Irrigation Research & Extension Committee

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In this edition

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Editorial

The IREC Farmers' Newsletter welcomes all suggestions and contributions for articles from irrigators, advisors and researchers in government and commercial sectors. If you have suggestions for articles or wish to contribute an article please contact the Editor. Please submit articles for the next edition, Autumn 2018, to the editor by February 2018.

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Cover: Daisy and Matt Toscan of Cavaso Farming, Darlington Point. Cavaso Farming is the Monsanto Cotton Grower of the Year for 2017. PHOTO: Virginia Tapscott

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Chairman's foreword

Welcome to the Spring 2017 edition of the IREC *Farmers' Newsletter*. I trust you are rested and ready for a busy summer cropping program.

THIS time last year we couldn't get onto our fields due to the big wet. It always amazes me how adaptive farmers have to be from one year to the next. Rest assured we will have a new suite of challenges for the year ahead!

I am very happy to announce that IREC has formalised a partnership with the Coleambally Community Bank® Branch and the Hillston & District Community Bank® Branch of the Bendigo Bank. Huge thanks to branch managers Chris Noack and Paul Lenon and their boards for future generous support of IREC. We look forward to working with them in the coming years.

IREC field station

Work is well underway on the upgrade of the recirculation and storage facility at the IREC field station at Whitton. We aim to have a fully automated storage and recirculation system that will further enhance current automation in the field, as well as the Murrumbidgee Irrigation (MI) total channel control project.

I would like to take this opportunity to thank the Cotton Research & Development Corporation for their continued support of the field station.

Going forward, the plan is to run a five-year rotation trial with cotton back to back, along with a wheat and fallow rotation. In the longer term it will possibly include other summer crops such as maize, rice and legume crops.

We have a working group made up of farmers and advisors who will have input into this and other projects. If you have any suggestions on what you would like to see within this trial, please don't hesitate to call our IREC office and let us know. This site is all about providing good demonstrations that lead to better outcomes for all of our members.

So, if you are not a member of IREC, click your way to the IREC website and become one. Make sure you nominate which irrigation district you are a member/shareholder of, for an even cheaper membership fee. Coleambally Irrigation Co-operative Limited (CICL) members are automatically IREC members, due to current arrangements in place. MI shareholders have access to a reduced fee but must register online to become an IREC member. Your support is much appreciated and will only strengthen your IREC.

MI project

The MI modernisation program is in full swing, with Division 3 automation on schedule for completion during the 2017–18 irrigation season. This will be a groundbreaking year for MI, with the use of new technology over such a large area of the MIA. Total channel control will dramatically improve the efficient delivery of water to the farm gate. It will greatly enhance our ability to reduce waste and improve the timeliness of an irrigation event on farm. I would like to congratulate the staff and board of MI for their progressive approach to this technology. This program will have wider implications in future for all irrigators within the MI supply system.

Drone and Technology Day

The Drone and Technology Day was a huge success with over 140 people attending. We were exposed to the many possibilities for technology in the future. There were plenty of technologies on display, which you can read about on page 27, where Iva Quarisa gives us a run down of events on the day. This day is another example of our excellent relationship with Deakin University. I would like to thank them for their involvement on the day and support over the past 12 months. We hope to grow this relationship into the future.

I hope you enjoy this edition of the Farmers' Newsletter and have a prosperous summer cropping season.

Regards,

Robert Houghton

Cotton harvest at Whitton in 2017. Early seed orders for 2017–18 indicate planting intentions of over 80,000 ha for the southern cotton growing region.

A CHALLENGING COTTON SEASON

Growing cotton in 2016–17 was difficult with a very wet start, cold shocks in November, high insect pressure before flowering, then hot conditions in a short flowering period.

Kieran O'Keeffe
Regional Extension Officer
CottonInfo Southern NSW

COTTON growers and advisors in the Lachlan, Murrumbidgee and Murray valleys completed an end-of-season survey. There were 24 responses representing 16,864 ha or 30% of the 2016–17 crop.

There were no surprises with yields, with most in the 8–10 bales/ha range and some earlier planted fields at 12–14 bales/ha. Crops planted in November had lower yields in most cases. In general, quality was base grade or better but there was some low micronaire and leaf discounts.

Prices for lint and seed remain well above the long-term average. Even in a below-average yielding season, the returns per ML still averaged $210/ML.

Gross margin averaged $1971/ha. In a challenging production season, it is pleasing to see that most growers achieved over the target gross margin of $1500/ha.

Four new *Bollgard 3* varieties were grown commercially for the first time and it will take a few more seasons to see where grower preferences end up. 714B3F was the highest yielding in three of four local trials, and 746B3F was highest at the Hay variety trial.

Constraints on productivity

The survey also asked, "What do you see as the biggest constraint on productivity?" By far the most common response was around water:

- water availability
- water price
- supply constraints within the irrigation system.

The second-most common response was the build-up of soil diseases such as black root rot.

The third-most common response related to spray drift issues.

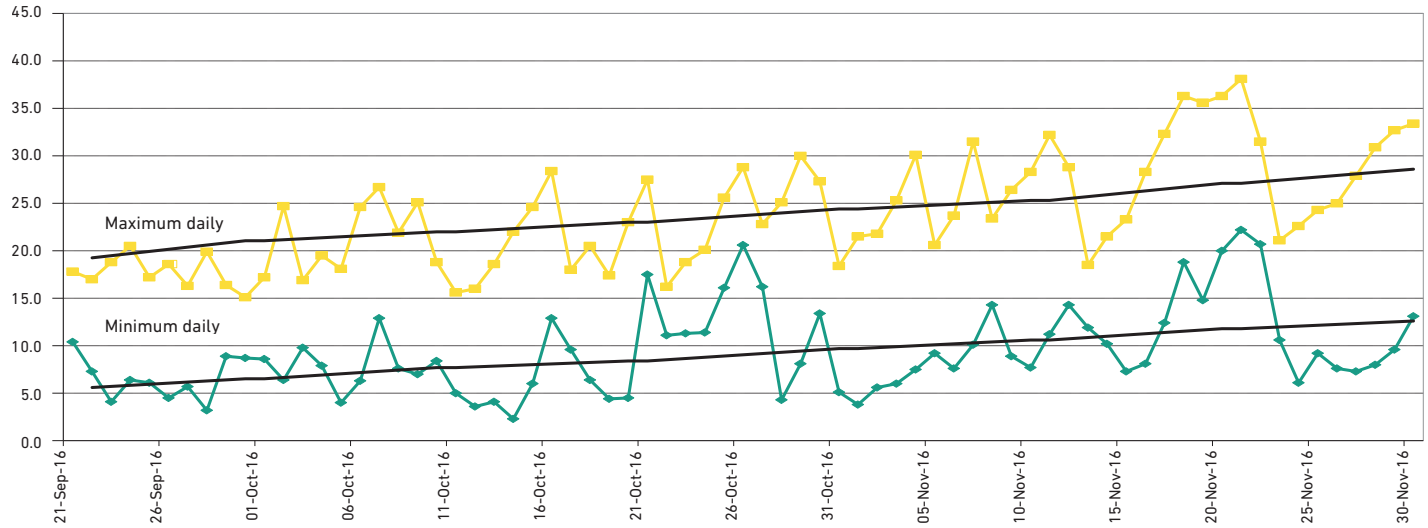

Figure 1. Establishment temperatures Griffith 2016.

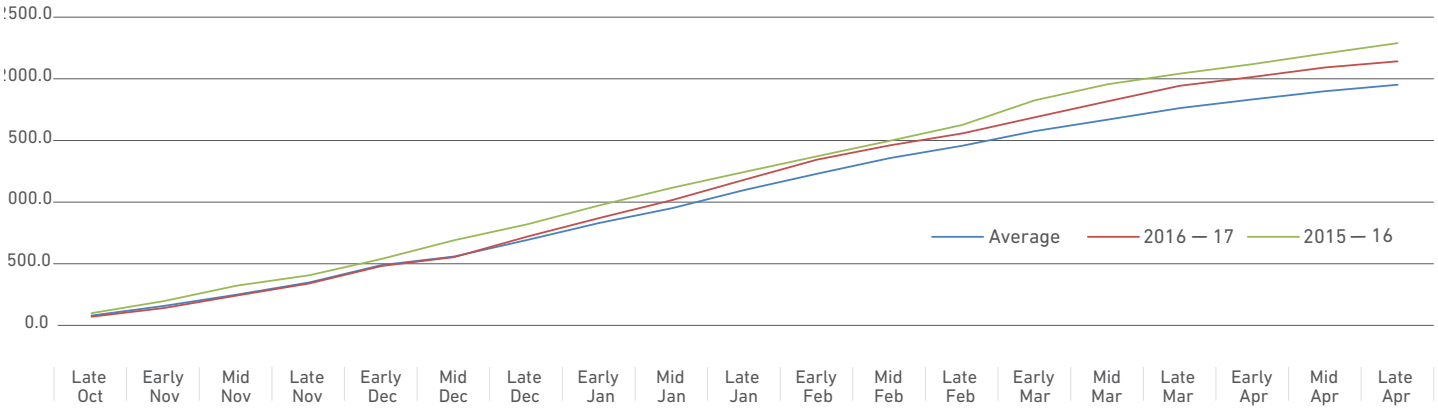

Figure 2. Day degrees 2016–17.

In a challenging production season, most growers in southern NSW achieved over the target gross margin of $1500/ha, with an average $1971/ha.

Table 1. Gross margin comparison for 2016 and 2017

Season	Total income	Variable costs	GM/ha	GM/ML
2016	$7200/ha	$3895/ha	$3305	$330
2017	$5376/ha	$3398/ha	$1971	$209

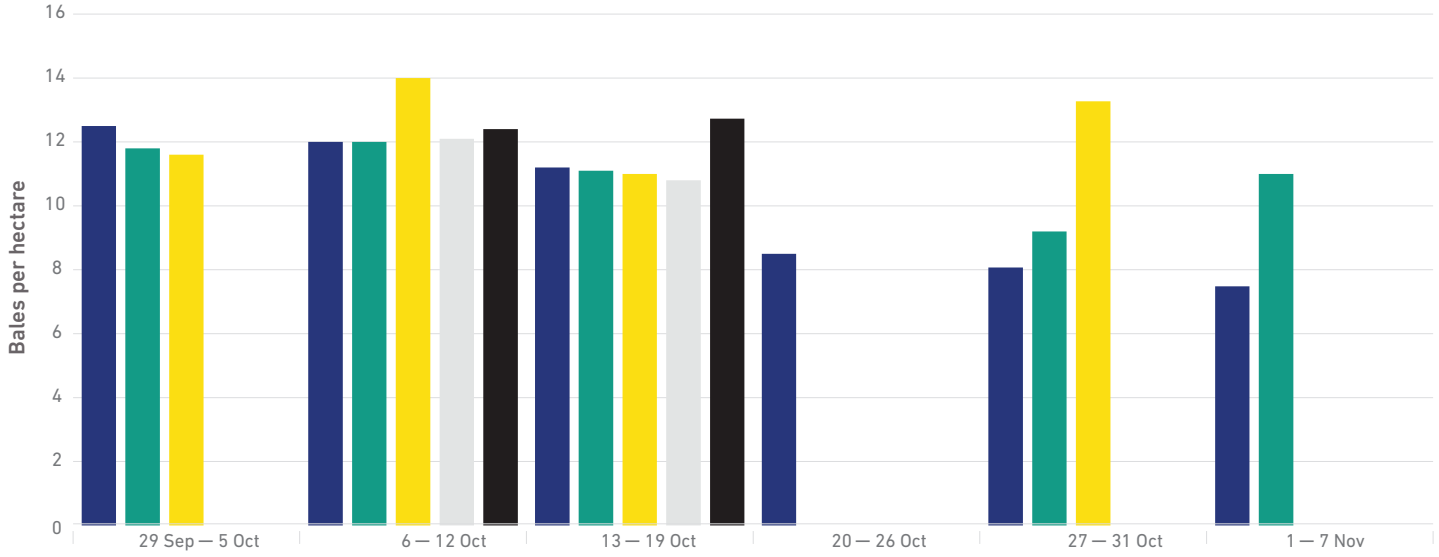

Figure 3. Time of sowing for best yielding crops, 2017.

