Growing rice with less water

Leigh Vial
Irrigator, Moulamein & Nuffield Scholar 2006

Adapted from Leigh's Executive Summary of his Nuffield scholarship study report

in a nutshell

- This Nuffield study overviewed work in several countries that is attempting to adopt aerobic and alternate-wet-and-dry (AWD) rice systems to increase water use efficiency
- The application of such systems in Australian rice growing has potential to lead to a 15–30% increase in water use efficiency, from evaporation savings
- Success of aerobic or AWD systems in Australia would require the rice industry to assess and adopt aerobic germplasm, refine AWD nitrogen management, consider Clearfield™ technology for broadleaf weed control and redefine rice soil suitability for AWD systems

The Australian rice industry is a world leader in yields, quality and marketing. Water supply is fast becoming its greatest limitation. Can we find a rice growing system that will grow more rice per megalitre?

My Nuffield study overviewed the efforts around the world to adopt aerobic and alternate-wet-and-dry (AWD) rice systems to increase water use efficiency. Aerobic rice is grown out of water and without irrigation for the whole season, whilst AWD systems flush irrigate for the whole season. What is the possible value of these systems to the Australian rice industry?

Rice growing systems across the globe

My studies took me to the International Rice Research Institute (IRRI) in the Philippines; Arkansas, California and Texas in the United States; and northern China. Water shortages are common in many of the world's rice-growing areas, so increasing the water use efficiency of rice is now a central theme in many rice research programs.

Aerobic and AWD systems have significantly increased water use efficiency of rice in more permeable soils (such as northern China), because up to 60% of ponded water is lost to percolation. On low percolation soils (such as Australia), water use efficiency is much less responsive as losses are much lower; less water means less transpiration and hence less yield. We could still expect 15–30% increase in water use efficiency, from evaporation savings if we use adapted varieties and best practice management.

Successful AWD rice needs adapted varieties, robust grass weed control, and careful nitrogen management and soil selection.

Aerobic germplasm, be it inbred or hybrid, is more drought tolerant than lowland varieties. It comes from increased early vigour and root volume, greater osmoregulation and better use of nitrate nitrogen. No observed germplasm, however, displayed increased yield per unit transpiration, confining its value to reducing water losses, rather than increasing the conversion of water to yield. C4 rice (or less temperature responsive germplasm) may be the only possible way of achieving this.

The Australian rice breeding program is now introducing some aerobic lines. Their useful traits should be available in about 10 years.

Figure 1: Root behaviour of China's Han Dao aerobic rice varieties. The Han Dao varieties are on the right in each comparison. The Han Dao varieties exhibit greater root volume (left picture) and greater root depth (right picture) when compared to lowland varieties on their deep loess soils. How would these varieties behave in Australian rice soils? Source: Wang Huaqi (2006).

Weed control in AWD rice focuses on grass weeds, particularly barnyard grasses (*Echinochloa* spp.), and is heavily reliant on herbicides. As many different modes of action as possible need to be utilised to avoid herbicide resistance. Across the world, there is adequate diversity in available modes of action, with herbicide groups A, B, D, E and F represented. Group E (molinate) is becoming less available in many rice growing regions, including Australia, and both groups A and B have a high resistance risk. Australia currently makes insufficient use of group B (eg Clearfield™) and group D (eg pendimethalin, currently registered). Both groups have useful soil residual herbicide activity and good crop safety.

A long-term grass weed management strategy may involve rotating between AWD rice and a flooded regime to vary both environments and control mechanisms.

Aerobic and AWD rice systems have greater potential for nitrogen losses, often recording less than half the nitrogen use efficiency of flooded systems (Australian flooded systems typically have 60–80% nitrogen use efficiency). Nitrogen losses are both expensive and a potent greenhouse gas (NOx is 310 times as potent greenhouse gas as CO_2). Low soil nitrate levels at sowing, conservative nitrogen strategies until permanent flood and particularly, controlled release nitrogen can reduce losses and increase efficiency. Controlled release nitrogen formulations have become much cheaper in recent years with increased manufacturing volumes, now available in North America (Agrium Ltd) for about a 40% price premium. They may well become part of mainstream Australian crop management in the near future.

Only some Australian rice soils, ie those with insufficient ability to store and then deliver water between rainfall/irrigation events, will be truly suited to AWD systems. Rice soil suitability assessment may need to be refined for AWD systems, to account for a soil's water relations as opposed to simply its percolation rates. EM38 soil survey techniques may well be a part of this refinement.

AWD rice systems may reduce the Australian rice industry's field emissions of greenhouse gases by about half – provided denitrification (NOx production) is controlled. Methane is 20 times as potent greenhouse gas as CO_2, and methane production from rice paddies currently forms about half of a typical rice growers' greenhouse emissions. During AWD culture, soil carbon is aerobically decomposed into CO_2 rather than methane. Methane trials conducted by the Ricegrowers' Association for their Greenhouse Scorecard showed that AWD for the first six weeks reduced methane emissions by about 60%.

An AWD regime for the first half of the growing season will be of great value to the Australian rice industry, but it would only yield marginal water savings. It will be of great value, however, in managing broadleaf weed herbicide resistance, establishment costs, wildlife problems and low initial water allocations. As such, this report recommends adopting some aerobic germplasm, refining AWD nitrogen management, considering Clearfield™ technology for grass weed control and redefining rice soil suitability for AWD systems.

Further information

Leigh Vial
E: leroy2@iinet.net.au

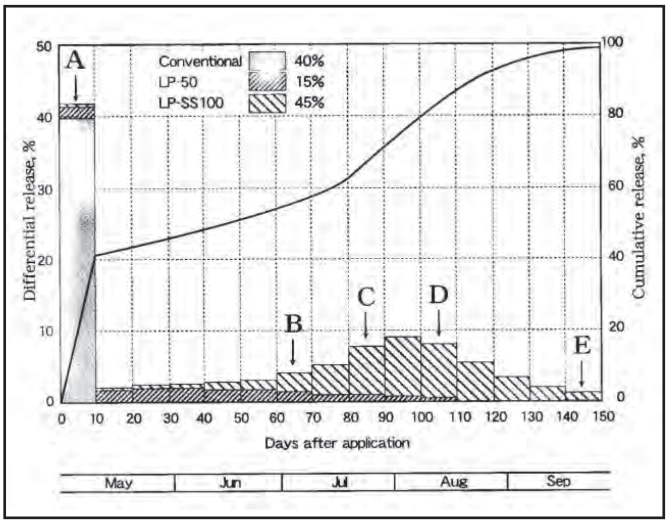

Figure 2: A typical nitrogen release curve for a blend of Meister, a controlled release fertiliser used for some time in Japan. All nitrogen is applied at sowing. Source: Fujita, T. and Shoji, S. (1999)* Kinds and properties of Meister fertilizers. *In:* Meister Controlled Release Fertiliser, *Ed. Shoji, S., Chapter 2, pp.13-33.

Figure 3: The author risking decapitation by an automated gas chamber at IRRI. The chambers close and sample the air above the crop for greenhouse gases.