential

Genomic analysis of the Yanco rice germplasm collection has shown that the Australian rice breeding program has two separate pools of elite germplasm, which could be the basis for a hybrid breeding program.

We investigated an F1 hybrid with the well-known commercial varieties Reiziq and Doongara as parents to see if combining the two pools of elite Australian rice germplasm would generate hybrid vigour, and provide an indication of the potential for developing hybrid rice varieties adapted for Australia.

We conducted an experiment in the rice breeding program glasshouse at Yanco, producing an F1 hybrid by controlled cross-pollination between Reiziq as the female parent and Doongara as the male parent. The trial was planted in 2017, and single plants were grown in 200 mm pots. We compared 10 replicates of the F1 hybrid and the hybrid parents at three times of sowing.

An experiment at Yanco is investigating hybrid vigour in Australian rice. From left to right are example plants of Reiziq, the F1 hybrid and Doongara, during grain filling in glasshouse trials.

The F1 hybrid showed very rapid seedling growth compared to both parents, with faster shoot elongation and 100% greater leaf area development at 20 days after sowing (Figure 1a). The hybrid also had a greater number of tillers before panicle initiation than either parent (Figure 1b). Hybrid plants were visibly larger in size at all growth stages. The F1 hybrid was significantly later to flower that either parent. At maturity, the F1 hybrid plants were taller and had more biomass than either parent (72% more than Doongara and 66% more than Reiziq, Figure 1c) and greater grain weight than either parent (57% more than Doongara and 35% more than Reiziq, Figure 1d).

The photograph on the previous page shows example plants for the F1 hybrid and each parent during grain filling.

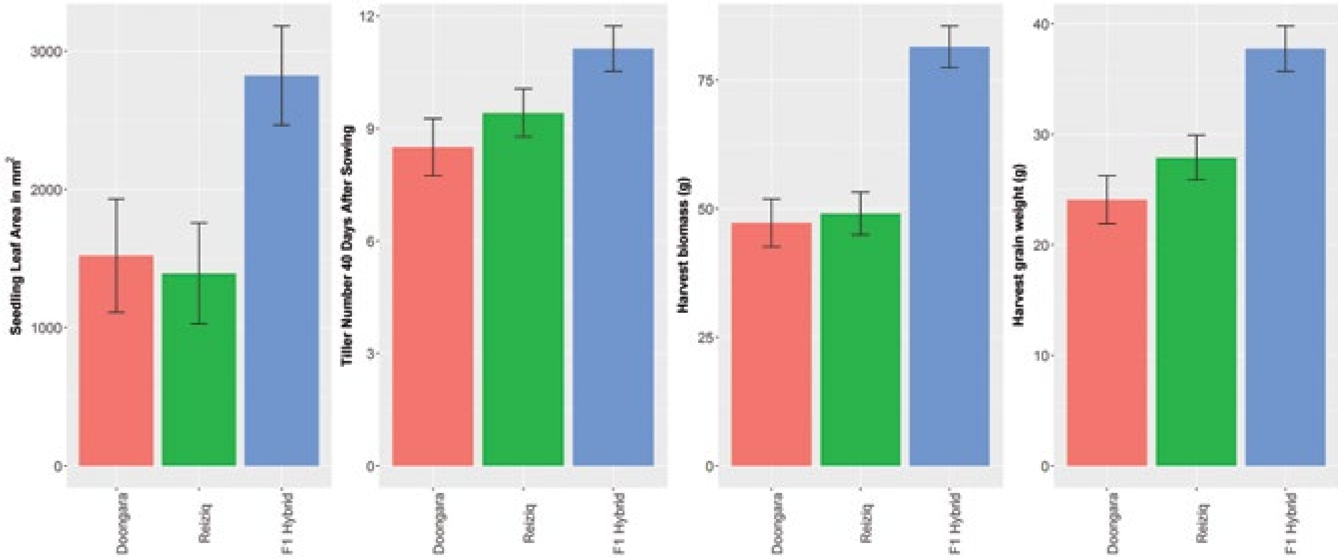


Figure 1. Hybrid rice outperformed both parents for a range of characteristics, including seedling leaf area (a), tillers at 40 days after sowing (b), harvest biomass (c) and harvest grain weight (d). The bars show Best Linear Unbiased Estimates with 95% confidence interval.