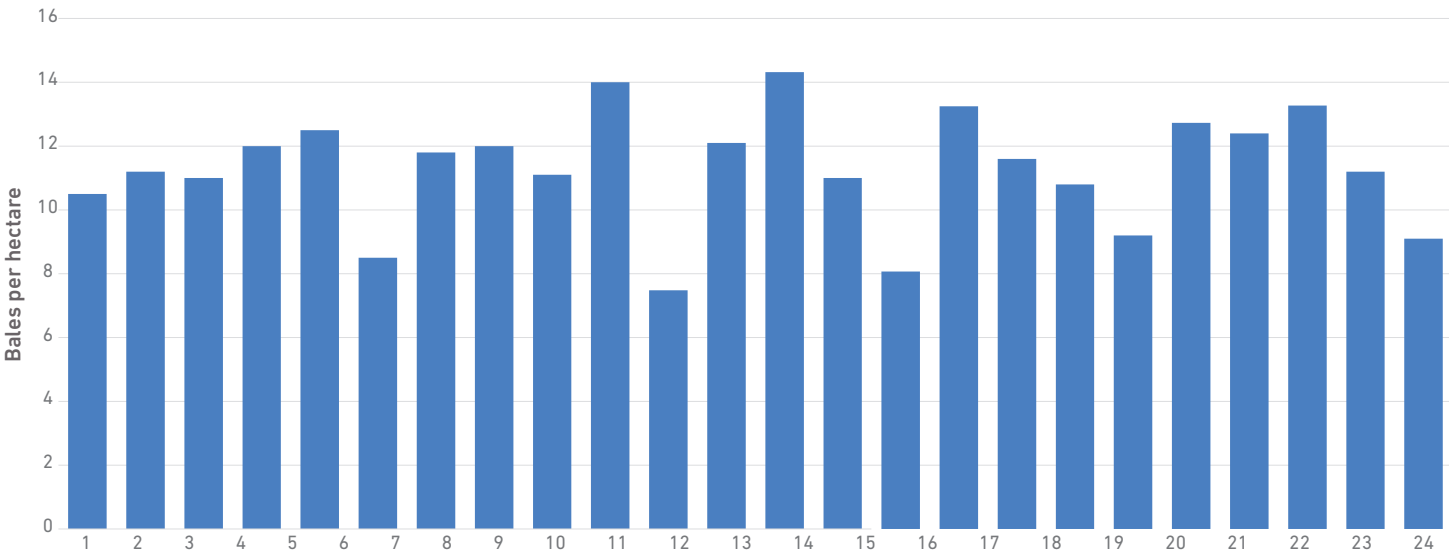

Figure 4. Highest yielding fields for 24 respondents, 2017.

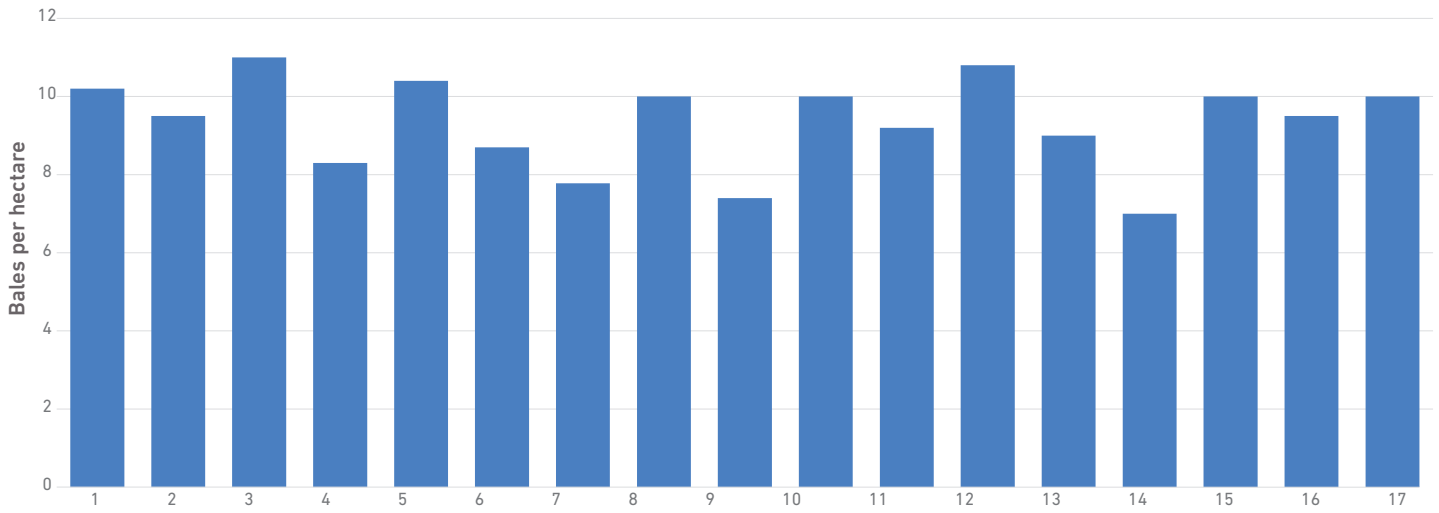

Figure 5. Farm averages for 17 farms, 2017.

Redevelopment of the CSD seed processing facility at Wee Waa aims to to service the industry for the next 30 years and produce cotton seed for one million hectares across Australia. PHOTO: Josh Smith CSD

From strength to strength

This year, the Cotton Australia Cotton Collective was held in southern NSW for the first time. Held at Griffith in late July, over 500 cotton growers, advisors and industry personnel attended the event. The Australian Cotton Industry Awards were held in conjunction with this event and the Monsanto Grower of the Year award went to Cavaso Farming, the local partnership of the Toscan family, at Darlington Point and Coleambally. This is a tremendous achievement for the whole Toscan team and a positive boost to the local irrigation industry.

The grower-owned company Cotton Seed Distributors celebrated its 50th anniversary this year. The company's $90 million redevelopment of the seed processing facility at *Shearstone*, at Wee Waa, is well advanced. The facility will have the capacity to service the industry for the next 30 years with a target of producing cotton seed for one million hectares across Australia.

There has been very strong interest from new growers about how to enter the cotton industry for the first time. Early seed orders for the 2017–18 season indicate that planting intentions are over 80,000 ha for the Lachlan, Murrumbidgee and Murray valleys.

Further information

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CottonInfo

CottonInfo is a joint venture of CSD, CRDC and Cotton Australia.

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Daisy and Matt Toscan of Cavaso Farming, Darlington Point. Cavaso Farming is the Monsanto Grower of the Year for 2017. PHOTO: Virginia Tapscott

VERSATILE IRRIGATION BUSINESS RECOGNISED AND AWARDED AGAIN

Cavaso Farming has achieved impressive results and improved the profitability of its farm operation since introducing cotton to the annual crop rotation seven years ago.

Lucy Kealey, Kieran O'Keeffe & Iva Quarisa
IREC

RECOGNISING its achievements growing cotton, Cavaso Farming, which is the business of Tony, Joyce, Matt, Daisy, James and Mel Toscan, was awarded the Monsanto Grower of the Year at the Australian Cotton Industry Awards 2017. This is the first time the title has been awarded to a farming business in the Murrumbidgee Valley.

Cavaso Farming is a 4200-hectare enterprise at Darlington Point and Coleambally that grows 1100 hectares of cotton, along with other crops including durum wheat, popcorn, maize and prunes. The Toscans have a cotton–wheat rotation employing minimum till and controlled traffic, using siphon and bankless irrigation, supplied by an automated system and they are now achieving average yields of 12 bales per hectare.

Integrated pest management (IPM) helps encourage beneficial insects and protect bees on the farms. Having Murrumbidgee river frontage means that the Toscans are focused on environmental improvements, including fencing off riparian zones and installing water troughs.

Farming in a new cotton growing area means biosecurity has been given the highest priority, keeping contractors and traffic entering the farm to a minimum and installing well signposted wash down facilities. The business has attained MyBMP certification and has meticulous record-keeping practices.

The Toscan family is a long-standing supporter of IREC and its activities. In fact, the family won the IREC Irrigated Farm Competition in 1997. At that time, the competition judges acknowledged and commended their implementation of best management practices, as outlined in the local Land and Water Management Plan, to achieve economic and environmental sustainability.

IREC congratulates Cavaso Farming on its latest achievement in agricultural excellence, and applauds the continual development of the business, through adopting new crops and practices in the pursuit of profitability and sustainability. They are very deserving ambassadors for the irrigation industry.

Integrated disease management is the key to prevent the profitability of cotton being reduced by the seedling disease, black root rot. PHOTO: Virginia Tapscott

BLACK ROOT ROT THREATENS PROFITABLE COTTON PRODUCTION

QUICK TAKE

- **Black root rot delays successful establishment of cotton crops, and makes seedlings more susceptible to other soil-borne diseases.**
- **Summer flooding of fields for 30 days when daytime temperatures are above 30°C is a recognised treatment of the disease in the USA. This could be an option for some growers, especially those with rice suitable soils and layouts.**
- **The best way to manage the disease is an integrated approach to black root rot management, which includes rotations of crops that do not host the disease, fallows, biofumigant crops and avoiding waterlogging during crop establishment.**

Black root rot fungus together with other seedling diseases can result in plant stand losses of 30% or more in new cotton crops.

Kieran O'Keeffe
Regional Extension Officer
CottonInfo Southern NSW

Andrew Watson
Plant Pathologist
NSW Department of Primary Industries, Yanco Agricultural Institute

BLACK root rot, caused by the soil fungus *Thielaviopsis basicola*, was first observed in Australian cotton in 1989. It has a wide host range causing disease in over 137 species of plants. The fungus survives for long periods in the soil as resistant resting spores. Infection of cotton is favoured by soil temperatures below 20 °C, which is normal at planting time.

