Irrigation Research & Extension Committee

FARMERS' NEWSLETTER

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Contents

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Front page left: Murray Valley rice grower, John Hawkins, discussing his Koshihikari crop with SunRice Grower Services field officer, Anna Jewell. Photo: SunRice

Front page right: Participants of the MyData project at the IREC Field Station. Photo: Iva Quarisa

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A WORLD WITHOUT PROBLEMS WOULD BE A WORLD WITHOUT PROGRESS

Rob Houghton
Chairman IREC
Irrigator, Gogeldrie

PHOTO: Just as our crops and businesses need nuturing and attention, the IREC Chairman encourages growers to do same for themselves and their industry and organisations. Credit: Emma Ayliff

QUICK TAKE

- Farming is all about managing the major challenges that we are faced with year in, year out.
- While the big challenges are out of our control, we have many tools to help deal with challenging scenarios.
- The dry time at the moment is the time to formulate strategies for getting crop in the ground on time regardless of how wet it is.
- IREC, inspired and driven by irrigators, provides a range of opportunities and demonstrations to help irrigators learn and give them tools to deal with ongoing major challenges.

Each time I sit down to write this article I start by outlining the challenges we are currently confronted with, and conclude with 'we are in difficult times' or something to that effect. I have only now come to the conclusion that being a farmer is ALL about managing major challenges that arise, year in, year out.

A BIG chunk of the challenges comes from our varying climate. It does have distinct seasonal patterns but generally no two years are ever the same. As irrigation farmers, we currently are being challenged by a dry sequence of seasons that has led to the depletion of stored water—this is out of our control. However, we have tools at our disposal to help address and manage challenges. Our tools to deal with this current dry scenario are:

- crop choice
- the water market
- on-farm watering systems
- moisture conservation
- managing expections
- being ready
- cost control
- having the ability to deal with stress
- having the capacity to make sound decisions under pressure.

Most farming operations today have survived drought before. That experience has already helped prepare us for our current challenge. Less crop and more time on our hands can be one of the biggest hurdles to overcome. How we use this time is key to being 'ready' for when the water comes back. This usually happens without much notice.

So now is the time to formulate strategies for getting crop in the ground on time regardless of how wet it is. Everyone will have their own way, that doesn't matter—what matters is that we act now to ensure a result when the water starts to flow.

Looking after the manager

We all readily look after our business and our gear, but no so much ourselves. No matter what age we are, healthy eating and regular exercise is an absolute advantage to getting the most out of our whole operation. Similar to maintaining our tractors, ute and headers, we should have a rock solid plan to maintain ourselves and stick to it. Like mechanics, there are many health and fitness professionals at our disposal so no matter what our 'issues' are, there is no excuse for doing nothing.

IREC is your organisation and the field station is open to all who would like to have a look around.

Supporting your organisation

I would like to encourage you to spread the word about IREC—your organisation—and what it is doing to enhance your business. Remembering that the main drive and inspiration for a lot of our current research has been driven by YOU, our members. IREC is the only overarching organisation for all our single crop organisations, creating strong pathways for collaboration between our research and development corporations (RDCs) to get effective outcomes for you—our members.

At the IREC Field Station we are demonstrating a range of irrigation layouts and automated control systems that are already available on a commercial scale. We now have a fully automated recirculation system. I would like to thank Mike Naylor for his design and installation, Bidgee Automation for automating the system and Cotton Reserach & Development Corporation (CRDC) for again funding the latest addition to the IREC site.

We currently have a pilot group of irrigators being educated and equipped to fully use the plethora of 'data' that we have at our disposal to assist us in achieving a credible 'precision ag' approach to our farming system. To date this technology has had a lot of potential but we need assistance to tackle the many 'blockers' that prevent progress. We thank Anthony Rudd from I-Ag who is guiding us through this process.

Remember, your involvement in IREC is key and will complete the loop by feeding 'benefit' directly back to your business.

Good luck with the upcoming winter crop season, and I will finish off with a quote from Nelson Mandela.

> "Everyone can rise above their circumstances and achieve success if they are dedicated to and passionate about what they do."

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INCREASING OPTIONS AND TOOLS FOR GROWERS

Iva Quarisa
Executive Officer, IREC

PHOTO: Along with its showcase of automated irrigation, the IREC Field Station has an increasing number of trials and demonstrations to help advance irrigated cropping systems in southern NSW.

QUICK TAKE

- IREC has successfully gained funding for a number of new projects, looking at better pulse management and better use of data generated by precision agriculture devices.
- On-going research at the IREC Field Station at Whitton continues to investigate and demonstrate issues and technology for the benefit of irrigated farm systems and businesses.
- IREC builds its program based on the suggestions of members through forums such as the IREC Breakfast Meetings. Casual feedback is also welcome throughout the year.

Recent success in attracting project funding means that over the next two years IREC will be involved in a number of projects ranging from exploring the use of technology for better water, soil and crop management, to preventing spray drift and to improving knowledge and skills for growing pulse crops.

SUCCESS in putting the case for funding of irrigated cropping systems research to key R&D organisations and government departments builds on the solid base of work and research that has been taking place at the IREC Field Station at Whitton. This work was showcased at the annual IREC Field Day on 22 January, and demonstrated the r ange of funded research taking place in the region. A condensed rundown of some of the research follows.

Field day features

Nutrients for cotton crops

The Cotton Research and Development Corporation (CRDC) has funded Dr Wendy Quayle from Deakin University, with a project asking "Can chicken litter be used as a reliable supply of supplemental in-crop nitrogen and phosphorus whilst simultaneously improving long-term soil health?"

Wendy has found that 4.0 t/ha of chicken litter gives approximately 50 kg N and 15–20 kg P in the year of application. Wendy will give a more detailed report on project findings in the next edition of the *Farmers' Newsletter*.

Drs Ben Macdonald and Dio Antille from CSIRO are researching dissolved organic nitrogen in high yielding cropping systems. They aim to quantify the uptake of dissolved organic nitrogen in different cotton varieties, determine if the dissolved organic nitrogen pool influences fertiliser nitrogen use efficiency, determine the impact of soil type on uptake, and understand the importance of the dissolved organic nitrogen pool relative to nitrate and ammonium for cotton nutrition. Through this research they hope to improve nitrogen management for cotton by determining the preferred form of nitrogen (nitrate, ammonium or dissolved organic nitrogen), to increase productivity and reduce environment impacts.