Hybrid vigour in Australian rice

Our results demonstrate clear evidence of substantial hybrid vigour in Australian rice. The significantly higher biomass accumulation and grain weight in the F1 hybrid are consistent with other reported results from much larger experimental and commercial comparisons showing hybrid rice has a significant yield and biomass advantage over the inbreeding hybrid parents.

Cultivated rice has two subspecies—*indica* and *japonica*. We used two *japonica* parents for our hybrid, in contrast to some hybrid production systems that use genetically wider crosses between the two subspecies. We combined the two separate pools of germplasm in the Australian rice breeding program and demonstrated that an F1 hybrid can outperform elite parents from both these pools. Hybrids between the two subspecies could be explored to see if they give better performance.

We are not aware of any other research documenting the performance of hybrids developed from Australian rice germplasm. We used two commonly grown varieties (Reiziq and Doongara) as an initial test for hybrid vigour. It is possible that other hybrid parents exist in the Australian breeding program that could give even better combinations of hybrid performance, especially where the two germplasm pools of elite breeding material in the breeding program could be combined.

Our experiment measured single plants grown under controlled conditions, so our results are likely to be different to results obtained from larger experiments conducted under field crop conditions. Our results raise further questions: Will the results we observed translate to the field environment? Is there any trade-off between hybrid vigour and increased yield and other characteristics important in Australian rice, like grain quality or reproductive cold tolerance? And how can hybrid seed be produced in a cost-effective way?

Hybrid rice technology and techniques have advanced considerably over recent years. Many of these questions have been addressed in other production systems over a long period of time, to the point where hybrid varieties are an established part of the production system in in several temperate rice growing regions internationally. In order to implement a hybrid breeding program in Australia, effective cytoplasmic male sterility could be integrated into Australian germplasm, or alternatively chemical gametocides could be employed. Other new methods of producing hybrid rice seed should also be explored to identify the best options available.

Hybrid technology could be a way of extracting a large genetic gain from elite Australian germplasm in a short time to rapidly realise the yield and water productivity benefits of hybrid rice. New breeding methods are being developed that could overcome many of the challenges previously faced in hybrid rice breeding, and our results indicate that there is a starting point of good hybrid vigour in elite Australian germplasm.

Further information

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New methods that could overcome many of the challenges previously faced in hybrid rice breeding have potential to rapidly realise the yield and water productivity benefits of hybrid rice.