Research in the USA has shown that severe disease symptoms result when the population of the black root rot fungus reaches 100 spores

Cotton seedlings grown in soil that had previously grown cotton (left), showing more severe symptoms of black root rot than seedlings grown in soil that had previously grown rice (right).

per gram of soil. Populations of 600–700 spores per gram of soil have been found in Australian cotton fields.

Black root rot fungus does not kill seedlings by itself, however severe infection will render cotton more susceptible to other seedling diseases such as *Pythium* and *Rhizoctonia*. Stand losses of 30% or more are common from combinations of these seedling diseases.

Seedlings affected by black root rot are stunted and slow growing. In effect, the disease 'steals' time from the crop leading to delayed maturity and yield loss. As weather conditions and temperatures improve, infected cotton crops will recover but in poor establishment conditions, yield reductions of 25–50% have been attributed to black root rot.

Initial investigation

A field in the MIA was identified as having reduced cotton yields due to black root rot. The field had a long cropping history of black root rot host crops, mostly 'back to back' cotton and one faba bean crop. Previous research in 2000 in northern NSW by NSW Agriculture researcher David Nehl showed that summer flooding of fields was very effective in reducing black root rot spore loads to very low levels (Table 1.)

Flooding of the field before planting cotton is a method used to control soil-borne diseases of cotton in parts of California. Growers there report that the severity of black root rot is reduced substantially in the next four cotton crops after flooding. Ambient temperature is an important factor. Flooding is most effective during summer when there is a minimum of 30 days with maximum air temperature at 30 °C or more.

One way to achieve summer flooding in California was to grow a rice crop in the field. This was also an option in the MIA field due to the bankless layout and good water availability in the 2016–17 season.

Soil samples to 15 cm were collected and sent to a specialist microbiology laboratory before and after the rice crop. Testing for black root rot showed that the spore level dropped from 180 spores/g of soil to 65 spores/g of soil. This test has the potential to be developed as a predictive tool for growers and consultants. Cotton seedlings were grown in glasshouses in the two soil samples at Yanco (NSW DPI) and the reduction in severity and incidence of black rot root symptoms was confirmed (see photos above).

Table 1. Decline in the population of *Thielaviopsis basicola* after summer flooding of a field at Merah North (west of Wee Waa) for 57 days, February and March 2000.

	Sampling position	
	50 m from head ditch	50 m from tail drain
Water depth (cm)	30	55
Soil temperature max* (°C)	26.2	25.6
Soil temperature min* (°C)	23.8	24.1
Population before (spores/g soil)	359	485
Population after (spores/g soil)	8	19
Population reduction (%)	98%	96%

*10 cm below the top of the bed

Biofumigant crops

The concept of biofumigation involves planting a crop that releases compounds that are toxic to pests or pathogens in the soil. It involves growing and harvesting the biofumigant plant as either a rotation crop or as a sacrificial crop that is sprayed out and incorporated (brown manuring) or freshly incorporated (green manuring) into the soil prior to planting cotton. The effectiveness of biofumigation relies on the bulk of the crop being incorporated at least four weeks before planting cotton to allow breakdown of the material so there are no phytotoxic effects on the following cotton crop.

A number of crop types have been trialed over the years as biofumigant crops including woolly pod vetch, mustard, canola and fodder radish. Three seasons of trials on different fields in northern NSW resulted in a 28–70% reduction in black root rot disease severity from Indian mustard and a 24–61% reduction from woolly pod vetch.

A biofumigant crop growing in northern NSW as part of CRDC Verticillium wilt management research. The crop will be green manured in mid-August and cotton planted at the start of October . PHOTO: Geoff Hunter, CottonInfo Namoi region.

Although biofumigation does not eradicate the disease from the soil it does reduce disease severity enough to warrant its use. Woolly pod vetch has been used successfully as a biofumigant for black root rot of cotton in the USA and Australia, and it has the added benefit of providing substantial amounts of nitrogen for the following cotton crop.

Integrated disease management

Rice in the rotation could be an option for some cotton fields in southern NSW to reduce black root rot spore loads. Layouts and soil type needs to be suitable for this to be a practical option. The rice crop should be followed by a cereal crop (not fully irrigated) and a summer fallow over summer before a return to cotton.

Summer flooding of fields for 30 days when daytime temperatures are above 30 °C may be a good alternative option for some growers.

The use of biofumigant green manure crops also has merit. Woolly pod vetch has been the favoured option as it provides significant nitrogen to the following crop and is not a black root rot host. Other crops such as canola, mustard and forage sorghum need further investigation and research.

The best option — don't get to this point! Use a sensible rotation with a break of non-black root rot hosts such as cereals and clean fallow periods.

It is important to have an integrated approach to black root rot management. Several control methods used together have the potential to hold black root rot at low levels, these include:

- Dynasty Complete™ seed dressing
- farm hygiene to stop further spread
- growing biofumigation crops
- avoiding rotation with crops that are hosts for the pathogen
- cultural methods such as delayed planting of fields
- good layouts to avoid waterlogged areas.

CottonInfo received funding for this investigation and microbiology testing from the Cotton Research Development Corporation.

Further reading

Disease management
CottonInfo — Information for growers

Black root rot fact sheet
CottonInfo — The IDN fast fact series October 2016

Black root rot and slow early season growth of cotton
CRDC, David Nehl, Final report, Project DAN 122C

Quinoa presents a new cropping opportunity for Australian grain growers, and as part of a national program, trials are underway to determine the performance of the crop in the Riverina.

QUINOA: AN EMERGING INDUSTRY FOR THE NSW RIVERINA

QUICK TAKE

- Quinoa is a relatively new food in western diets, popular with consumers and presenting a new cropping opportunity for Australia farmers.
- Australia relies heavily on imported product to meet consumer demand, with over 1000 tonnes of quinoa being imported annually, while national production is about 400 tonnes.
- In Australia, quinoa can be grown as either a summer or winter crop and is seen as a good fit within existing cropping programs, depending on soil type, rainfall and environment.
- Trials at Leeton are part of a national project evaluating varieties and required agronomy to successfully produce quinoa in various regions throughout Australia.

Quinoa is increasing in popularity in Australia and other developed countries due to its nutritional qualities. The seed has high protein content, low glycemic qualities and is gluten free.

David Troldahl
R&D Agronomist Southern Irrigated Cropping Systems
NSW Department of Primary Industries, Yanco Agricultural Institute

QUINOA has been grown as a crop in Peru and other South American countries for approximately 10,000 years and has been a major staple in the diet of the indigenous Andean people. Since the 1990s there has been a resurgence of growing quinoa and other traditional crops in South America due to government support in this area.

Quinoa is a versatile seed that can be consumed whole or processed into a range of food products. Global production of quinoa needs to meet global consumer demand while honoring appropriate biosecurity and intellectual property regulations. Up until 2014, global demand was greater than production but since then production has risen and there is currently a small oversupply of quinoa worldwide.

Preliminary trials at Leeton are promising but some aspects of crop management need addressing before recommendations are made.

The national trial program will provide understanding of required growing conditions and challenges to quinoa production in Australia.

Opportunity for import replacement

Australians consume more quinoa than is currently produced here and import over 1000 tonnes of quinoa annually, while only producing around 400 tonnes. Australia therefore relies heavily on imported product. This situation presents an opportunity for Australian growers to replace the imported quinoa with locally produced quinoa.

The main factors limiting the development of a quinoa growing industry in Australia include:

- growers not being able to access seed that has known growing characteristics and performance suited to their geographical location
- growers not having to access seed that has a certified germination rate and is free from weed seeds
- access to facilities to remove saponin (soap-like glucosides) from seed
- clear marketing options for seed produced.

The quinoa industry in Australia is in its infancy and scaling up will require time and investment to overcome key barriers along the supply chain, from paddock to plate.

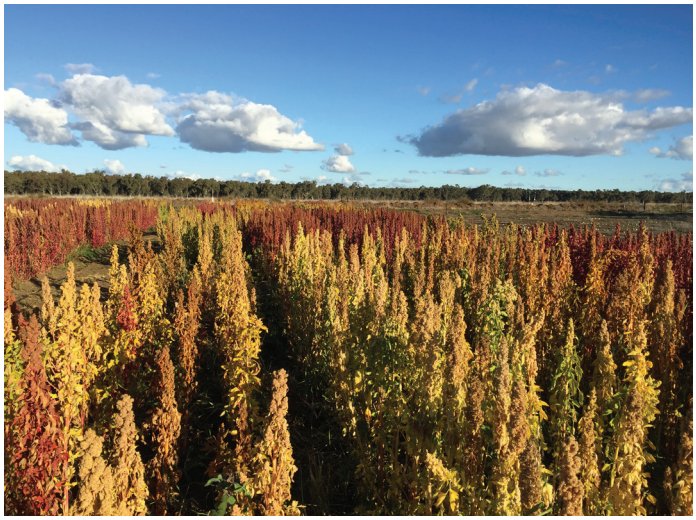
Australian investigation of quinoa

Interest by prospective growers in the Riverina was shown at a quinoa information day held late in 2016 and at the first quinoa field day held at NSW DPI's Leeton Field Station in June 2017. The field day highlighted the ability for quinoa to be grown in the Riverina, however this is a preliminary trial and a number of crop management issues still need to be looked at before any recommendations can be made.

Quinoa can be grown in Australia as either a summer or winter crop and it is seen as a good fit within existing cropping programs, depending on soil type, rainfall and environment. The experiments carried out by NSW DPI at Leeton Field Station are part of a national project *Quinoa as a new crop in Australia* co-funded by the Rural Industries Research and Development Corporation (RIRDC) and state departments of primary industry or agriculture. Other experimental sites are in South Australia (Naracoorte), Northern Territory (Katherine and Alice Springs) and Western Australia (Kununurra, Northam and Perth).

The field site at Leeton is evaluating sowing density, sowing time and varieties. The density trial is investigating the effects of sowing density with sowing rates of 2 kg/ha, 4 kg/ha and 8 kg/ha. Time of sowing is being investigated for two varieties. There is also a variety trial evaluating 13 different varieties to identify the best performing variety for the Leeton area and on the soil type at the research site, which is a heavy grey self-mulching soil typical of the surrounding area. This soil at Leeton Field Station is very different to the lighter soils that quinoa is normally grown on in its native South America and compared with soils at the other national trial sites.

The Leeton trials are very important in the understanding of the growing conditions and challenges to a quinoa crop in south eastern Australia. The development of an agronomy package that will set out the best growing practices along with nutritional needs, irrigation requirements and pest and weed management options needs further investigation with more time and trials.



The Australian quinoa industry is in its infancy. Time and investment are required to overcome key barriers along the supply chain.

The saponin-containing layer on quinoa seed needs to be removed before eating, so growers need access to seed processing facilities.

Understanding seed quality

Understanding and developing quality parameters is an essential part of the projects activities and integral in growing this industry in Australia. The quality parameters include:

- nutritional aspects, including protein and amino acid efficiency
- physical aspects, including seed size and colour
- chemical composition, including saponin.