Weed management strategies

Eric Koetz, Research Agronomist with NSW DPI, has a demonstration site examining residual herbicides at the field station. The site was included in an evaluation of pre- and post-emergent chemistry, residual and layby herbicide applications, and integrating chemical and non-chemical tactics. There is also a demonstration trial with test strips, evaluating application timings and strategies for layby and residual herbicides.

Irrigation automation

One of the highlights of the field day for many was the chance to learn about the fully automated pump site. The variable speed drive 16-inch pump has the full range of automated functions. The fully-automated system can be remotely started and stopped, it can also be set to start on a specific water level. Not only does it allow us to observe how much water is in the drain, measure runoff off from different layouts but it also ties in very well with existing automation systems.
The automation was generously funded by CRDC with contributions from Murrumbidgee Irrigation and Bidgee Automation.

A demonstration at the IREC Field Station is examining a range of herbicide strategies for weed control, and the potential to integrate non-chemical tactics.

New projects and programs for IREC

Pulse Check

The Grains Research & Development Corporation (GRDC) has funded a project to improve skills and knowledge in growing pulses in southern NSW. IREC will be forming a pulse check group and if you want to be involved please contact IREC (details below). Learn more about this project in Phil Bowden's article on page 25 of this edition.

Managing data better

IREC has been very fortunate to obtain funding in round one of the National Landcare Program, *Smart Farms Small Grants* program with the project "Ag Tech Sprouts About — using technology to improve management of natural resources". This project will fund several activities including a tour to northern NSW to see how technology is used to improve crop management. A focus group has been formed to develop case studies and easy-to-use checklists to make ag data more manageable. Read more about the focus group in the article on page 15. This activity received grant funding from the Australian Government Department of Agriculture and Water Resources.

Machinery demo day in May

After the success of the 2018 machinery demonstration day, IREC will again be hosting a demonstration day this year. This gives machinery dealers and farmers the opportunity to run machinery and show firsthand how the different implements work and perform. Last year growers relished the chance to actually operate the different sprayers, tractors and implements, getting hands on experience with them. This year the focus will be on sprayers and different nozzles, mulchers, root cutters and planters.

Spray drift prevention

Spray drift was rated a top issue with all groups at the last round of IREC Breakfast meetings, with a number of drift incidents occurring every year. As a result, through the Southern Valleys Cotton Growers Association and the CRDC Grassroots Grants program, IREC is leading the formation of a Spray Drift Stakeholders group. This group includes representation from all commodity groups, EPA, chemical applicators, chemical reps and councils. The aim of the group is to develop a series of initiatives (educational events and tools) aimed at reducing the incidence of spray drift.

Keep us on track

As you can see IREC is involved in a variety of things, we welcome your feedback to make sure we are on the right track and delivering the best for our members and irrigators in our region.

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MAPPING RICE FOR BETTER CROPS AND PRODUCT

Rob Walsh
Grower Services Digital Officer
SunRice

PHOTO: Murray Valley rice grower, John Hawkins, discussing his Koshihikari crop with SunRice Grower Services field officer, Anna Jewell. Credit: SunRice

QUICK TAKE

- MapRice GIS is a geographic information system (GIS) operated by SunRice Grower Services for the benefit of growers and the industry.
- The information gathered and provided by MapRice GIS is instrumental for analysis, planning and accountability of rice production by SunRice, and for providing location-specific information and services to rice growers.
- SunRice Grower Services is continually working to improve the functionality and services of MapRice GIS with a number of new developments expected over the next 12 to 18 months.

MapRice GIS is a secure, flexible mapping system introduced by SunRice in 2015. It provides each rice grower with greater visibility of all aspects of on-farm operations. It is a geographic information system (GIS) developed and maintained by Agtrix.

The Agtrix platform has been implemented across a number of Australian primary industries. The system developed for SunRice requires growers to record their on-farm operations in MapRice GIS. The information is instrumental for analysis, planning and accountability of rice production, enabling SunRice Grower Services to:

- forecast crop sizes and prepare for crop intake logistics
- establish industry input and yield benchmarks
- analyse important rice growing trends
- develop management guidelines to assist growers
- plan milling, packaging and distribution programs
- assure SunRice customers of the traceability and accountability of the quality and purity of Australian grown rice.