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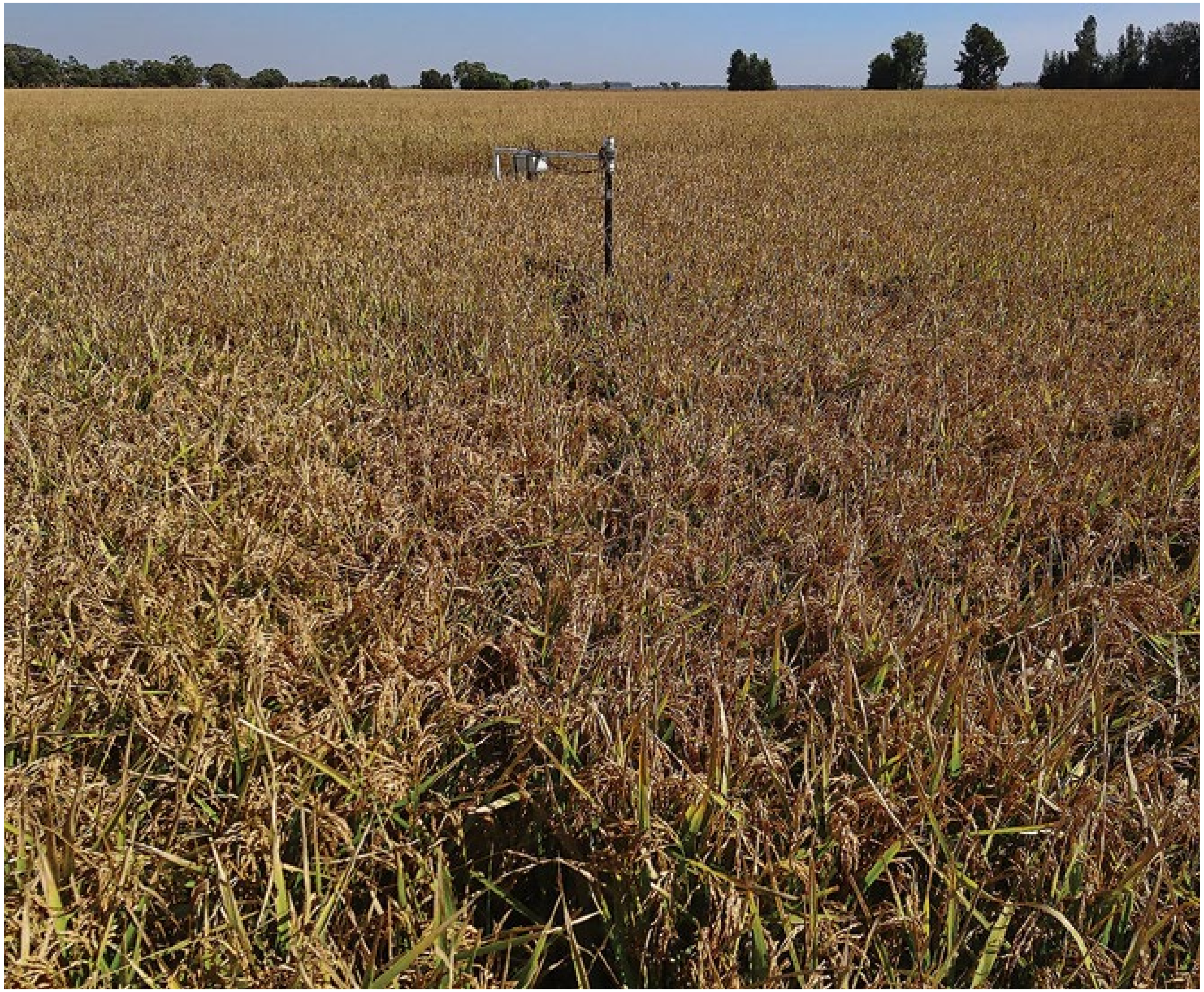
IN-FIELD SENSING SYSTEMS FOR MAXIMISING RICE FARM PRODUCTIVITY



James Brinkhoff and John Hornbuckle
Deakin University, Centre for Regional & Rural Futures, Griffith NSW

PHOTO: A WiField logger in a rice field near Whitton, NSW, April 2018. The logger is measuring water depth using an ultrasonic sensor and an Enviropro multi-level capacitance probe, as well as the temperature profile and soil moisture. PHOTO: James Brinkhoff

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QUICK TAKE

- **The use of in-field sensing tools for rice production has lagged behind other industries.**
- **Recently Deakin University developed a WiFi-enabled sensing system specifically for rice production systems. It monitors soil moisture profile, temperature profile and water level simultaneously using one probe, enabling growers to save water and maximise yields.**
- **The system can be used for optimising irrigation timing when using delayed permanent water, precisely managing water depth to protect the crop during cold periods and monitoring dry down after lock up.**
- **Data is available online in real time and can be linked to automation.**

Increased costs of irrigation water are driving rice growers to maximise returns on water and reduce water use as much as practically possible.

MOVING to management approaches such as delayed permanent water and precision ponding to optimise water use requires good knowledge of the soil and water environment in order to maintain productivity and profitability.

The demands of growing rice in temperate regions are quite different from those of growing other crops.

Low temperatures at the microspore stage cause spikelet sterility, particularly for low temperatures around the rice plant panicle and to a lesser extent around the root zone. Deep ponded water has been used in temperate rice-growing regions to insulate against cold-temperature events. However, in semi-arid regions, water is scarce, and ponded water leads to an increase in rice crop water use.