The saponin-containing layer on the quinoa seed needs to be removed prior to eating. This layer is the plant's way of protecting itself against insects and it gives the quinoa a very sour taste. The saponin layer can be removed by scarifying the seed or by washing and drying it prior to sale or processing.

Future priorities of NSW DPI for quinoa R&D are to increase productivity and innovation in agriculture through improved:

- agronomy, by identifying key management practices to improve grain quality and yield potential of varieties identified as suited to this area
- grain quality, by identifying and developing industry-relevant screening tools for colour and size
- communication, by publishing outcomes of these trials and the project in general across various forums.

Further information

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Drill sown rice variety experiment showing differences in lodging potential.

LEARNING TO MANAGE FACTORS AFFECTING LODGING IN RICE

QUICK TAKE

- **The severity of lodging in rice varies between seasons due to weather impacting stem strength. The weather cannot be controlled but others factors that influence lodging can be managed to help reduce its occurrence.**
- **Some rice varieties are more tolerant to lodging than others, due to physical factors such as plant height, stem thickness and density.**
- **Sowing method has a large impact on lodging potential in rice with drill sown crops less likely to lodge than aerial sown crops.**
- **Nitrogen rate and timing of application both influence lodging potential as do water depth, plant density and time of draining.**

As growers push for maximum grain yield, lodging is becoming a more significant problem in rice production, increasing the time and cost of harvest and often reducing grain yield.

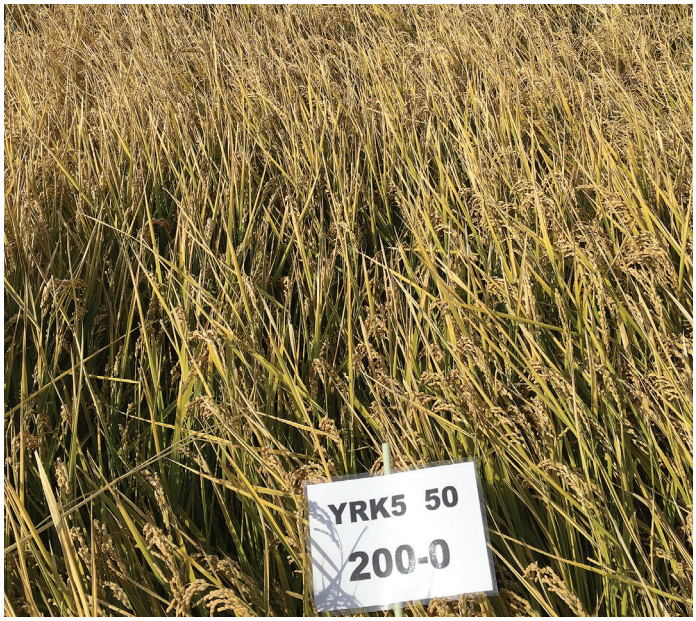
Brian Dunn and Tina Dunn
NSW Department of Primary Industries, Yanco Agricultural Institute

LODGING of rice is worse in some seasons than others due to weather impacting the ability of the rice stem to support the weight of the grain.

Several factors influence lodging susceptibility, these include: variety, sowing method, nitrogen rate and timing, plant density, water depth, time of draining and wind and rain nearing crop maturity. Some of these factors can be managed, thus providing the opportunity to reduce the potential of crop lodging.

Variety

The physical structural characteristics of the rice plant, which include height, stem strength, sturdiness of the lower part of the plant and



YRK5 drill sown at sowing rates of 50 kg/ha (left) and 150 kg/ha (right) and fertilised with 200 kg/ha urea applied before permanent water.

potential grain yield, all influence the ability of a variety to stand up at maturity, even with high grain yields.

Data collected in the 2015–16 and 2016–17 seasons show that rice varieties that are more prone to lodging are generally taller in stature and have thinner stems, as shown by decreased stem weight per cm (Table 1). Varieties such as Doongara, Topaz® and Reiziq® are relatively tolerant to lodging, while Koshihikari and YRK5 are highly susceptible (Table 1). When growing varieties that are more susceptible to lodging it is important to use all available management options to reduce the lodging potential of the crop.

Sowing method

Aerial sown crops are more prone to lodging than drill sown crops, and crops with delayed permanent water are the most tolerant to lodging. Better lodging resistance under drill sowing is due to better root anchorage in the soil and resistance against stem bending and breaking.

Water management also affects lodging resistance as crops that are fully flooded from germination grow taller and have thinner stems than rice crops grown with intermittent irrigation during the establishment and tillering period.

Plant density

Although research has shown grain yield potential of rice to be the same between plant densities of 40 and 400 plants/m^2, higher plant densities can lead to increased lodging. Recent research on YRM70 and YRK5 varieties showed that higher plant densities (150 kg/ha seed resulting in about 250 plants/m^2) tend to be more prone to lodging than lower plant densities (50 kg/ha seed resulting in about 100 plants/m^2). Lodging in the higher sowing rate areas was considerably worse than in the lower rate areas (see photos above).

To reduce lodging potential, it is important not to use higher than recommended sowing rates, especially for the small grain varieties, which have many more seeds per kilogram. Recommended sowing rates for rice varieties based on seed size and average varietal establishment percentages from field experiments are presented in Table 2. The smaller seed varieties (e.g. Opus®) have more seeds per kilogram so should be sown at a lower rate to achieve the same plant population.

Table 1. Average lodging score, plant height and stem weight for current rice varieties. Samples collected from several research experiments in the 2015–16 and 2016–17 seasons.

Variety	Lodging score (1=standing, 10=fully lodged)	Plant height (cm)	Stem weight (g/cm)
Doongara	1.0	75	0.028
Topaz®	1.0	81	0.022
Reiziq®	1.1	80	0.024
Sherpa®	1.2	83	0.022
Opus®	2.0	81	0.022
Langi	2.1	86	0.022
Illabong	2.4	86	0.022
YRM70	2.6	85	0.019
Jarrah	4.2	85	0.021
YRK5	5.6	93	0.018
Koshihikari	6.1	91	0.018

Table 2. Sowing rates to meet plant population recommendations, based on seed size and average varietal establishment percentage.

Variety	Sowing rate (kg/ha)
Reiziq®, Illabong & Topaz®	150
Sherpa®, Langi, Doongara & YRM70	130
Opus®, Koshihikari & YRK5	120

Nitrogen rate and timing

Nitrogen is very important in achieving high grain yields but excessive nitrogen applied pre-permanent water increases lodging, especially for lodging-susceptible varieties. Higher nitrogen rates result in increased lodging susceptibility in rice, due to increased tiller numbers, the length of lower internodes, plant height and reduced lower stem cellulose and lignin content, which reduce straw breaking strength and bending stress.

Extensive lodging in an aerial sown rice crop.

A nitrogen rate and timing experiment conducted on drill sown YRK5 at Finley in 2016–17 highlighted the impact that high rates of nitrogen applied before permanent water can have on increasing lodging in susceptible rice varieties (Figure 1). Increasing nitrogen applications before permanent water significantly increased lodging potential compared with nitrogen applied at panicle initiation.

For varieties that are very susceptible to lodging (e.g. Koshihikari and YRK5), it is important to reduce the rate of nitrogen applied before permanent water by up to 50% of the normal application that would be applied to a Reiziq crop grown in the same field. The crop's nitrogen uptake should be measured at panicle initiation, and then if required, nitrogen top dressed.

When applying nitrogen to crops, growers need to be aware of not only the nitrogen rate applied but also the evenness of spreading patterns. Areas or strips that receive heavier application rates often lodge, sometimes also bringing down surrounding areas of crop.

Water depth during establishment

The need for the seedling to emerge from the water and intercept sunlight for photosynthesis combined with the buoyancy provided by the water result in taller weaker plants in deeper water. It is important to keep water depth shallow during establishment and through to mid-tillering so plant height is not increased, which will increase crop lodging potential.

Draining

When to drain the water from a rice crop for harvest is a very important and difficult decision. If the field is drained too early, and sufficient soil moisture is not available to take the plants through to physiological maturity, the crop will "hay off". Haying off makes the stem very weak resulting in considerable lodging, which reduces grain yield and whole grain millout.

Weather

A high yielding crop is often finely balanced as it nears maturity, so anything that upsets the balance, such as heavy rain or strong winds, can cause it to lodge. You cannot control the weather but harvesting as soon as the crop is mature helps reduce the chance of lodging and also ensures good grain quality.

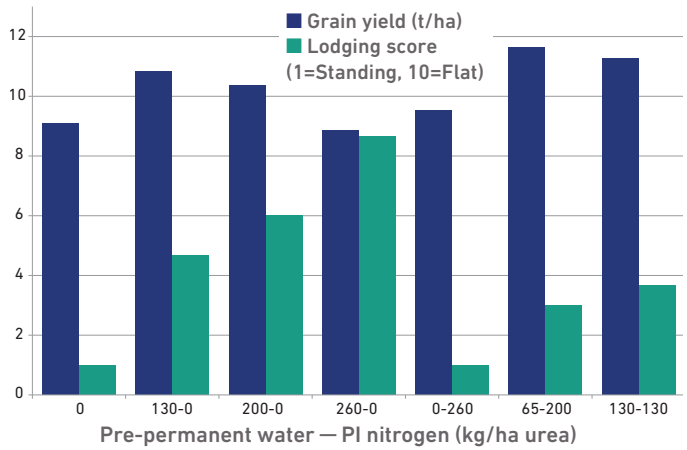


Figure 1. Grain yield and lodging score for nitrogen timing and rate treatments on YRK5. Nitrogen was applied before permanent water and/or at PI, at total rates ranging from 0 to 260 kg/ha of urea.

Acknowledgements

This research was co-funded by the NSW Department of Primary Industries and the Rural Industries Research and Development Corporation.

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Rice growers from the Finley area have compiled a list of checks and barriers for the practice of delayed permanent water on rice.

COLLECTIVE EXPERIENCE OF DELAYED PERMANENT WATER

QUICK TAKE

- **Rice growers in the Finley Discussion Groups have shared their experiences with delayed permanent water on rice for the 2016–17 rice season, to consolidate their list of checks for success.**
- **The key requirements for successful delayed permanent water include a good irrigation layout, good paddock preparation, good weed management, early sowing and good water management.**
- **Barriers to adoption of delayed permanent water include high seed burdens of barnyard grass, wet conditions early in the season, poor/slow water supply at time of permanent water application, and not having the labour to match the demands of rice crop establishment and winter crop harvest.**

Delaying permanent water on rice can be a profitable way to grow rice with less water, however there is always more to learn.

John Lacy
Agricultural Consultant, Finley

SINCE the first trials and farmer experiences of delayed permanent water, the Finley Discussion Groups have been updating practices for and barriers to successful rice growing with delayed permanent water. Adding the experiences and observations of the 2016–17 rice season to their accumulated knowledge, this article outlines an updated list of key practices to implement (checks) and barriers to overcome.