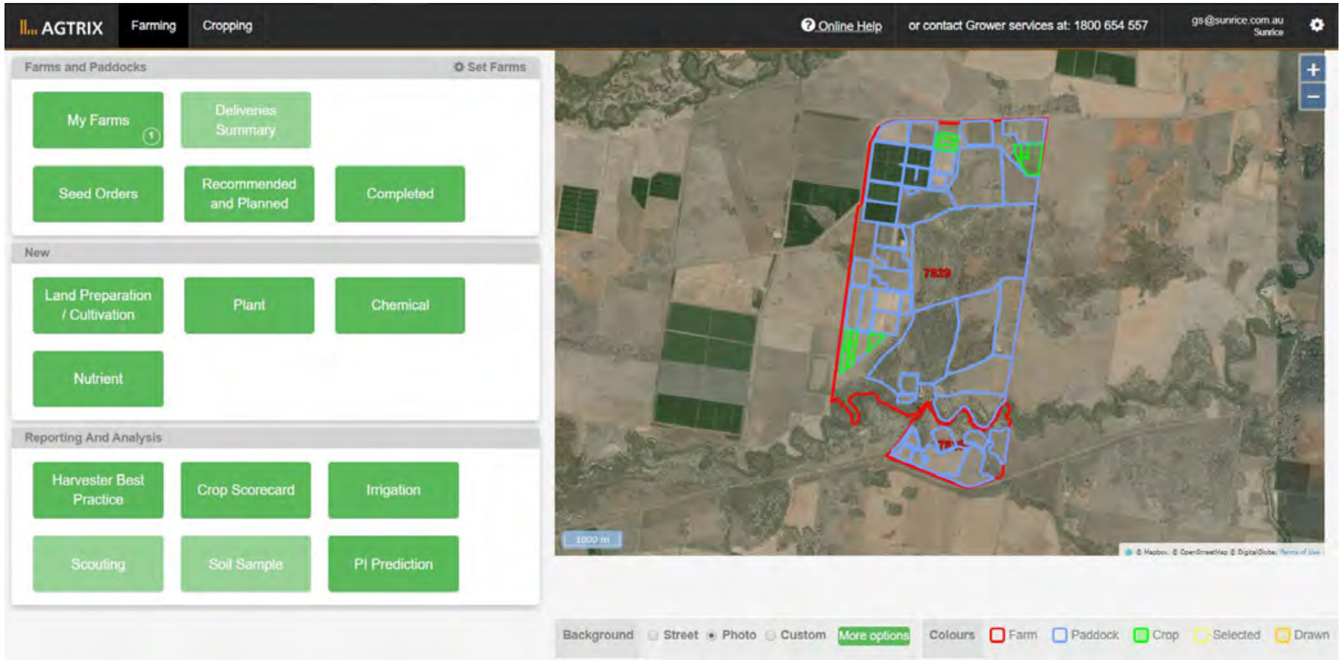

Figure 1. Pictured is the home page of MapRice GIS, which can be accessed by rice growers on the SunRice Growers Web at https://growersweb.sunrice.com.au

What can I do in MapRice GIS?

MapRice GIS can be used to record every step of the rice growing operation, from land preparation and seed ordering, through to harvest. It is a valuable planning and management tool for growers and SunRice alike.

Map your farm

You can draw and redraw farm and paddock boundaries to reflect your latest paddock layouts.

View your farm

MapRice can provide views of your farm using variously sourced maps and aerial photos or the latest Sentinel satellite imagery including NDVI and NDVI Vigorous Growth (Figure 2).

Order seed and confirm plantings

You can order your seed directly using MapRice GIS by selecting the variety, paddock, sowing rate and seed pickup location. Once you have sown your seed, you can easily confirm your plantings directly in MapRice GIS.

Record land management

You can record land preparation and cultivation operations, such as levelling, bed forming and stubble burning. This information can be used for analysis by Grower Services to understand industry best practice.

Record chemical and nutrient applications

Did you know MapRice GIS can be used as a spray diary? You can record all your chemical and nutrient applications on your farm through the system.

Record irrigation

Record all your irrigation activity and water use including flushes, permanent water application and drainage events to generate comprehensive water use statistics and facilitate accurate PI predictions.

Predict panicle initiation

Using recorded sowing dates and irrigation activities, MapRice GIS can more accurately predict PI dates for your plantings. This service interfaces directly with the PI Predictor developed by Rice Extension and NSW DPI.

View deliveries and appraisals

You can use MapRice GIS to view your paddy deliveries to SunRice weighbridges daily during harvest and to review your appraisal results for each lot as they become available.

How do I access MapRice GIS?

Rice growers can access MapRice GIS on the SunRice Growers Web at https://growersweb.sunrice.com.au

You will need your User Name (unique grower number starting with G found on your SunRice financial statement) and password to log into the site.

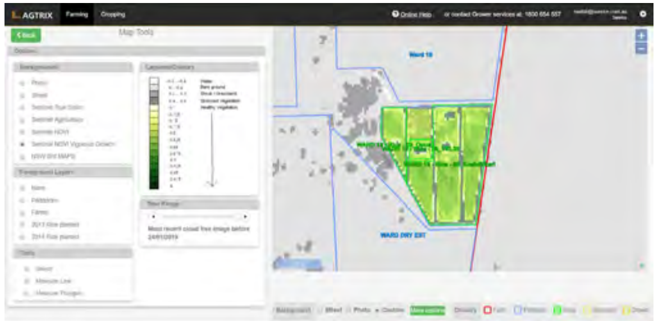

Figure 2. MapRice provides many views of your farm based on data entered, and aerial and satellite images.

Future developments of MapRice GIS

SunRice Grower Services are continually working with Agtrix to incorporate more functionality and services into MapRice GIS and growers can expect to see a number of new developments for MapRice GIS over the next 12 to 18 months.

Through building more capability into MapRice GIS, both the SunRice Grower Services team and SunRice growers will have access to more information, enabling more advanced analysis and deeper insights into crop performance and trends, while assuring customers of the traceability and accountability of the quality and purity of Australian-grown rice.

Where do I get help?

Comprehensive online help is available from within MapRice GIS which includes step-by-step guides for all functionality, with extensive screenshots and commentary.

Of course, there is always personalised help and assistance available from SunRice Grower Services. We can help with one-on-one support through on-farm visits, by phone or remotely with TeamViewer.

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Twitter:	@growerservice

Table 1. Planned new developments for MapRice GIS during 2019–20

Agtrix mobile app	Soon you will be able to access MapRice GIS through a mobile app available on both iOS and Android platforms and available for free on the Apple App Store and Google Play stores. The Agtrix app will enable you to record your on-farm operations while in the field and will use your phone's GPS capabilities to accurately record the relevant spatial information.
Data sharing with farm management systems	We are working with a range of popular farm management systems to share data between MapRice GIS and their own widely used systems. The aim of this functionality is to eliminate the need to record data in more than one system, so that data recorded in MapRice GIS can be automatically available within your own farm management system, and vice versa.
Integration with BoM weather data	An important element of recording many on-farm operations is to record weather data. This integration will reduce the need to look up the weather data and manually enter those details, as MapRice GIS will detect the closest BoM weather station and record the relevant weather data at the time of the activity.
More predictions and forecasting	SunRice are continually working with Rice Extension, NSW DPI, and other industry bodies to incorporate more predictive and forecasting capability into MapRice GIS to assist rice growers to optimize yields and maximize rice quality.
Benchmarking	SunRice Growers who are MapRice GIS users will soon have access to a greater pool of information to enable advanced analysis and deeper insights into crop performance at individual paddock, farm, region, and industry wide levels, to allow you to compare and benchmark your operation and use that information to ultimately improve your profitability.

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GETTING THE MOST OUT OF AG DATA

Anthony Rudd
I-Ag Pty Ltd, Leeton

PHOTO: A group of irrigators participated in a case study, to identify factors limiting the adoption of precision agriculture. Credit: Iva Quarisa

QUICK TAKE

- Irrigators are keen to collect on-farm data and use precision agriculture but a range of issues has limited adoption to date.
- A new project has conducted a case study of eight irrigators to identify the factors limiting adoption. The growers named many factors but there were some common themes across the responses.
- The understanding gained from the case study will be used to develop a tailored process to facilitate the adoption of precision agriculture.

