Automated irrigation and successful aerobic rice production

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AT A GLANCE…

- Reducing or eliminating the period of permanent flooding of a rice crop by flush irrigating can substantially reduce rice water use, however, this comes at a significant increase in labour and a requirement to understand the crop water demands.
- Automated surface irrigation systems act as an enabling technology to overcome the increased labour burden associated with high frequency flush irrigation of rice.
- Key to maximising water productivity in an aerobic rice system is the need to understand irrigation requirements. Integration of sensing and forecasting (soil moisture conditions and extreme weather events) with smart sensing automation systems allow for irrigation events to be forecast, allowing water to be applied when required.
- Deakin University is working in collaboration with commercial growers and Padman Automation to develop low-cost smart sensing and automation products ready for industry uptake where the user determines the level of automation desired enabling significant labour and water savings.

TO remain competitive with other seasonal crops such as cotton and maize and permanent horticultural plantings, the Australian rice industry needs to significantly increase water productivity. The industry has set a goal of 1.5 tonnes per megalitre (ML) by 2030 – considerably higher than the current average of under one tonne per ML. Recent advances in water productivity have come through higher yielding varieties and sowing practices to reduce the time of permanent water, thereby reducing percolation and evaporative losses.

This transition from aerial sowing into permanent water to drill sowing has successfully reduced water use for many growers. Further water savings and advances in water productivity have been achieved overseas in aerobic rice, which involves frequent flushing, without ever applying permanent water.

Cold tolerance is a limitation of aerobic rice in southern Australia. Cold temperatures in the cold-sensitive early pollen microspore and flowering periods can severely limit yield, with high rates of nitrogen application increasing susceptibility.

Irrigation management is another major limitation to adoption of aerobic rice, with a major increase in labour needed for the (about) 30 irrigations required for the season.

Furthermore, there are no set irrigation thresholds to trigger irrigation for high-yielding Australian rice varieties – nor cost effective smart sensing systems capable of triggering irrigation events.

But with the emergence of the Internet of Things (IoT) in agriculture it is possible to have information about soil, crop, and weather conditions available at real time and at a lower cost than ever before. The use of this technology for sensing and controlling existing irrigation structures that works across a range of irrigation water outlets/stops has the potential to make the

Aerobic rice field walk at De Bortoli Wines, Griffith.

IMAGE 1: Watermark soil moisture sensors were used to trigger irrigation events.

adoption of automated irrigation systems more affordable and attractive for irrigators.

The research objectives were to develop linked sensing, forecast and automation systems and to determine thresholds to trigger irrigation events to achieve optimal water management in aerobic rice systems.

The trial site

The aerobic rice trial was pioneered by Darrell Fiddler, farm manager at De Bortoli Wines in Bilbul near Griffith NSW. The site was a 35 hectare, nine-bay border check field with three irrigation triggers investigated (soil tension at 15, 30, 70 kPa in the vegetative period with all under 15 kPa in the reproductive period).

Short season rice variety Viand was drilled into an undisturbed cereal hay stubble in early November. Irrigation was triggered off watermark soil moisture tension sensors (Image 1) installed to a depth of 15 cm and monitored at real time.

Initial irrigations were done manually – pulling slides (Image 2). The first irrigation took four days to complete all nine bays in the field. This involved Darrell driving to and from the field 12 times to check or change water (including a 5:00 am, 4:00 am and 1:00 am water change). This totalled seven hours of labour and 168 km travelled. (7 hours X $45 per hour) + (168 km x $0.72 per km) = $436 plus sleep deprivation, missed opportunities doing other jobs (e.g. spraying) as well as some bays over-irrigated resulting in greater tail water.

Once Padman portable rubber inserts and Autowinchs were installed (Image 3), the irrigation could be controlled via the web app from the workshop/tractor/holidays. As seen in Figure 1, irrigation was triggered based off in-field soil moisture sensors sending an alert and water ordering assisted by soil moisture forecasting. IoT control structures (Padman Autowinch) were used to open/close irrigation stops and in-field water height sensors (Padman Sensor Pro) were installed near the end of the bay to trigger closing/opening of current/next bay.

The Padman IoT equipment communicated with the webapp using a LoRaWAN gateway. This reduces annual connectivity costs relative to CAT-M1 when a number of devices are used.

IMAGE 2: Old school slide gates used in manual irrigation.

IMAGE 3: Padman Seasonal Autowinch and portable rubber inserts used in the automation of aerobic rice at De Bortoli Wines.

FIGURE 1: Illustration of how the automated irrigation system works

FIGURE 2: Autowinch position in February 2021 – 17 irrigation events for the month

The gate is fully open at 100 per cent and fully closed at 0 per cent. Whilst the bay is being irrigated, the gate was set to 40 per cent to enable overflow in the case of an unforeseen supply issue, allowing water to overflow into the bay rather than burst the channel.

What we found

The smart sensing and automation system successfully automated 264 irrigation events for the season, creating substantial labour-saving benefits. Farm manager Darrell Fiddler explained how automation enables him to "conduct our daily business, such as harvesting and spraying-out other crops without having to stop half-way through the day to change the water".

Such frequent irrigations (Figure 2) as required in aerobic rice systems would not be possible without automation.

"I actually feel redundant as an irrigator now. I take an afternoon drive-by to see if it is working every day and every day it seems to be working. I have to find an excuse to check the paddock now, as opposed to having to check every five to six hours with traditional irrigation systems," Darrell said.