1. Good lasered layout

Check: A good lasered layout waters and drains the crop well.

Barrier: Without a lasered layout, delayed permanent water is not possible.

2. Paddock preparation

Check: Ideally, fallow in autumn and keep the paddock weed free, so the soil is soft by sowing time.

3. Reduced barnyard grass

Check: Choose paddocks and winter crop rotations with lower barnyard grass seed banks. There is no perfect way of reducing barnyard grass, so avoid paddocks with too much to start with.

Barriers: A history of high barnyard grass is a barrier to delayed permanent water. A lot of winter crop paddocks still have a seed burden from barnyard grass growing in summer. With tighter rice rotations and selection of lower water use paddocks, rice may be reduced to 25% of the farm area. This means it is harder to choose low barnyard grass paddocks, resulting in less winter crop in the rotation. Ordram® is still the best control of barnyard grass in aerial sowing.

4. Earlier sowing

Check: Earlier sowing is required for delayed permanent water because there is moisture stress between flushes, which will delay the rice growth. This can be overcome a little by sowing crops with later recommended sowing dates, such as Sherpa®, YRK5 and YRM70.

Barriers: Sowing earlier means that it is cooler, which may limit rice vigour at establishment. The Murray Valley is 1–2 °C cooler than the MIA. Early sowing can be hindered by wet conditions as occurred this last sowing season. It's a matter of being patient.

5. Controlled late BYG germinations

Check: Late barnyard grass germinations must be controlled, ideally with Barnstorm™ and Aura®, which require the soil surface to be very wet but with no surface water. Spraying before sunrise is best. If it is too hot, as often happens in late November/early December, the ground will dry out quickly and a high water rate is needed when spraying. Some farmers claim better results using a helicopter.

Barrier: Barnstorm and Aura do not work consistently. When the soil is wet, it is hard to get a ground rig on. Some farmers say the cost of Magister® and Stomp® at $110/ha plus Barnstorm at $130/ha is too high. Delaying the permanent water further, increases the chance of more weed germinations.

6. Water management

Check: When flushing, use flume gates that allow water on and water off faster, ideally watering with 25 ML per day.

Barrier: Avoid moisture stress to the crop, as it slows growth and development. However, there may be supply constraints if everyone on the supply channel decides to fill at about the same time.

7. Water savings less than research results

Check: Normal drill sowing with two flushes (the first a soaking) will be sufficient for crop emergence. Delay permanent water until rice is 10–15 cm tall in late November/early December. The rice will be stressed but this will save water and not delay rice too much.

Barrier: Unlike small research plots, farmers may not be able to recycle irrigation drainage, which can push up water use for delayed permanent water. There is always loss from seepage and ET with reirculated water, so water recovery is not 100%. There is not much difference between slightly delayed permanent water and delayed permanent water three weeks later. Reported water savings in practice are only 1 ML/ha, less than the 2.2 ML/ha showed by research results. Note, this year's results showed a 1.4 ML difference.

8. Labour clash

Check: Delayed permanent water is best suited to small paddocks or farms where there are only one or two paddocks of rice, so farmers have time to supply the required labour.

Barriers: Many growers do not have the manpower for delayed permanent water if sowing several paddocks. Some do not own spraying gear and may not be able to obtain a contractor at the right time, therefore aerial sowing is easier. Spraying in late Nov./early Dec. or flushing can clash with winter crop harvesting and sheep work.

Generally, ducks are not a problem with aerial sowing but wind can be. Normal drill has no ducks or snails, allowing two flushes and permanent water before winter crop harvest. Rice crops near creeks and rivers have the main duck issues.

Aerial sowing uses less labour, so timing of practices is better. Rice harvest later in the autumn is more likely with delayed permanent water and clashes with April canola sowing.

9. Gross margin/ML

There is a need to compare costs and gross margin per megalitre of delayed permanent water with drill or aerial sowing.

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Drone technology has assisted the rice industry in investigating a range of sensors to better predict nitrogen uptake at PI.

PROGRESS IN REMOTE SENSING OF PI NITROGEN UPTAKE

QUICK TAKE

- NDVI is of limited value in detecting differences in nitrogen uptake in rice crops at panicle initiation (PI) due to its saturation at nitrogen uptake levels above 80 kg N/ha.
- NDRE uses wavelengths in the red edge band and it provides a stronger relationship with nitrogen uptake in rice at PI than NDVI.
- A preliminary calibration has been developed for the MicaSense RedEdge sensor to directly predict PI nitrogen topdressing rates for Koshihikari, Doongara and YRK5 rice varieties using NDRE values, without the need to physically sample the crop.
- Rice varieties requiring nitrogen topdressing at higher levels of PI nitrogen uptake, will still require physical sampling of the crop at PI to determine PI nitrogen uptake.

The ability to measure real-time crop characteristics is allowing improved nitrogen management during the season, giving potential to increase productivity and profitability in the rice industry.

Brian Dunn and Tina Dunn
NSW Department of Primary Industries, Yanco Agricultural Institute
Remy Dehaan
Charles Sturt University
Andrew Robson
University of New England

ADVANCES in and availability of new remote sensing sensors has provided greater opportunities for agriculture.

Our team has spent five years investigating the potential of remote sensing in rice by comparing the available research, investigating commercial drone, aircraft and satellite sensors and platforms, with the aim of better predicting nitrogen uptake in rice at panicle initiation (PI).

We have identified a number of remote sensing options for rice growers. This research is part of an ongoing Rural Industries Research & Development Corporation (RIRDC) research project.

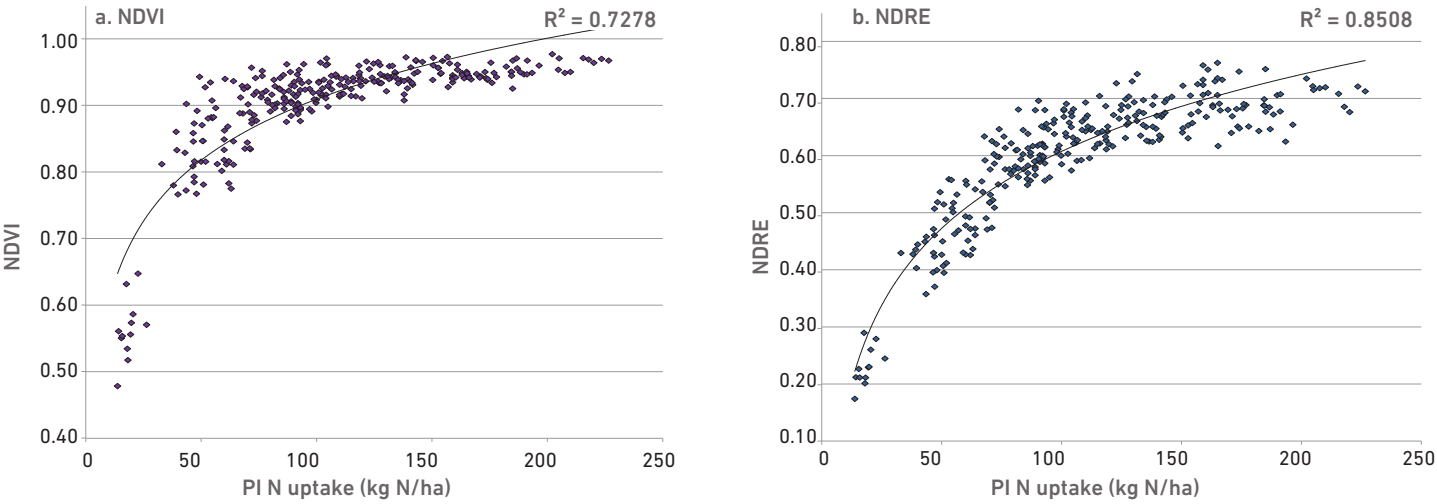

Figure 1. Relationship between MicaSense RedEdge data collection from 288 sites over 2 seasons and 4 rice varieties with a) NDVI and b) NDRE.

NDVI vs NDRE

Remote sensing in rice historically involved the use of *normalised difference vegetation index* (NDVI) maps of rice fields generated from satellite, aircraft or drone sources. Although these maps can appear to show significant differences within fields, once the rice crop develops a full canopy, which often occurs before PI, NDVI becomes saturated and cannot detect difference in crop biomass or nitrogen uptake. Our research and other research across the world have shown that above a nitrogen uptake of approximately 80 kg N/ha, NDVI cannot detect difference in crop growth at PI (Figure 1a).

Many new sensors have become available in the last few years that measure an additional wavelength band called the *red edge*, which is a narrow band (710 to 740 nm) located between the *visible red* and *near infrared* (NIR) regions of the light spectra. This region of the spectra is very sensitive to changes in foliar chlorophyll content, which is strongly related to plant nitrogen concentration. Vegetation indices that include the red edge region, such as the *normalised difference red edge* (NDRE) have been found to saturate at a much higher nitrogen concentration than the commonly used NDVI. Our research shows that a better relationship exists between NDRE and PI nitrogen uptake (Figure 1b) than NDVI and PI nitrogen uptake (Figure 1a).

Once the rice crop gets past mid-tillering and particularly once it has reached PI, NDVI images of rice fields are of little value, however NDRE images are able to show differences in nitrogen uptake of the crop (Figure 3) at this later stage. Although NDRE is much better than NDVI, its value decreases for PI nitrogen uptake values above approximately 100 kg N/ha, and cannot be used as a direct nitrogen uptake prediction tool for rice varieties that require high levels of nitrogen, e.g. Reiziq®, Sherpa® and Opus®.

Available sources of NDRE imagery

In our research we compared NDRE (red edge) imagery from a number of sensors to nitrogen uptake in rice at PI. These sensors included Worldview 3 satellite and a range of drone mounted sensors (the Parrot Sequioa, MicaSense RedEdge and SlantRange). From Figure 2 it can be seen that a strong relationship between NDRE and PI nitrogen uptake exists for each sensor, but they all flatten out and become of limited value above a nitrogen uptake level of around 100 kg N/ha.

The other important factor that is evident in Figure 2 is that the relationship between NDRE and PI nitrogen uptake is different for each sensor so an individual calibration needs to be developed for each sensor. The reason for these differences is thought to be due the different location of the red edge waveband in each sensor and how the red edge shifts left or right with varying levels of plant chlorophyll.

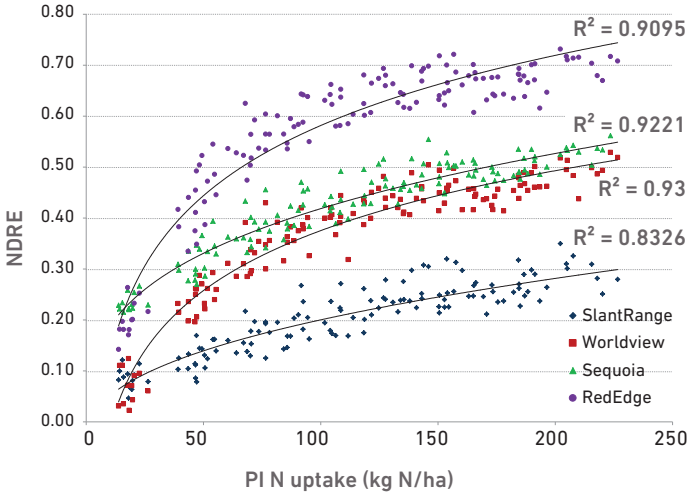

Figure 2. Relationship between NDRE and PI nitrogen uptake for remotely sensed data collected from 132 sites in one season from 4 rice varieties with the SlantRange, Parrot Sequoia, MicaSense RedEdge cameras and the Worldview 3 satellite.