A new project will investigate on-farm data management, to understand what is limiting its use in irrigation farming systems, and what would enhance its use. The project is a partnership between IREC and I-AG Pty Ltd and the activity has received grant funding from the Australian Government Department of Agriculture and Water Resources.

PART 1 of the project will develop case studies designed to expose and highlight the difficulties growers face in their quest to adopt precision agriculture into their current farming process. Using this information, best practices will be defined and a process guide document will be developed as a reference for growers in their quest to use on-farm data.

Part 2 of the project focuses on the implementation of a tailored precision agriculture adoption process.

The case study group consists of eight irrigation farmers from the Murrumbigee area with varying levels of adoption of precision agriculture and data management capabilities. The farmers participated in a recorded interview using a baseline set of questions for all participants. An audit of machinery used was also conducted, to determine the ranged and current level of machinery hardware and software capabilities.

Some of the common elements extracted from the interviews were:

- the apparent knowledge gap within the machinery dealership network relating to the capabilities and integration of product
- the lack of easily accessible support
- the data knowledge gap, file compatibility
- the lack of suitable back-end map generation and prescription generation software
- conflicting information from social and mainstream media, advisors and agronomy
- the lack of contractor capabilities/responsibilities to provide good data
- data standardisation issues.

Part 1 of the project is near completion and a full case study report is being written at the time of publication. A big thank you to the case study group for your time and your honest and at times entertaining interviews. Without you this could never been achievable.

One interesting outcome of note is THE VALUE PROPOSITION, what is it?

A statement was created by the so-called experts in this field to explain the lack of data generation and precision agriculture adoption in our country. In short, the statement suggests that farmers do not see the value in data therefore have not moved forward in their adoption of precision agriculture.

The case study clearly proves that this philosophy is simply wrong. Each of our case study growers gave up their time and were willing to invest in the process because they *do* see value in data. The elements listed above are to blame here, not the farmers' commitment to the betterment of their operation.

While agricultural data is readily collected, the case study identified many factors that limit the use of the data in farm operations. Credit: Iva Quarisa

IREC has played a key role in supporting this project, giving I-AG Pty Ltd access to the IREC Field Station at Whitton and encouraging IREC members to take part in the case study. Without ongoing support from IREC this type of case study would never be possible.

We are very excited to begin Part 2 of the project, which is looking at solution delivery and process adoption.

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This case study is part of the larger Ag Tech Sprouts About project funded through the *Smart Farms Small Grants* program of the National Landcare Program, which runs from September 2018 to March 2020. While building on the awareness and knowledge of new cutting-edge technologies and tools, Ag Tech Sprouts About aims to accelerate the uptake and adoption of these tools and technologies. Ultimately, the project will enable land managers to adopt management practices leading to more productive and profitable agriculture, while adapting to climate change and protecting and improving the condition of soil and vegetation resources.

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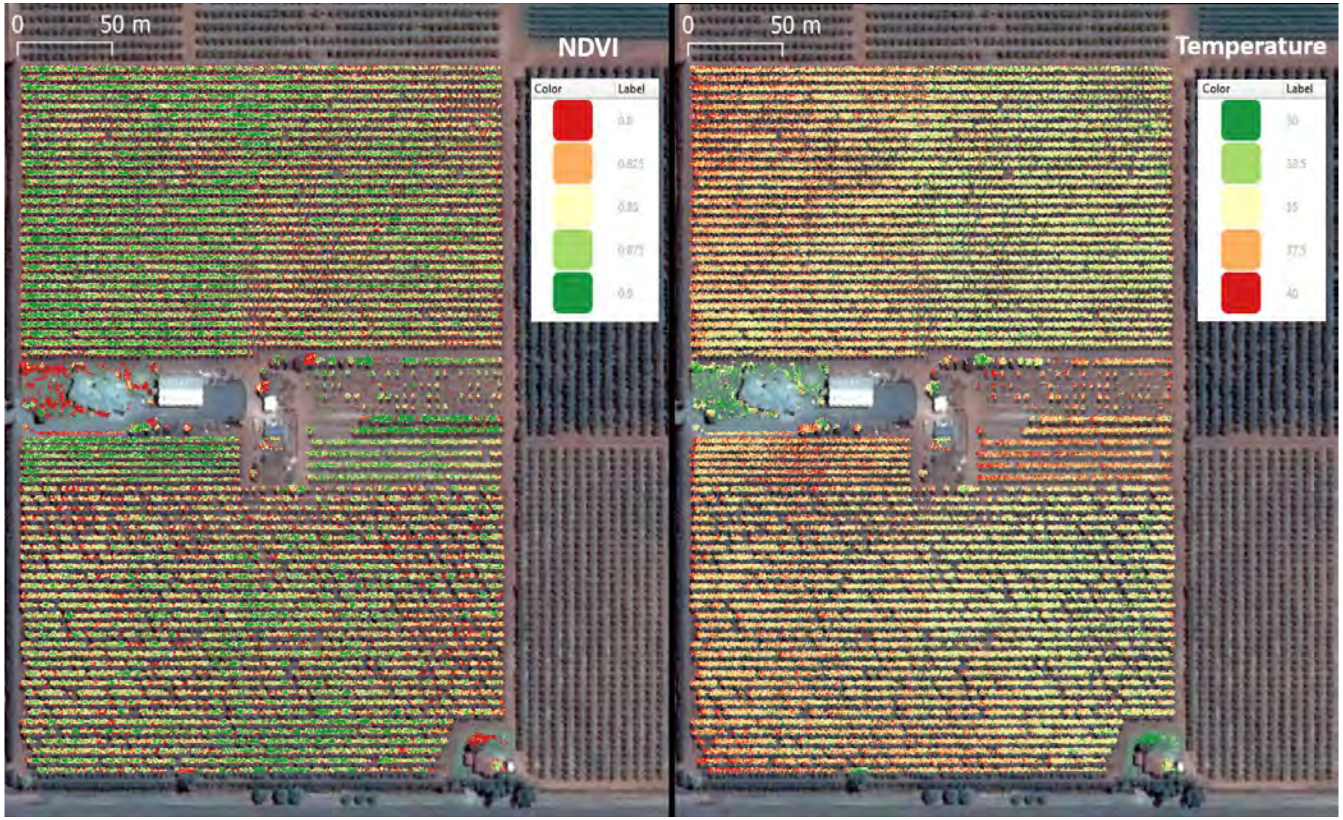
DRONES AT THE SERVICE OF AGRICULTURE



Carlos Ballester and John Hornbuckle
Centre for Regional and Rural Futures
Deakin University, Griffith, NSW

IMAGE: NDVI map (left) and temperature map (right) of a 9.1 hectare cherry orchard at Griffith, obtained with a Matrice 100 drone at 120 metres above ground level. The high NDVI areas have higher canopy temperatures than other areas indicating water stress in these areas due to under-irrigation.