Careful management of water depth in rice fields is critical to achieve environmental and productivity goals. This necessitates monitoring and management of water level, as well as monitoring of temperatures at the root zone, in the water, at panicle height and ambient.

Recently, techniques to minimise water use have been investigated, such as alternate wetting and drying and delayed permanent water. Also, growing rice aerobically in temperate regions is gathering interest. These developments require the monitoring of soil moisture to ensure sufficient water is available for rice plant growth during periods where the water is drained.

Water scarcity and the resulting competition to secure water is seeing many farmers actively look to dynamically manage water height for controlling the temperature the rice crop is exposed to during critical growth periods. This will aid in maximising yield and improving water use efficiency by maintaining high water levels only when required.

Various sensors can be used to automatically monitor these parameters (water depth, temperatures, soil moisture status) in research settings, however simple, compact and robust options for commercial production environments have not been available. In order to overcome this limitation, the application of commercially available multi-level capacitance probes (MCPs) commonly used in cotton and horticultural industries (e.g. Enviropro probes) was investigated.

Determining water levels from MCPs

Water level is a critical measurement for rice crop management. MCPs have not previously been used for water level measurement. Commonly available MCPs have capacitance sensors spaced at 10 cm increments along the probe, allowing them to sense moisture throughout the soil profile. This project set about developing new relationships between these capacitance measurements and water levels. Laboratory and field based tests undertaken during the project showed a strong agreement between MCP-based determinations of water levels and those directly measured using ultrasonic sensors and manually. This provides advantages over the traditional method of using multiple sets of discrete sensors. A single MCP can measure temperatures at multiple heights and soil volumetric water content (VWC) data, along with water depth.

A multi-level capacitance probe (MCP) sensor installed at rice sowing time. The installation of the sensor with half above and half below the ground allows a full characterisation of the rice growing environment (soil-water-ambient) from a single robust probe.

Simple sensor installation

The installation of MCPs in rice fields is similar to that used in non-ponded crops. However, rather than install the probe to full depth, half of the probe is installed in the soil and the other half of the probe above soil level. This allows a single probe to measure both the soil moisture and root zone temperatures as well as measure ponded water depth and crop temperatures, all at 10 cm intervals.

Common probe lengths are 80 cm, 100 cm, 120 cm, so that at least 40 cm is available for soil measurement and 40 cm for water and ambient measurement.

Data at your finger tips

The MCP sensors can be linked to WiFi data loggers developed by Deakin University and sold through Goanna Telemetry, called WiFields. This approach provides up-to-the-hour data on websites that can be viewed from computers or mobile phones. One advantage of using MCPs in this application is the range of useful data available. As well as water depth, soil moisture and temperature readings at fine intervals (10 cm) can be obtained. The soil moisture data is shown in the lower graph of Figure 1. Early in the season before permanent ponded water is applied, the soil at 50 mm and 150 mm starts to dry out considerably during the delayed permeant water phase and the sensors can be used to trigger irrigation events to ensure the rice root system is not stressed. Figure 1 shows that it starts to dry again after the ponded water is drained in early-April. Using the soil moisture information is particularly important in these early and late parts of the rice growing season to ensure the soil does not reach moisture stress levels, which would be detrimental to yield.

Figure 1 also shows associated crop temperature data over the growing season. It can be seen that there are periods when the crop temperature is falling below the critical 15 °C level which is likely to have impacts on crop yield. The MCPs can be used to see the impacts of ponded water depth and its effect on temperature buffering the crop from cold weather events and can be used modify water depth management.