Figure 3. NDRE image of a rice variety by nitrogen experiment at Yanco in the 2016–17 season. Varieties run from left to right across the plots and pre-permanent water nitrogen rates top to bottom.

From the NDRE and PI N uptake relationship data shown in Figure 2 it can be seen that both the MicaSense RedEdge and Worldview 3 relationships are relatively steep at lower PI nitrogen uptake values, while the SlantRange and Sequioa relationships are much flatter at the same levels. The slope of these relationships and spread of the data highlights the possibility that the MicaSense RedEdge and Worldview 3 sensors show potential for PI nitrogen uptake predictions below a nitrogen uptake value of approximately 100 kg N/ha (Figure 2).

Using MicaSense RedEdge NDRE values

Our research showed that below an NDRE of 0.6, the MicaSense RedEdge camera has what we consider an acceptable level of accuracy for predicting PI nitrogen uptake (Figure 4). Above an NDRE of 0.6, the curve flattens significantly and the prediction accuracy is poor and not suitable for the prediction of PI nitrogen uptake, as shown by the red box in Figure 4.

The NIR tissue test has nitrogen top dressing recommendations in the program that are based on many years of research and provide recommendations based on crop PI nitrogen uptake for each variety and water depth at microspore. The top dressing recommendations have been converted into a direct relationship with NDRE (Figure 5) based on the relationship between NDRE and PI nitrogen uptake shown in Figure 4. When the area of the graph with NDRE above 0.6 is shaded out (the red box) due to its poor prediction accuracy of PI nitrogen uptake, there is still potential for Koshihikari, Doongara and YRK5 PI top dressing requirements to be predicted using MicaSense RedEdge NDRE values directly (Figure 5).

Drone and satellite red edge options

From these results, drones and red edge sensors clearly have a role for rice growers looking at spatial variability of nitrogen in individual rice fields. However, as an industry-wide option the use of drones is limited by short flying time (battery life), line of sight regulations, wind and cloud conditions, often 70% image overlap requirements and the short daily data collection period (only 3 hours either side of solar noon).

Satellite imagery is really the only practical option for covering all of the rice crops in the industry in the short PI timing window. The Worldview 3 satellite based sensor has shown considerable potential with good correlations with PI nitrogen uptake, daily revisit time and 1.25 m resolution. However images are very expensive, i.e. approximately $55 per km^2 with a minimum capture of 100 km^2. The Sentinel 2 sensor offers free imagery, a 10-day revisit time and a red edge waveband (705 nm), but the resolution of the red edge band is 20 m, which is too coarse for measuring zonal variability in rice fields that contain contour banks. Another option, which is yet to be investigated, is the RapidEye satellites that have a red edge waveband, daily revisit time and 5 m resolution. Data from RapidEye is much more cost effective than Worldview 3 but future research needs to determine its accuracy at predicting PI nitrogen uptake and if the 5 m pixel size is suitable.

Remotely sensed images of rice crops can highlight within field variability of crop nitrogen uptake. Through targeted agronomy this information can greatly improve crop management decisions leading to improved grain yield and quality and ensure sustainability of rice growing in Australia.

Where to now?

In the 2017–18 rice season a calibration will be developed between NDRE and PI nitrogen uptake for the RapidEye satellites testing its accuracy and potential for commercial use. Options will be investigated into making satellite based red edge images available to growers in a timely manner at an acceptable price. Calibrations for the MicaSense RedEdge sensor will continue to be updated across more rice varieties.

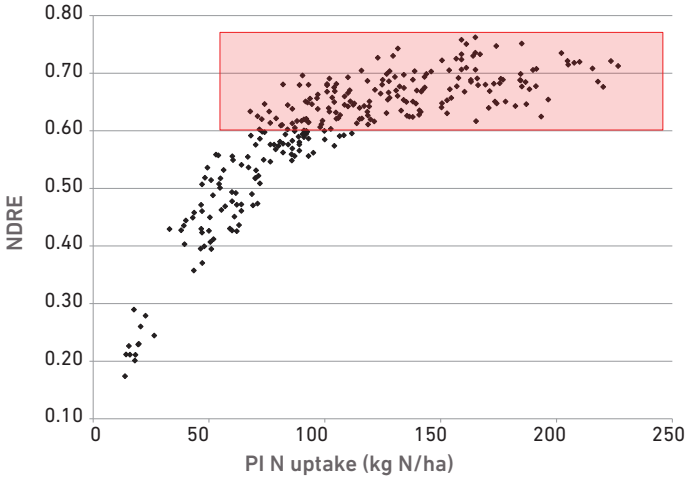

Figure 4. Relationship between NDRE and PI N uptake for data collected from the MicaSense RedEdge camera from 288 sites over 2 seasons with 4 rice varieties. The red box shows NDRE values above 0.60 where prediction of PI N uptake is not sufficiently accurate.

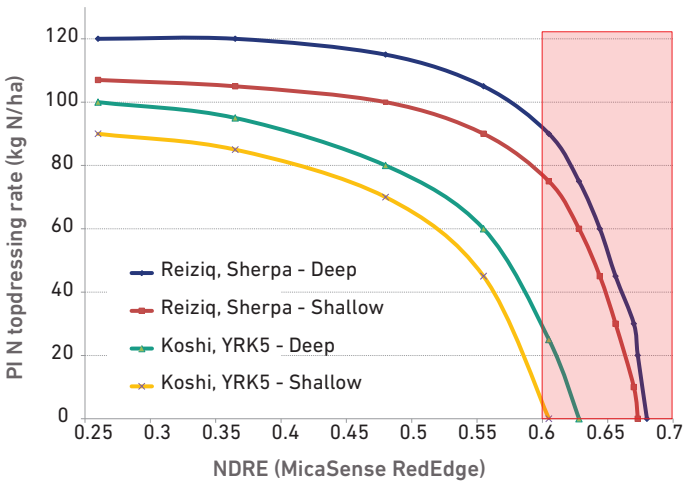

Figure 5. PI N topdressing recommendations for variety and water depth used in the NIR Tissue Test calibrated against NDRE using the MicaSense RedEdge relationship between NDRE and PI N uptake shown in Figure 3. The red box shows NDRE values above 0.60 where prediction of PI N uptake is not sufficiently accurate.

The project team will also monitor and test new and rapidly evolving technology as it becomes available.

RIRDC Project PRJ-009772
Moving forward with NIR and remote sensing

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Drones provide a way to collect less expensive, more timely, more target-specific and higher resolution images of fields, than is possible with satellites or aircraft. IMAGE: John Hornbuckle

DRONE AND TECHNOLOGY DAY

QUICK TAKE

- **The Drone and Technology Day was a cross-commodity event hosted by IREC, Deakin University and Murrumbidgee Landcare Inc. It provided a forum to share new knowledge on drones and technology with irrigators, industry, researchers, educators, agencies and government.**
- **Practical ways of using drones on farm was discussed, as well as the advantages that drones offer over satellite and aerial monitoring of crops and farms.**
- **A series of case studies was presented, showing different ways of using sensors fitted to drones to manage irrigation, nutrition and disease in annual and permanent plantings.**

Drones are the new kid on the smart agriculture block. They provide cheap, timely and targeted collection of data from annual and permanent crops.

Iva Quarisa
Executive Officer, IREC

SMART Ag was the theme of the Drone and Technology Day held in Griffith, in June 2017. The day, hosted by IREC, Deakin University and Murrumbidgee Landcare Inc., provided a unique opportunity for irrigators, advisors and researchers to learn all about the practical application of drones, as well as some new technologies being developed by Deakin University.

Closer and more accurate images

Keynote speaker of the event was remote sensing expert Dr John Sulik from the US company, MicaSense. Dr Sulik explained that remote sensing is the science of obtaining information about objects or areas from a distance. In the past, remote sensors were mounted on satellites and aircraft but now they can be mounted on drones.

There are a number of advantages of using drones over other technologies. Drones are cheaper, target specific fields, enable higher resolution images to be taken, and take images in a more timely fashion.

When mapping a field, drones fly between 30 and 150 metres above the field with varying flight speeds. The lower the flying height, the slower the drone should go (5–25 metres per second). Drones fly in overlapping transects across the field to get a complete picture. Images taken by the sensors are then "stitched" together to form a high resolution and comprehensive map of the field.

It is important that the sensor camera should face straight down. Most drones use a gimbal to adjust for pitch. During flights, operators need to aim for consistent light conditions, i.e. either clear and sunny or overcast. Changing light conditions, as with patchy and scattered clouds, make it difficult to obtain a clear image.

Getting the most from drone-gathered data

Following Dr Sulik was a presentation from Dr John Hornbuckle, Associate Professor with Deakin University, based at Griffith. Dr Hornbuckle covered the foundations of imaging and the significance of the light/colour spectrum on the images derived from drone-mounted sensors. Like yield maps, it's all very well to collect the data and make images, but what they can tell us?

The type of sensor (camera) used on a drone will be determined by what information the grower requires. All plants reflect different parts (wavelengths) of the light/colour spectrum and by different amounts. The amount of colour reflected is based upon plant health, as well as water and nutrition status. There are also sensors that measure temperature, which can be an indicator of plant health and stress.

Dr Hornbuckle discussed four different types of sensors:

- true colour (RGB – red green blue)
- multispectral
- longwave infrared (IR) or thermal
- hyperspectral.

True colour (RGB) sensors simply produce a colour photograph. Entry level drones usually come with this sensor. In agriculture RGB can be useful for identifying crop variability and pinpointing where samples should be taken. For more accurate plant health analysis, more expensive sensors are required.

Multispectral sensors capture specific colour wavebands which are not visible to the human eye. These are professional sensors for agricultural remote sensing. While Normalized Difference Vegetation Index (NDVI) is the primary output of multispectral sensors, output may also be Normalized Difference Red Edge (NDRE), Visible Atmospherically Resistant Index (VARI) and Simplified Canopy Chlorophyll Content Index (SCCCI).

The NDRE images indicate variations in nitrogen so these are most commonly used in nitrogen management of crops, such as variable rate top dressing of rice and winter cereals and identifying nitrogen deficiencies in cotton.

The SCCCI images show chlorophyll content of leaves. Images appear "greenest" when leaves are approaching physiological maturity and so chlorophyll is at its maximum. These images can be used to identify disease and certain fertiliser deficiencies.