QUICK TAKE

- Drones are handy and valuable tools, especially for precision agriculture.
- The development of new sensors opens the doors to new applications of drones in agriculture.
- Australia's safety rules must be followed when operating drones—even on your own land.

The popularity of drones all over the world in the last decade and their potential application across industries very diverse in nature has not escaped the attention of the agriculture sector. Agricultural industries have embraced this technology and are excited about its capability for precision agriculture, but also remain wary of the hype associated with the technology.

DRONES, also known as unmanned aircraft vehicles (UAVs), are mainly used as platforms where tools and sensors of different types can be attached to perform specific tasks. The constant development of more reliable and easy to use drones with longer battery life, as well as more advanced and miniaturised sensors for use on drones, has awakened the interest of farmers and agronomists in this technology in ways they did not consider in the past.

In the last few years, there has been significant research on the study of the applicability of drones in agriculture. At Deakin University's Centre for Regional and Rural Futures (CeRRF), for instance, research has been conducted to provide more efficient identification of weeds in irrigation channels, which if not treated properly, usually reduce the water flow and affect the efficient delivery of water to farms. Other topics that CeRRF is working on is the study of aerial multispectral and thermal imagery for water and fertiliser decision management in crops.

Nowadays, it is clear that drones can do things other than just recording harvesting videos or collecting nice pictures of the crops and landscapes. However there are still a lot of people wondering what services can this technology really provide for farmers.

Uses of drones in agriculture

Automatic plant counting is now possible from high-resolution images (< 3 cm) taken from drones at low altitude. Agriculture companies either provide this service to their customers or provide them with user-friendly plant counter tools that are useful to assess whether or not replanting is needed in some areas.

Crop mapping using aerial multispectral and thermal images (page 18) is one of the most common services provided for monitoring nutrient and plant water status as well as for disease detection. Thermal images show areas of plants with a higher temperature, indicating lower transpiration due to either low soil water availability or a malfunction of the plant vascular system due to disease. Aerial thermal images from drones are also used to evaluate surface and subsurface drip irrigation systems. Multispectral images collect information about the percentage of light reflected by the canopies at specific bands. Data from these bands can be combined to obtain so-called vegetation indices, which depending on bands used, can illustrate differences in plant biomass, chlorophyll content and other crop factors.

New sensors are already available in the market that provide thermal and multispectral data simultaneously, which offer the advantage of collecting different types of information with just one flight. Images at one specific date illustrate the existing variability in a paddock and are useful to pinpoint in the field the reasons for that variability and take decisions accordingly to manage it. Examples include thermal flights for identifying leaks in drip systems (Figure 1) and looking at water infiltration (subbing) in surface irrigated beds (Figure 2). Time series of images, on the other hand, provide information about the evolution of the crop as a result of specific irrigation or fertiliser strategies, which is useful to fine-tune the best management practices for a crop locally.

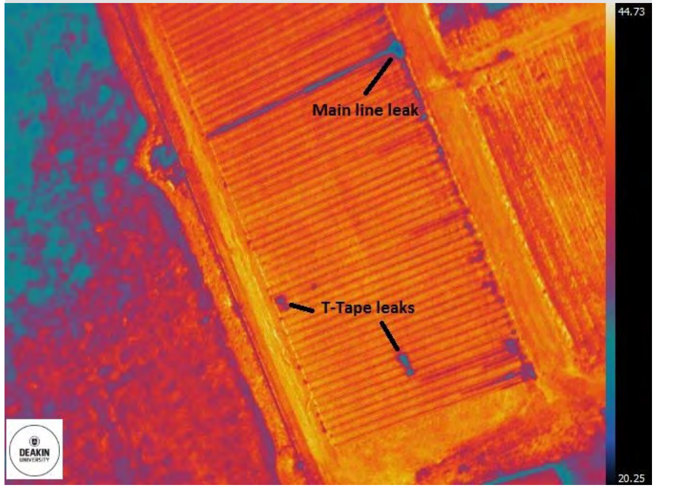


Figure 1. Thermal image of a drip irrigated field showing lateral drip line emitter leaks and main line leaks.

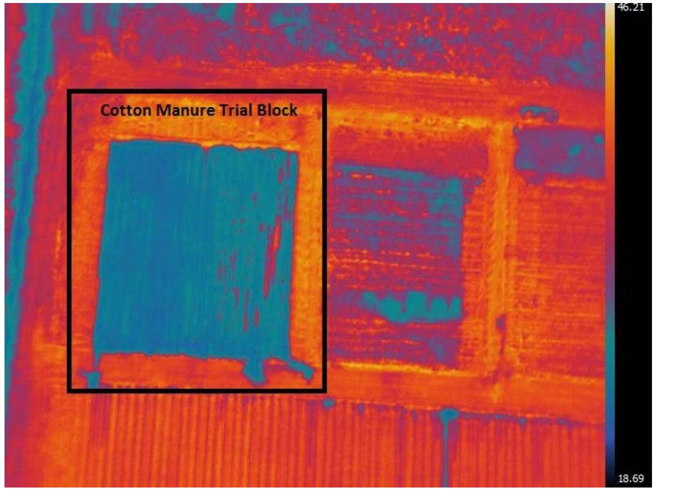


Figure 2. Thermal image showing poor lateral movement of water (subbing) across raised beds.

Spraying for fertiliser plan corrections and localised pest and disease control is now possible with specialised drones equipped with nozzles and tanks with a liquid capacity of more than 10 litres. Drones follow a previously configured flight plan to spray exclusively the areas of interest, saving product and time of application. In countries such as Japan for example, agriculture companies rent these specialised drones for spraying crops, mostly in rice paddies.

Weed detection, soil compaction assessment and release of beneficial insects over the farms at low altitude to control pests and prevent reductions in yield are also among some of the more recent applied uses of drones in agriculture.