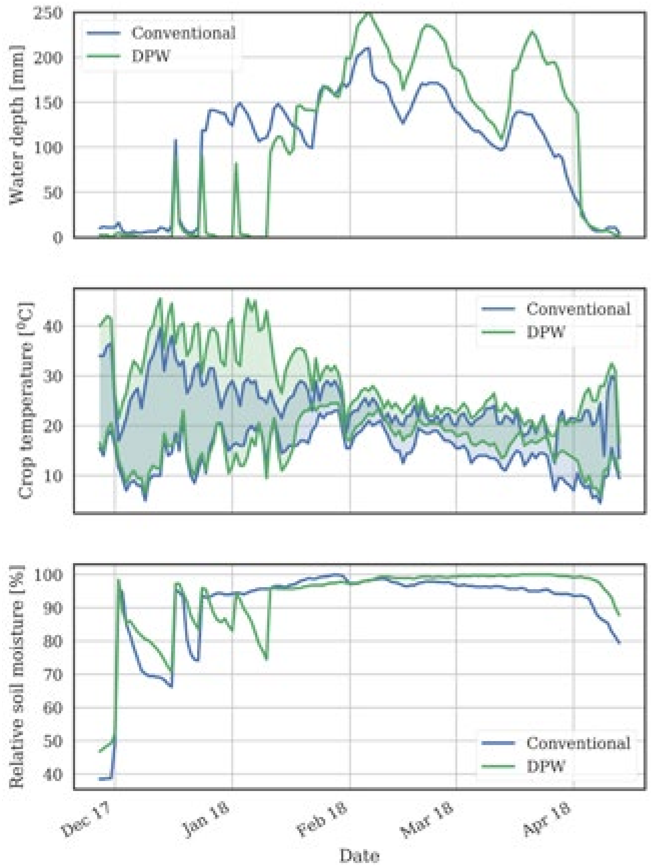

Figure 1. MCP sensor data for a comparison of DPW and conventional rice growing systems. Water depth, minimum and maximum daily temperatures at 15 cm above the soil and total relative soil moisture are shown.

The multi-level capacitance probe (MCP) sensor just prior to rice harvest.

Temperature data from the rice field at two dates is shown in Figure 2. On both of these dates, there were significant cold events. The first date is 15 February 2018, which for a late-sown crop in NSW, Australia would fall close to the critical microspore phase. If the rice panicle was subject to the cold ambient temperature of 6 °C, there would likely be a significant negative impact on yield. The second date is 8 April 2018, when there would not be such sensitivity to cold because the rice has passed the microspore phase. On the first date, the water was around 200 mm. It can be seen that this provided effective insulation against the cold temperatures at panicle height (around 200 mm), keeping the temperature there above 12 °C. The water effectively maintains warmer temperatures above the surface of the water through its stored energy. In contrast, at the second date, no such insulation was provided as the water had been nearly drained. This provides a useful illustration of how temperature at multiple heights can be used to manage rice paddy water depth to effectively insulate the crop from cold temperatures.

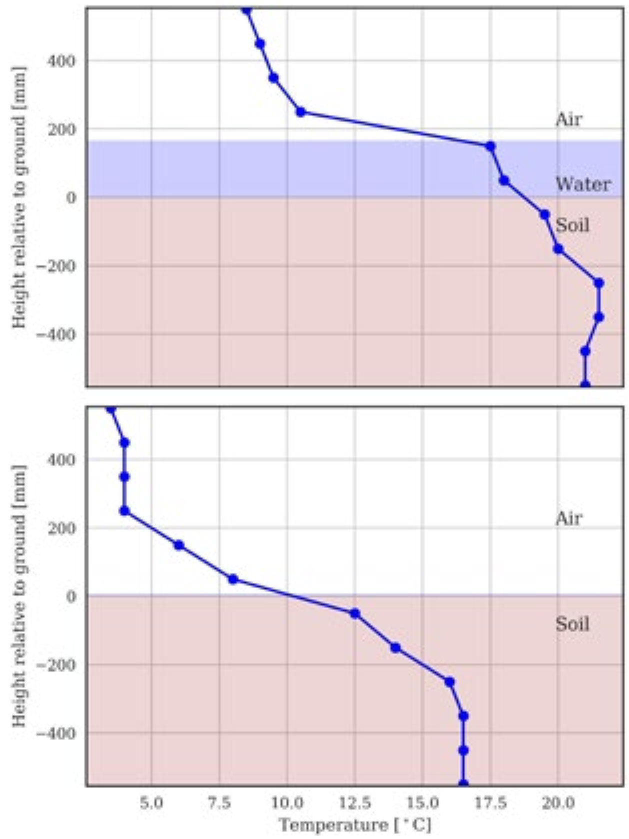

Figure 2. Temperature profiles measured by the MCP during cold temperature events (15 February 2018 and 8 April 2018 6 am). The measured water depth is indicated with blue shading.