Longwave IR or thermal sensors measure the temperature and indicate water or heat stress of plants. They are thus useful in assisting with irrigation management. While these sensors have good qualitative capabilities they do have limitations which include difficultly in stitching images together and difficulty in comparing data/maps taken at different times due to temperature variabilities.

Hyperspectral sensors capture a large number of wavebands simultaneously and are used mainly for research purposes and for the classification of plants.

Dr Hornbuckle stressed that the real benefits of remotely sensed data collected by drones comes from putting data into a format that makes it easy for irrigators to make decisions around fertiliser and irrigation management, so they can modify practices and improve management.

Practical examples of drone technology

Dr Sulik presented several case studies demonstrating the practical use of drones in farm management.

Citrus tristeza virus, which causes chlorosis and dieback, is the most economically damaging disease to citrus in the world. The virus is transmitted by the brown citrus aphid and has killed over 80 million trees in South Africa, Argentina, Brazil and the USA. Tree decline and total dieback can take years after the first symptoms of chlorotic leaves first appear.

Drones fitted with NDVI and NDRE sensors have been used to identify unhealthy trees in orchards. NDVI was used as a general indicator of canopy density, while the NDRE sensor, which is sensitive to chlorophyll content in leaves, and may indicate variability in leaf area.

In another case study, Dr Sulik showed how multispectral composite has been used to identify wheat streak mosaic virus infection in wheat. Wheat streak mosaic virus is carried by a mite that lives in volunteer wheat and other grass weeds that act as a green bridge between successive wheat seasons. Early detection is the key to identifying and managing the virus. Infected wheat is not detected by RGB or NDVI sensors.

Multispectral sensors have also been used to identify problems in a plum orchard. Chlorophyll maps were produced using data collected from the sensors. Bicarbonate build-up from use of groundwater caused the trees to stress, which could be identified by variations in tree health as indicated by the chlorophyll maps. Early detection not only saved money but also saw trees return to full health shortly after switching back to a surface water source for irrigation.

Other high-tech developments

Technology is rapidly changing and advancing within agriculture, as well as in fields supporting agriculture. Further, developments in other fields one day may also have applications to agriculture. With this in mind, several other technologies under development at Deakin University were presented to participants on the day. These were:

- lab-on-a-chip technology
- virtual reality
- artificial intelligence.

Lab-on-a-chip technology

Miss Kim Quayle introduced the possibilities and potential applications of lab-on-a-chip technology. Kim is currently studying for her PhD at Deakin University, which involves the development of a lab-on-a-chip device to detect performance-enhancing substances in thoroughbred racehorses, with the intention of conducting track-side analysis.

Lab-on-a-chip devices allow multiple tests that previously were only available to be conducted within a laboratory to be performed simply by a user at the time and place of need. Samples, commonly biological, are placed into a micro-fabricated plastic device where they are mixed, extracted and reacted before detection, using a battery operated detection platform. The device can be interfaced with a smart phone or laptop, and typically produces a result in 5–10 minutes.

These portable devices are low cost and provide rapid quantitative results, removing any need for lengthy and costly laboratory testing. The time-saving factor of these devices will be important to many industries. If this technology existed fifteen years ago, imagine the hundreds and thousands of livestock and millions of dollars that could have been saved when there were outbreaks of foot and mouth disease in the UK and avian influenza sweeping through poultry farms in Australia.

Kim identified a broad range of potential applications for this technology. A few examples of these applications are as follows: bio security, medicinal, DNA testing, infectious disease identification, food quality and environmental monitoring. She believes the lab-on-a-chip technology can have drastic economic impacts and applied solutions in irrigated agriculture.

Virtual reality

Virtual reality through the use of virtual reality goggles, provides a 360-degree view of particular surroundings and allows us to experience that place without actually being there. The use of virtual reality in combination with haptics technology is transforming training across many industries and professions. Virtual reality haptics technology is being developed for firefighter training and medical training at the Deakin University Virtual Reality Lab.

With firefighting training, virtual reality haptics is used to demonstrate how much strength is needed to control firehoses and the stamina needed to fight fires. In the medical area, virtual reality haptics allows the user to 'feel' how much pressure to apply when injecting a patient or cutting with a scalpel, all while working in the virtual world.

Artificial intelligence

Professor Rajesh Vasa from the Deakin University – Software and Technology Innovation Lab highlighted the areas where artificial intelligence can be used in our everyday lives. Artificial intelligence assists us to make great use of information collected from wearables (such as Fitbit), in monitoring anxiety and stress level or predicting epileptic fits.

Artificial intelligence, through Sofihub Smart Homes, enables the construction of dementia-friendly homes. Professor Vasa explained that Sofihub is the command centre for a home. It can identify when something unusual happens and will automatically raise an alert. Sofihub can also be linked to Google Calendar to remind people of appointments, or provide prompts such as a 'hydration reminder'.

Deakin University is keen to explore new applications and opportunities for use of all of these technologies within the agricultural industry and would be happy to hear your suggestions. Presentations from the Drone & Technology day can be found on the IREC website.

Further information

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Growers and researchers at the maize trial at Numurkah, one of two locations for field trials as part of the *Maximising on-farm irrigation profitability* project.

MAXIMISING ON-FARM IRRIGATION PROFITABILITY

QUICK TAKE

- The *Maximising on-farm irrigation profitability* project is investigating strategies to increase water and nitrogen use efficiency, which may be made in addition to efficiencies gained through automated surface irrigation systems and infrastructure upgrades.
- Cotton yield was highest at 9.6 bales/ha when the crop was watered every 7 days (short deficit) but maturity was later, compared with crops watered every 14 and 19 days (standard and long deficits). Overall, increased nitrogen increased yield, although not significantly.
- Maize yield, approximately 14 t/ha in 2016–17, generally increased by applying fertiliser upfront, over two seasons. Nitrogen uptake rates in the crop were no different at different growth stages for different irrigation and nitrogen timing strategies.

Infrastructure investment has increased irrigation efficiency, however irrigators continue to look for ways to take full advantage of infrastructure investment to ensure future certainty for farm businesses in changing times.

Wendy Quayle[1], James Brinkhoff[1], Carlos Ballester[1], Sam North[2], John Smith[3], John Hornbuckle[1]
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[2]NSW Department of Primary Industries, Deniliquin, NSW
[3]NSW Department of Primary Industries, Yanco, NSW

MAJOR water buyback rounds of the Murray–Darling Basin Plan have ended and many of the low-hanging fruit in terms of infrastructure gains have been captured. However, questions remain about the magnitude of increases in water and nitrogen efficiencies that can be achieved and the risks involved to offset infrastructure investment. This information is vital for both farmers and policy makers.

These questions will be addressed to a large extent by information coming out of the *Maximising on-farm irrigation profitability* project (or the Max project). Within the overall objective of the project, there are two

Data from the cotton trial will be used to guide system targets for optimising irrigation scheduling using automated layouts.

main aims. The first is to assess the impact of varying surface irrigation management strategies (scheduling and frequency) on nitrogen use efficiency, water use efficiency and overall system profitability. The second is to develop irrigation design criteria that allow precise application of water in basin irrigation layouts, such as bankless channel systems.

Commercially relevant trials

The Max project established cotton and maize trial sites with IREC at Darlington Point and ICC at Numurkah, respectively, to investigate the interaction between irrigation and nitrogen, as well as other management interactions.

In the cotton trial, treatments were irrigated with siphons in order to achieve the most accurate water control at a commercial scale. The intention was to obtain data to guide system targets for optimising scheduling when using automated irrigation layouts.

In the maize trial, treatments were irrigated using fully automated border check irrigation systems.

At both sites, different irrigation schedules that applied approximately the same amount of water over the season were tested.

The aim of both the cotton and maize trials was to see what irrigation and nitrogen strategy produced the best productivity and nitrogen recovery in the two crops, to provide information for greater management flexibility, within the realms of commercial risk taking.

Cotton at Darlington Point

In the cotton trial, there were three different irrigation schedules:

- short deficit — watered every 7 days at -30 to -40 kPa
- standard deficit — watered every 14 days at -70 kPa
- long deficit — watered every 19 days at -110 kPa.

Figure 1 shows the soil tension data from gypsum blocks for each of the irrigation treatments. Soil tension is the measure of how much suction a plant needs to extract water from the soil. A zero reading means the soil is waterlogged.

Each irrigation treatment was overlain with two different nitrogen rates, with nitrogen supplied as urea:

- 180 kg N/ha — 90 kg N/ha top dressed on 21 November and 90 kg N/ha on 28 December
- 270 kg N/ha — 90 kg N/ha top dressed on 21 November and 180 kg N/ha on 28 December.

The treatment plots were 1.38 ha each and replicated three times in a factorial design. Each plot was picked commercially, modules were weighed on a weigh trailer and each module was ginned individually at a commercial gin.

Cotton results

The trial at Darlington Point was planted at 18 seeds/linear metre into fairly wet conditions with minimal land preparation. Establishment resulted in a plant stand of 11 plants/m.

All treatments were irrigated with the same volume of water on 3 January, and thereafter different irrigation timings were imposed until a final irrigation to all treatments on 15 March (Figure 1).

The first fertiliser application was late in the third week of November, followed by a second application in the fourth week of December.

There was no insecticides used throughout the entire season.

Overall yield was 9.8 bales/ha, 9.1 bales/ha and 8.4 bales/ha for the short, standard and long deficit irrigation treatments respectively. Gin turnout was 42% for all treatments. The short deficit treatment matured 26 days later than the long deficit and 19 days later than the standard practice (Table 1).

The greater nitrogen application rate increased yield in all treatments but not significantly (Figure 2).