Although there are agronomists and drone-related companies that provide most of the services mentioned above, some people may prefer to buy and operate their own drone to monitor their crops. If that is the case, there are some considerations that must be taken into account.

Can everyone fly a drone to monitor crops?

Current drones are fun and easy to fly especially when using apps that enable the planning of automated flights. However, when trying to use these platforms for crop monitoring using thermal or multispectral sensors instead of standard cameras, some skills are needed. First, the sensors have to be integrated into the drone, which requires the use of an external battery (in which case, drone take-off weight should not be surpassed for safety) or the connection of the sensor to the drone battery. Second, image processing is needed to create a single high-resolution image of the whole field from all the images collected. Some platforms provide this service at a fixed or variable price depending on the area covered although software such as Pix4D or Agisoft, for example, can be obtained to process the images on your own. Lastly, specific vegetation indices have to be calculated from the data collected depending on the aspect of the crop to monitor, and variability then interpret, which is not always straightforward.

Even if the drone is not going to be used for commercial purposes and it is going to be used on your own land, there are general rules from the Civil Aviation Safety Authority (CASA) that should be followed.

Among the most important safety rules are:

(i) you must only fly during the day and must be able to see the drone with your eyes at all times

(ii) you must not fly your drone higher than 120 metres above the ground

(iii) you must not fly within 30 metres of people, unless the other person is also controlling or navigating the drone

iv) you must keep at least 5.5 kilometres away from controlled aerodromes.

Detailed information on operating your own drone can be found at CASA's website https://www.casa.gov.au/aircraft/landing-page/flying-drones-australia

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IDENTIFYING 'HARD' SOIL PROBLEMS IN THE RIVERINA

Sam North and Alex Schultz
NSW Department of Primary Industries, Deniliquin

PHOTO: Soil water potential and soil strength were determined at 23 sites across the irrigated areas of the Murrumbidgee and Murray valleys. At the site pictured, a logger to measure soil water potential was installed on a red brown earth after crop establishment.

QUICK TAKE

- This study highlights the prevalence of hard sub-soils in all soil types commonly found under irrigated systems in the Riverina.
- Just over 85% of sites investigated had soils that would inhibit root growth at a water potential of only -35 kPa, well short of the recommended irrigation trigger point of -60 kPa.
- To investigate the impact of hard soil on productivity, its cause and possible solutions, GRDC is funding research through active learning groups.
- Locally-based grower groups will provide an opportunity to, among a range of issues, identify better ameliorating techniques tailored to local soils.

Soils of the irrigated areas of the Murray and Murrumbidgee valleys are known to have dense sub-soils with low final infiltration rates. While these are well suited to growing rice, restricted infiltration and low available water holding capacity present difficulties for other crops. These 'hard' soils have the potential to adversely affect plant growth through reduced root growth and plant available water.

TO INVESTIGATE the nature and extent of hard soil problems in the region, both soil water potential and soil penetration resistance (i.e. soil strength) were measured at 23 irrigated wheat sites across the Murray and Murrumbidgee irrigation areas. This allowed the non-limiting water range (NLWR) concept to be used to assess the effect of soil structure on crop growth.

Non-limiting water range is the range of soil water content in which plant growth is not restricted by waterlogging, drought stress or hard soil. Plants are most productive when the soil is drier than field capacity (i.e. not saturated and pores contain greater than 5% air), but not so dry and hard that roots are unable to penetrate the soil.

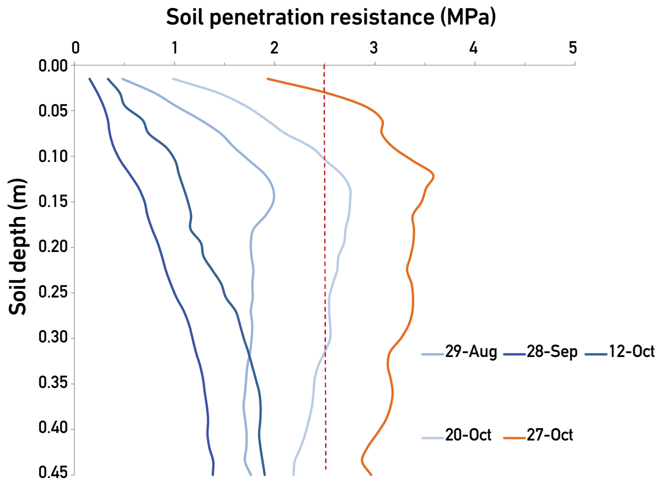
Soil water potential was measured instead of water content as it provides a measure of both aeration status and plant water stress, while not requiring calibration for different soil types. A cone penetrometer was used to measure penetration resistance. The relationship between penetration resistance and water potential defines the soil strength characteristic.

Different locations, similar characteristics

Most soils showed a similar soil strength–water potential relationship at the 3 cm and 30 cm depths. This group comprised 20 of the 23 sites and included all soil types commonly found in the Murray and Murrumbidgee irrigation areas: red-brown earths, transitional red-brown earths, non self-mulching clay and self-mulching clays.

At three sites however, all self-mulching clays, the soil was markedly different, having a lower penetration resistance across the range of water potential measured at all three depths, as well as a lower rate of increase in penetration resistance with increasing water potential at the 15 cm and 30 cm depths.

There was a clear difference between the duplex soils (red-brown earths and transitional red-brown earths) and the uniform clays (self-mulching clays) at the 15 cm depth. The duplex profile had a zone of very high soil strength at 10–15 cm, whereas the self-mulching clays did not. Soil strength in the duplex soils increased more rapidly in the 10–15 cm zone than in the rest of the profile when drying, whereas in the self-mulching clays it increased more uniformly through the profile (Figure 1).



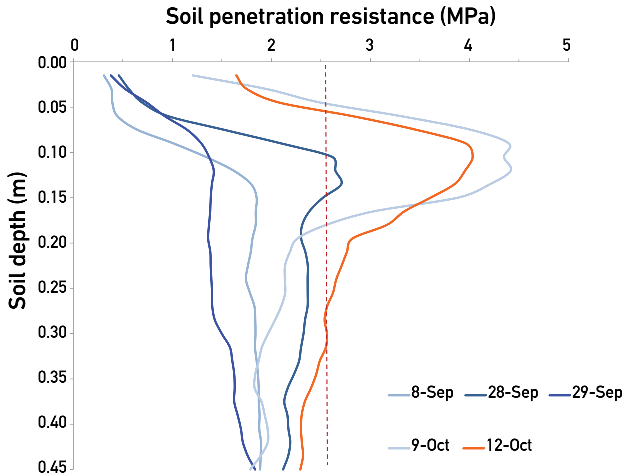


Figure 1. Soil penetration resistance in self-mulching clays (top) and transitional red-brown earths (bottom) showing changes in soil strength with wetting and drying.