Where to from here

The developed in-field sensing systems using MCPs have proven to be robust and well suited to the rice growing environment. Parameters measured by the sensing system are applicable to automation, and this would provide maximum benefit for rice growers. A smart automated rice irrigation system that linked this sensing data with weather forecasts and automated water control has the potential to deliver significant water saving and productivity gains.

Acknowledgments

The authors acknowledge the support of project funding from AgriFutures Australia, and thank Garry Knagge, Chris Morsehead, Russell Ford, Alex Schultz, Don Griffin and Samuel North.

More information

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For more information on the method, see the full paper at http://www.mdpi.com/1424-8220/18/1/53

The developed in-field sensing systems using MCPs and WiField loggers are available from Tom Dowling at Goanna Telemetry: info@goannatelemetry.com.au

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WHAT'S THE LIKELIHOOD OF GOULBURN, MURRAY AND MURRUMBIDGEE RIVER INFLOWS IN 2018?

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This article is based on a paper presented by the author at the GRDC Grain Research Update (Moama), 26 July 2018

QUICK TAKE

- The 2018 season is delicately poised, for both winter and summer crops.
- At the time of writing, there is no El Nino but there are indicators that one could form. However plenty of random things need to happen first.
- The Indian Ocean has started playing unfair with a positive Indian Ocean Dipole like cooling off Indonesia and associated lack of cloud; stronger pressure needs to decrease, or the effect could be similar to either phenomena, i.e. El Nino or positive Indian Ocean Dipole.
- Catchments of the south-eastern Murray–Darling Basin are influenced negatively by high pressure, particularly during winter.

Many weather models predicted an El Nino for spring and the odd model forecast one for late winter. During the winter, only one climate indicator seemed to be within a 'bull's roar' of an El Nino.

DESPITE models and predictions, rainfall in many areas was less than average in autumn and winter—what we might expect with an El Nino event. So, what has got the models fired up this year?

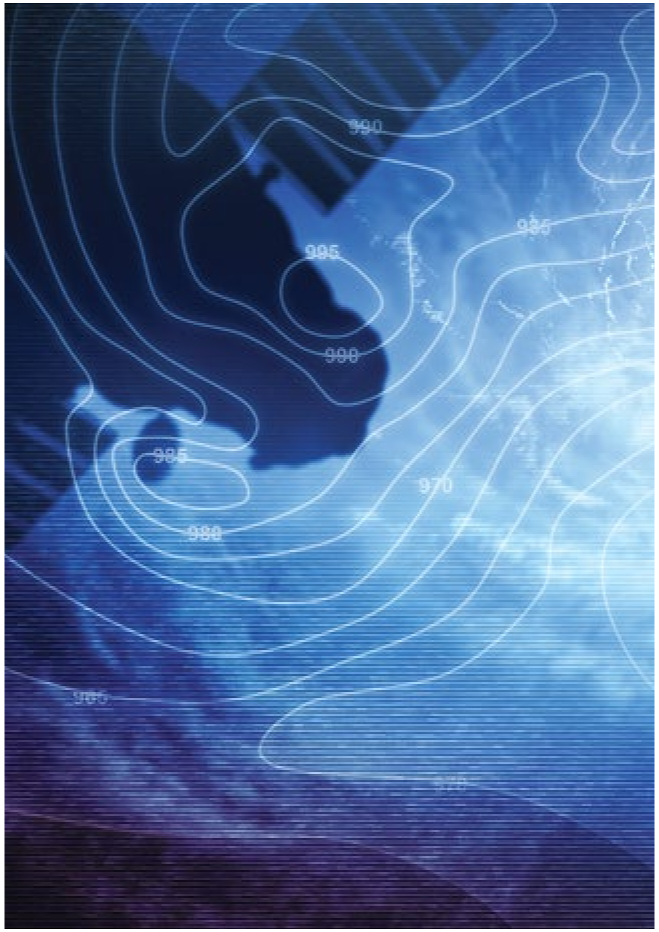
It's all to do with the undersea heat that developed in the eastern equatorial Pacific Ocean as a result of a strong burst of reversed trade winds in February. This strong west wind near Papua New Guinea sent warm water under the Pacific and on its way to the South American coast. Such a beginning is essential for the start of an El Nino, but fortunately it doesn't guarantee one.