Cotton conclusions

The short deficit (7-day watering) resulted in a 1 bale/ha or greater yield than longer watering deficit strategies at Darlington Point, on clay loam soils. Evapotranspiration was approximately 0.5 ML/ha greater, harvest date was up to four weeks later and the crop required

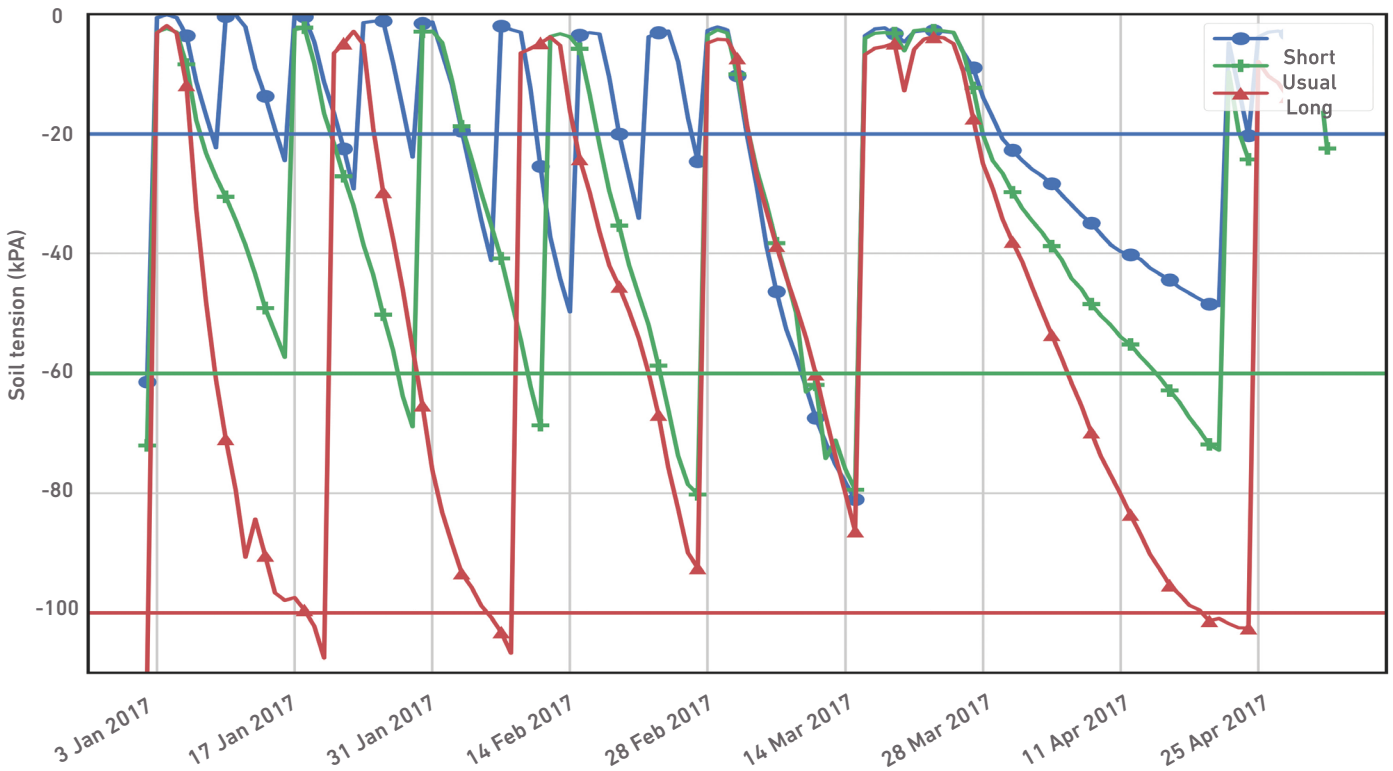

Figure 1. Continuous logging of soil tension (kPa) illustrates the three irrigation schedules imposed on cotton at Darlington Point, 2016–17.

three defoliations compared with two in the standard and long deficit treatments (i.e. 14 or 19 day irrigation schedules).

There was a yield increase with 270 kg N/ha compared with 180 kg N/ha but there was no interaction between irrigation and nitrogen rate for yield.

The data highlights that in the 2016–17 season, short irrigation deficits optimised cotton yield but needed to be carefully balanced against crop production costs, fertiliser and chemical use that reduce efficiencies, risk associated with delayed harvest date, and cotton prices.

With flexible water control that is now be available in automated systems, further efficiencies may be achieved by applying short deficits at critical growth periods such as flowering and boll filling, and longer deficits at other times. Further testing with such scenarios will be considered in the 2017–18 season.

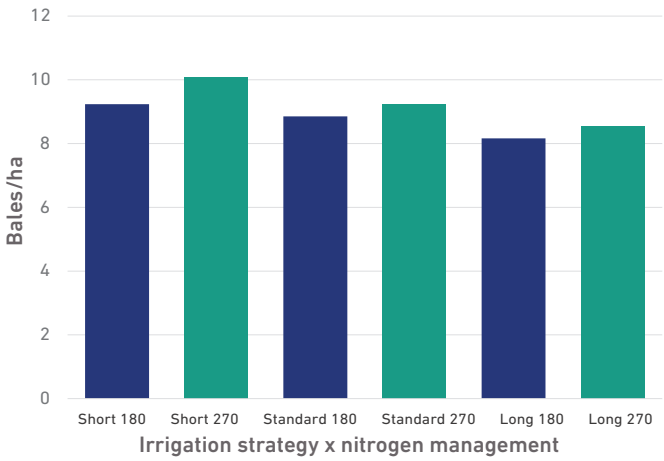

Figure 2. Cotton lint yield from the different irrigation x nitrogen treatments at Darlington Point, 2016–17.

Table 1. Management and maturity of different irrigation deficit x nitrogen treatments at Darlington Point, 2016–17.

Irrigation x fertiliser strategy	No. of pix	No. of defoliations	60% open boll date	Harvest date
Short 180 N	3	3	25 Apr 2017	30 May 2017
Short 270 N	3	3	27 Apr 2017	30 May 2017
Standard 180 N	3	2	21 Apr 2017	11 May 2017
Standard 270 N	3	2	24 Apr 2017	11 May 2017
Long 180 N	3	2	18 Apr 2017	4 May 2017
Long 270 N	3	2	17 Apr 2017	4 May 2017

Ray Thornton (left), co-operator for the maize trial, explaining crop management during the second year of the trial.

Maize at Numurkah

In the maize trial, there were two different irrigation schedules:

- watered every 5 days at -30 kPa
- watered every 7 days at -45 kPa.

Each irrigation treatment was overlain by two nitrogen fertiliser treatments:

- upfront – 70:30 (upfront: in crop)
- split — 45:18:18:18 (upfront: in crop: in crop: in crop).

Maize results

In Year 1 of the maize trial (2015–16), establishment conditions were difficult with a 40 mm rain event just after planting, which had followed pre-watering. Grain yield was relatively low for the region at around 10 t/ha. Following a wet start, yield was influenced by nitrogen strategy and irrigation deficit (figures 3 and 4). In these conditions, yield was optimised by nitrogen application that was predominantly upfront and short irrigation deficits.

In Year 2 of the trial (2016–17), establishment was good with more than 92,000 plants/ha. Overall there were no differences in nitrogen uptake at 7-leaf stage or at maturity. Grain yield was around 14 t/ha and improved by longer irrigation deficits and nitrogen fertiliser timing had no effect (figures 3 and 4).

Maize conclusions

Applying fertiliser upfront to maize generally increased yield compared with split fertiliser application in both years, when growing conditions provided low and high yield potential. Nitrogen uptake rates were no different at different growth stages for the different irrigation and nitrogen timing strategies.

The data suggests predominantly upfront fertiliser application may be possible without yield penalty or reduced nitrogen use efficiency, which potentially could decrease labour costs and trafficking of the field.

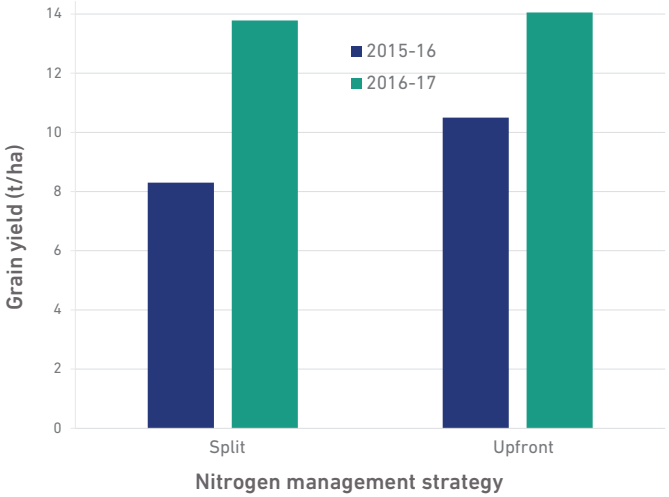

Figure 3. Grain yield of maize at Numurkah, as influenced by nitrogen management over two cropping seasons.

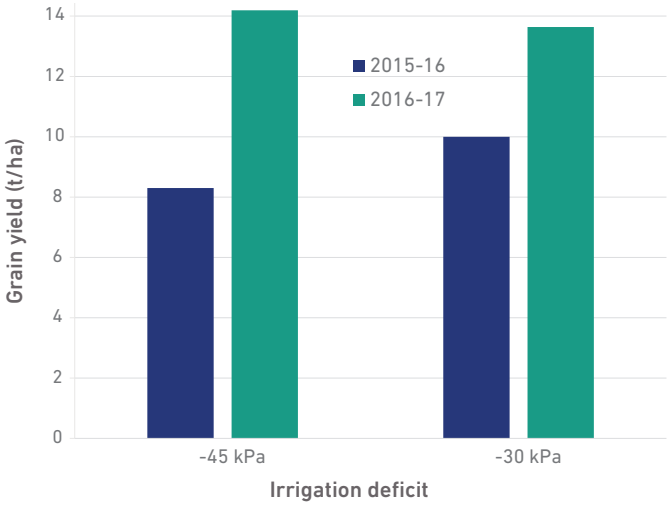

Figure 4. Grain yield of maize at Numurkah, as influenced by irrigation management over two cropping seasons.

Acknowledgements

The *Maximising on-farm irrigation profitability* project is conducted by NSW DPI and CeRRF, Deakin University in conjunction with the three regional irrigation grower groups — Irrigated Cropping Council, Southern Growers and Irrigated Research and Extension Committee. Each of the grower groups hosts field experiment sites for the project, which are key sites for the extension of project findings. Organisations such as Local Land Services, CottonInfo and Rice Extension are also involved in project extension.

The project is supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit Programme, the Cotton Research and Development Corporation and the Rural Industries Research and Development Corporation.

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A new decision support calculator for crop sequencing will help irrigators decide on the merits of double cropping on their own property.

CRUNCHING THE NUMBERS ON DOUBLE CROPPING

Growing two crops in 52 weeks is a honed skill and for many years, southern irrigators have believed it was impossible to continuously double crop.

Damian Jones & Bree Laughlin
Irrigated Cropping Council

MANY growers achieve three crops in two years, and some achieve five crops in three years. However, very few claim to have mastered continuous double cropping.

The project *Correct Crop Sequencing for Irrigated Double Cropping* aims to identify and overcome barriers to double cropping by updating and expanding knowledge and information on management practice guidelines and providing up-to-date economic comparisons of double cropping sequences.

As part of the project, NSW Department of Primary Industries and the Irrigated Cropping Council, in collaboration with irrigators, have jointly produced a calculator to help irrigators decide on the merits of double cropping on their own property.

The calculator is a series of spreadsheets designed to support decision making about the correct crop sequence. It aims to provide an easy way for irrigators to assess the gross margin outcomes for different rotations, attribute an average water price to those rotations and customise the output for their own business.

The calculator includes a rotation planner for a period of up to 10 years; and it will compare variations in commodity price and yield; yield and water price; and commodity price and water price.

Follow the link to the Correct Crop Sequencing Decision Support Tool or go to the NSW DPI website: www.dpi.nsw.gov.au/agriculture/budgets/costs/cost-calculators/correct-crop-sequencing-decision-support-tool

GRDC Project VIC00010 Correct Crop Sequencing for Irrigated Double Cropping

This research was co-funded by the NSW DPI, the ICC and the Grains Research & Development Corporation.

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