When comparing the water use efficiency (yield achieved per millimetre of water applied), transitional red-brown earths achieve a higher water use efficiency on average, ranging from 11.5 to 17.5 kg/ha/mm. Duplex soils had a wider spread ranging from 6.0 to 17.2 kg/ha/mm. Three compacted problem soils confirm a trend of reduced water use efficiency with a smaller non-limiting water range due to 'harder' soils (Figure 2).

Water availability limited at 85% of sites

Soil aeration is considered limiting in soils wetter than field capacity (i.e. water potential between 0 and -10 kPa). Irrigation should be applied to avoid drought stress and obtain maximum yields of cereals when water potential at the bottom of the active root zone (i.e. 30 cm) dries to -60 kPa. Furthermore, very few roots are able to penetrate a soil when penetration resistance is greater than 2.4 MPa. Based on these criteria, 85% of the sites tested in this survey had a non-limiting water range restricted by high soil strength at 15 cm and 30 cm.

There was not a strong correlation between non-limiting water range and yield, with good irrigated wheat yields achieved at the majority of sites studied. Crop root growth through these soils is only likely to occur when they are fairly moist (i.e. between -10 and -35 kPa). As winter crops grow under conditions of high soil moisture and low evaporative demand, the high soil strength of these soils did not appear to adversely affect the yield of winter crops.

In contrast, summer crops are likely to experience a period of low root growth during every irrigation cycle, particularly in the duplex soils as penetration resistance at 15 cm and 30 cm in these soils becomes limiting well before the -60 kPa irrigation trigger point is reached. The effect of this on yield and water use is still not understood for summer crops.

Although there is no strong relationship with wheat yield and soil strength in the paddocks investigated, we do see a trend indicating that high water use efficiency is harder to achieve in soils with a narrow non-limiting water range, as seen in the duplex soils with a 'hard' pan at 10–15 cm (Figure 2).

This study found that just over 85% of sites investigated had soils in which penetration resistance would inhibit root growth at a water potential of only -35 kPa, well short of the recommended irrigation trigger point of -60 kPa. This highlights the prevalence of hard sub-soils in all soil types commonly found under irrigated systems in southern NSW.

To investigate the impact of this on productivity, its cause and possible solutions, the Grains Research & Development Corporation (GRDC) is funding research through *active learning groups*. It is important to get involved in your local group as this will lead to better ameliorating techniques tailored to your soil.

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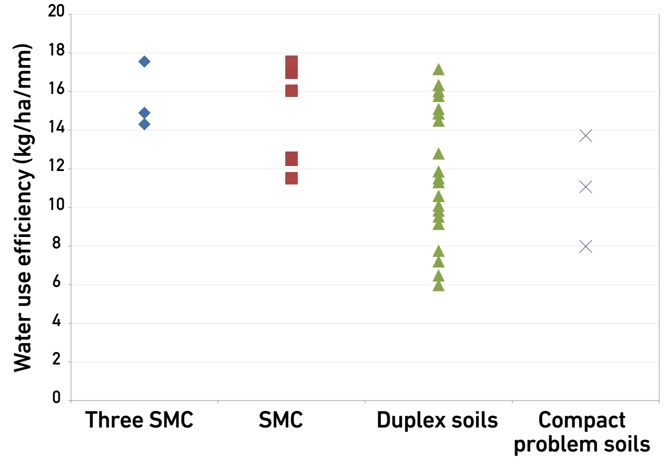

Figure 2. Water use efficiency shown for different soil groups. SMC = self-mulching clays

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NEW GROWER GROUPS TO LIFT PULSE PRODUCTION

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PHOTO: Drone view of winter crop experiments at NSW DPI Leeton Field Station, with chickpeas in front, canola in middle and faba beans at the back.
CREDIT: Tony Napier

QUICK TAKE

- A GRDC-funded project looks to improve the knowledge and capacity of growers and advisors to grow a range of pulse crops.
- A situation analysis will be conducted early in the project to provide information about current pulse production, and to inform GRDC and IREC about gaps in knowledge or capacity, to guide extra funding for research or greater marketing support.
- Participant-guided activities will enable growers and advisors to increase their knowledge and capacity to grow a range of pulse crops. These activities may include talks by experts, field demonstrations and trials, and benchmarking workshops.

Grower discussion groups are being set up across the Grains Research & Development Corporation (GRDC) northern region to improve the knowledge and capacity of farmers and advisors to grow a range of pulse crops. IREC is one of six grower groups in southern NSW participating in the large GRDC-funded project for 2019 and 2020.

'PULSE Check' discussion groups are being formed and will use participant-guided activities to give the latest advice and support on agronomy and marketing of pulses. There are two components to the project: the formation of discussion groups and development of a situational analysis of pulse growing in the region.

A discussion group structure was selected as previous experience shows that grower extension activities have the greatest chance of continued engagement if they are directed by the group members themselves and supported by active and skilled facilitation.

Local group for local issues

The IREC Pulse Check group will meet twice per year during the project, depending on seasonal conditions (such as late crop emergence), and likely as pre-season and pre-harvest information sessions.

The meetings will be facilitated by IREC, with guest presenters including marketers, researchers and experienced growers. The purpose of these discussion group meetings will be to increase growers and advisor capacity in pulse production while building a network of support. Activities may include:

- expert lectures on key management topics such as disease, weed, insects, nutrition, plant physiology, inoculant management, breeding and marketing
- group learning activities such as field walks, tours, workshops or similar
- demonstration and field trials where a need is identified
- pulse agronomy training workshops
- grower information and benchmarking evenings using case studies or focus paddocks
- grower and advisor mentoring programs.

Situation analysis

The project has a second part that involves preparing a situation analysis to identify specific regional benefits, constraints and risks to pulse production. It will include:

- which pulses are or could be grown in the region
- current grower and adviser knowledge, skills and ability to grow pulses
- grower motivation for including pulses in their farming system
- agronomic drivers of pulse production
- economic drivers of pulse production.