Looking at some recent undersea cross section data from 1982 to the current date, the years where undersea temperatures were warm in winter have been extracted and followed onto spring to see what eventuated (Table 1).

Strong warming that developed early and lasted through the season, such as 1997, 2009 and 2015, is fortunately not

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)



Despite no indications of El Nino in climate models through winter, the season remains dry.

as common as other years. More common is the warming that starts in the winter and develops in the spring, such as 1982, 1991, 2002, and 2006. Some years show promise for the development of an El Nino but it does not eventuate, such as 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 years, but have often been joined by a positive Indian Ocean Dipole in winter, which has resulted in very dry seasons. Likewise, some of the failed El Ninos have been dry due to the positive Indian Ocean Dipole popping up. This year the Indian Ocean has been behaving strangely with a suspiciously positive Indian Ocean Dipole "like" cooling off Java in Indonesia and an associated lack of cloud off Sumatra. Pressure has also been higher over the Indian Ocean, making moisture transport from the north-west harder.

Models were adamant in July that a positive Indian Ocean Dipole was going to occur. This hasn't really happened and yet north west cloud band activity has been very poor, a common result of positive Indian Ocean Dipole. So, what of this year?

Well apart from the warm Pacific undersea, as of July, there were no El Nino indicators and little evidence by the Pacific Ocean to develop one. The Southern Oscillation Index, trade winds and cloud patterns at the dateline were not interested in forming an El Nino either. Even if they started during winter, it would be unlikely that an El Nino would be seen for many months.

Yet things aren't as wet as we would like. The reason for this has been the domination of higher pressure over south east Australia for May and June. Sometimes the positive Indian Ocean Dipole 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 south east Australia for the last 110 years.

Effect of conditions on river inflows

Figures 1, 2 and 3 show river flows in various years. High pressure during winter has a strong effect on catchment drying, but not in every year. It also affects spring 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 effect (but not always), quite like higher pressure.

Figures 1, 2 and 3 also indicate the effect of so called 'neutral years' where the Pacific and Indian oceans do nothing. Historically, river flow was close to climatology in those years, i.e. an equal third of the time the outcome was drier, average or wetter. For this same reason, model predictions for average rainfall are actually the same as 'neutral years'. Occasionally models have a stronger probability of average being the outcome, but in my years of monitoring models, this has been uncommon.

Catchments of the south-eastern Murray–Darling Basin are highly affected by the ENSO and IOD phenomena during winter and spring. They are also influenced negatively by high pressure, particularly during winter.

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High pressure during winter dries out the catchment (but not every year) and affects spring flow rates due to slow charging of the catchment.

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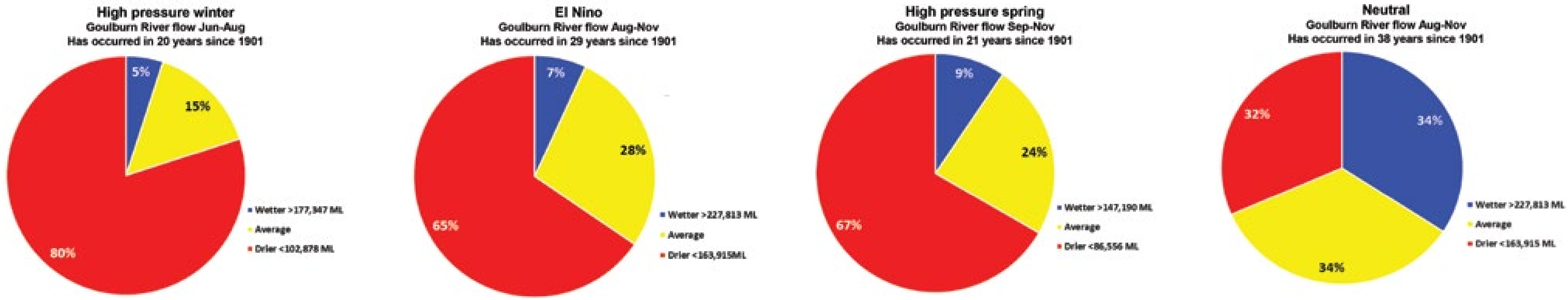