The partnership between Deakin University and Padman Automation has enabled in field Sensor Pros (Image 4) the capability to add watermark soil tension sensors. This means one sensor can initiate an irrigation event based on soil moisture tension as well as measure water height during the irrigation event to control water changes automatically during irrigations. This removes the need for third party sensing and reduces the cost of smart sensing integration with automated irrigation infrastructure.

Increasing soil moisture deficit during the vegetative period resulted in a significant delay in maturity. This meant the more water stressed treatments were severely affected by cold temperatures – as were many traditional ponded crops with the coldest minimums in 25 years during the 2020–21 season.

Despite this, a better-than-expected yield was achieved (8.1 tonnes per hectare) with the aerobic rice when irrigated at a soil tension of 15 kPa throughout the season.

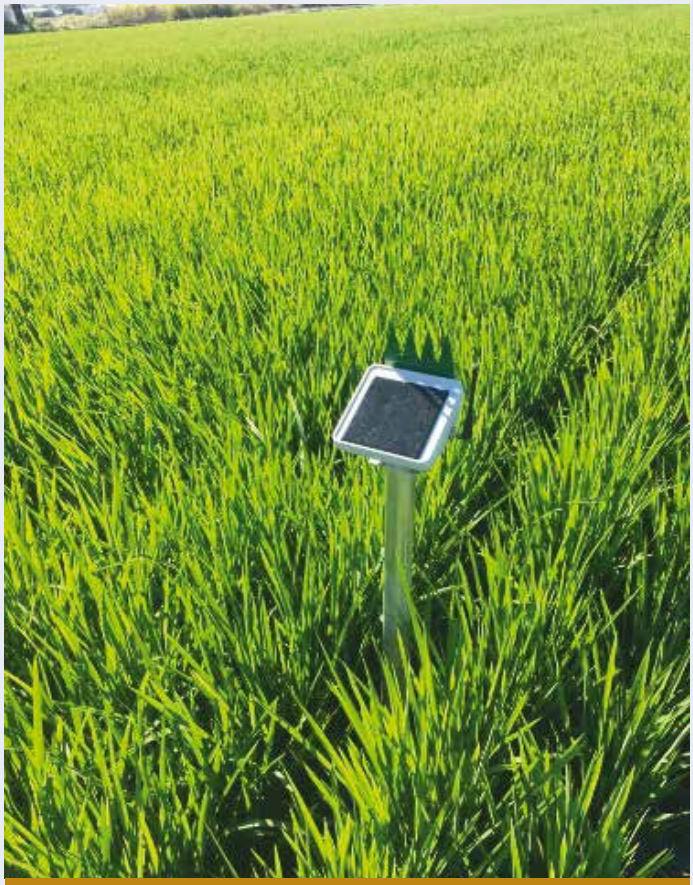
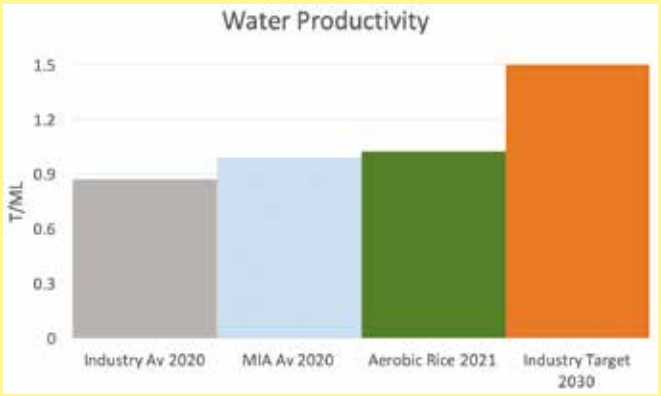


IMAGE 4: Sensor Pro capable of sensing water height and soil moisture.

Commercially successful aerobic rice – grown under automated irrigation – being harvested in April 2021.

FIGURE 3: Water productivity of aerobic rice in 2021 versus whole of industry and Murrumbidgee Irrigation Area (MIA) averages for 2020 (SunRice) and the industry target of 1.50 tonnes per ML by 2030



Note: 2021 water productivity data was not available at time of publication however preliminary results indicate below 2020 and long-term average due to the cold season reducing yield.

Appropriately irrigated aerobic rice was found to be possible in southern NSW and feasible at a commercial scale with cost effective automated irrigation scheduling. A total of 7.95 megs per hectare was applied, estimated as 30 per cent less than traditional flooded rice in C21 with water productivity over one tonne per ML (Figure 3).

Automation and sensing cost varies from $200 to $700 per hectare depending on bay size and can be easily moved between and within seasons to further reduce capital costs.

What does the future hold?

This trial demonstrated that even in an exceptionally cold year, aerobic rice with an appropriate irrigation schedule can be grown successfully in a commercial setting in southern NSW. Previous overseas research has shown that maximising water productivity (tonnes per ML) will result in decreased yield but in low water allocation years – or in higher water use areas – we believe aerobic rice could be a viable option.

Automation and smart sensing enables precise and easy water control. In the event of forecast extreme hot or cold events, during sensitive periods, strategic ponding could be used to mitigate against yield loss whilst maximising water productivity.

Deakin University is looking to work with growers to trial this technique as well as a repeat of the aerobic rice experiment at De Bortoli's in the C22 rice season.

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STOP THE PRESS...

Darrell Fiddler, Farm Manager of De Bortoli Wines – and pioneer of the aerobic rice trial – has been named the *C21 SunRice Grower of the Year*. An excellent and well-deserved achievement. Congratulations Darrell.