Ground view of pulse crop experiments at Leeton Field Station. Chickpeas are planted in the foreground and lentils in background. CREDIT: Tony Napier

The situation analysis will be developed following consultation with local growers and will be completed in the early stages of the project, giving information about current pulse production. It can then be used to inform GRDC and IREC about gaps in knowledge or capacity that need attention such as extra funding for research, or greater marketing support.

Significant information captured from meetings and interaction with participants demonstrating their motivations, attitudes, knowledge, abilities, technology requirements and their scope for change will be added to the analysis. This information will be obtained through baseline survey results and tracked over the course of the meetings.

Several other grower groups in NSW, Farmlink at Temora and Riverine Plains Inc. at Rand, have initiated their Pulse Check group meetings, with good responses.

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RICE BREEDING IN AUSTRALIA – CHALLENGES AND OPPORTUNITIES

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NSW Department of Primary Industries
Yanco Agricultural Institute

PHOTO: **The rice breeding program involves large-scale logistical operations involving thousands of packages of seeds representing new genetic combinations.**

QUICK TAKE

- There will always be a need to improve rice varieties to achieve high yield and premium quality, as well as addressing other traits such as seedling vigour, lodging resistance and growth duration.
- Plant breeding, including rice, requires a broad range of knowledge (including genetics, physiology, cereal chemistry, pathology, agronomy and statistics) and a multi-disciplinary team effort.
- The challenge for current breeders is to use, to the advantage of growers and the industry, the recent deluge of new genomics information and implement efficient new molecular breeding strategies.

Plant breeding often has been described as an endless task because there are always improvements that can be made in response to changes in the environment or market. New varieties are the primary output of a breeding program and have improvements in at least one character compared to the current varieties. However there will always be improvements needed in the future especially regarding improved yield and quality, as well as other traits.

RICE breeding has long history in New South Wales. After the initial introduction of varieties from California, USA, in the 1920s, a rice breeding program was formally established at Yanco around 1928. The early phase of the breeding program focused on preliminary testing, seed purification and re-selection of these introduced varieties. It soon became clear that new varieties adapted to local conditions had to be developed rather than imported.

There were major disruptions in breeding due to World War II until the mid-1950s. Since then, breeders based at Yanco have developed a wide range of over 20 varieties with different grain quality types. Since 2011, the rice breeding program has been based on a partnership between NSW DPI and SunRice, with funding support provided by AgriFutures.

Plant breeding in a nutshell (and why it is complicated)

There are two universal features of breeding programs regardless of the crop species. Firstly, breeding programs require large logistical operations, similar to a factory production line. Secondly, all plant breeding programs require a long time to develop new varieties, which is related to the biology of the crop species, because self-pollinated crops like rice are not 'genetically stable' during early generations.

There are two common elements of crop breeding programs:

- crossing (also called 'hybridisation')
- selection.

The purpose of crossing is to create plants with new genetic combinations by combining genes from both the female and male parents. After crossing, large breeding populations (usually tens or hundreds of thousands of genetically different individual plants) derived from many specific cross combinations are produced.

Selection involves evaluation of the new plants for agronomic and quality traits. More advanced stage testing involves multi-location trials over several years so that new breeding lines are tested in different weather conditions and soil types. During selection, the poor performing plants are discarded and the 'good' ones are promoted for further testing (similar to a final series in sports).

Plant breeding requires a broad range of knowledge (including genetics, physiology, cereal chemistry, agronomy, pathology and statistics) and a multi-disciplinary team effort.

Collection of field data is a critical stage of variety development in a plant breeding program.

Challenges

Rice breeders constantly need to combine a wide range of traits into a new variety. The Australian rice industry is targeted towards premium quality and therefore new varieties for southern NSW need to have high yields and specific quality attributes. Breeders have also targeted essential agronomic traits such as seedling vigour, lodging resistance and growth duration. They strive to increase to make improvements for at least one trait (referred to as 'genetic gain') with fixed resources.

Predicted climate variability will almost certainly affect water availability and a range of abiotic stresses such as cold and heat tolerance, straight-head tolerance and transient drought. These traits are difficult to study and accurately measure, preventing routine screening methods to be developed. Improving water use efficiency and adaption to water-limited conditions at different growth stages will be a top priority.

New molecular technologies

In the past 30 years, the development of 'DNA markers' (also called molecular markers) have provided breeders with new tools for selection and analysis. DNA markers provide breeders with genetic information by 'fingerprinting' rice plants to track specific genes or make predictions for traits based on the genetic makeup. The methods used are very similar to the methods used in forensic science labs (as shown in late night TV shows!).

Using markers to screen breeding populations — marker-assisted selection (MAS) — is more efficient than using conventional methods leading to improved accuracy, reduced labour or cost savings. The implementation of molecular breeding has been widely adopted in most plant breeding programs around the world.

The Yanco rice breeding program has been using molecular markers in rice breeding for many years for traits such as amylose content and fragrance, and was in fact an early adopter of marker technology on par with the most advanced rice programs in the world, to speed up the breeding process.

There have been incredible advances in rice molecular research in the last 20 years. Due to its small genome size and use as a model cereal species, rice was the first crop genome to be sequenced in 2005, representing a major scientific breakthrough.

In 2014, due to recent technological improvements, more than 3000 rice genomes are now publicly available. This amount of information is not available for other crops. Genomics has enabled considerable information to be discovered about the genetic control of traits by using gene mapping approaches. Once a gene has been mapped, it provides opportunities to use markers for routine screening. It is expected that genomics research will facilitate the characterisation of genes controlling high priority traits.

Future endeavours

The challenge for current breeders is to exploit the deluge of genomics information and implement efficient new molecular breeding strategies. In the future, we plan to upscale the use of DNA markers to screen breeding material, especially at the early stages of the program. Future technological developments will undoubtedly provide rice breeders with new tools. Continued advances in crop physiology and molecular biology will enhance our understanding of yield potential and stress tolerance, and rice quality. Imaged-based technologies may also have a wide range of applications from screening to trial monitoring to accurate in-field measurements. Data management of trial and molecular data will become increasingly important as new more sophisticated analytical methods continue to be developed.

Finally, and equally importantly, closer integration with agronomy will ensure that the newest varieties are grown to maximise yields in the field.

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Irrigation Research & Extension Committee

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