Figure 1. Goulburn River flows since 1901 when the season has experienced high pressure, El Nino or it has been a 'neutral' year.

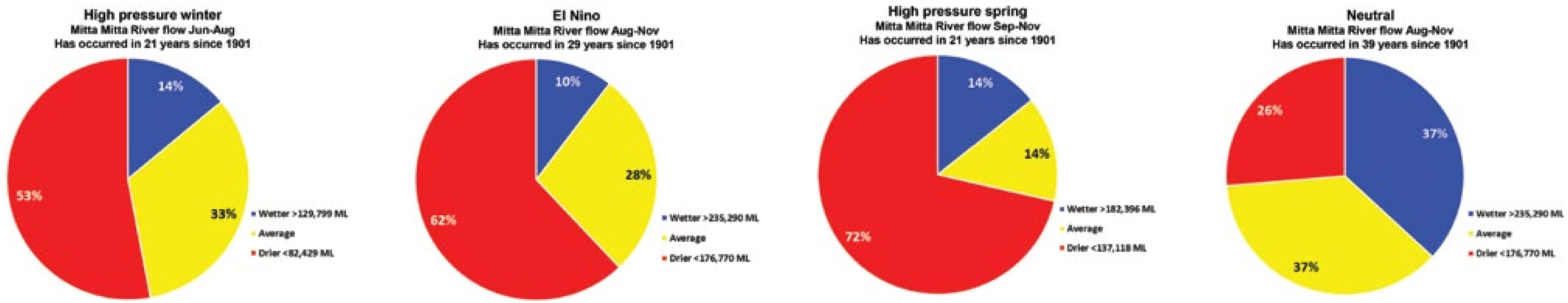

Figure 2. Mitta Mitta River flows since 1901 when the season has experienced high pressure, El Nino or it has been a 'neutral' year.

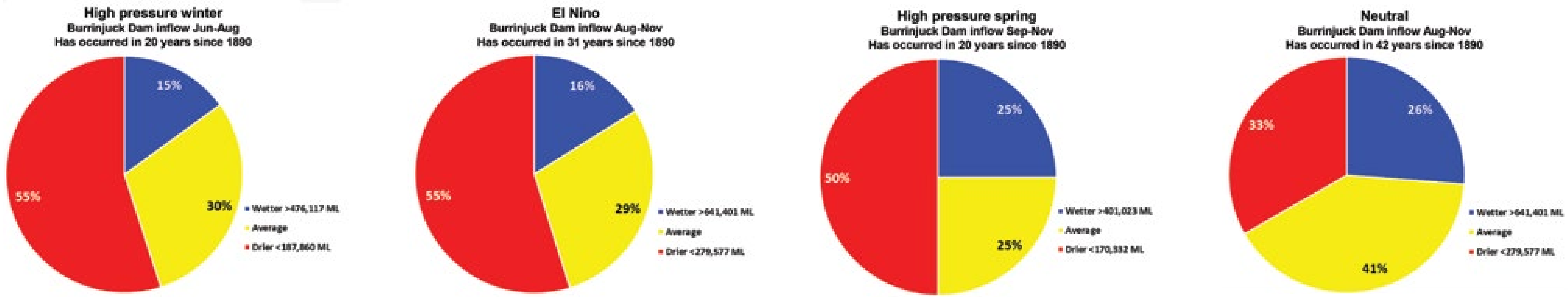

Figure 3. Burrinjuck Dam intake since 1901 when the season has experienced high pressure, El Nino or it has been a 'neutral' year.

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