**Growing rice on raised beds in south-eastern Australia.**

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Abstract

The performance of conventional ponded rice grown on a flat layout was compared with rice grown on 1.84 m raised beds with flood, furrow and sub-surface drip irrigation at Coleambally, NSW. The traditional flat flooded treatment achieved the highest grain yield of 12.7 t/ha, followed by the Bed.ponded treatment (10.2 t/ha). The furrow irrigated bed treatment yielded 9.4 t/ha and the Drip treatment the lowest (8.3 t/ha). Grain yield from all bed treatments was reduced due to the wide furrows (0.8 m between edge rows on adjacent beds), which were not planted to rice.

Rice crop water use was significantly different between the layout/irrigation treatments. The Flat and Bed.ponded treatments had similar irrigation water use (mean of 18.4 ML/ha) while the Furrow treatment used 17.2 ML/ha and the Drip 15.1 ML/ha. Water use efficiency (WUE) of the Flat treatment (0.68 t/ML) was higher than the raised bed treatments, which were all similar (mean 0.55 t/ML). The delay in physiological maturity (11 days) of the bed treatments, particularly at high N rates could cause planting delays when growing a winter crop immediately after the rice crop. The increase in length of growing season for the bed treatments also increased the period of irrigation, thus reducing the potential for water savings.

**Media summary**

Innovative and conventional irrigation approaches are being compared in a rice-based irrigation experiment in NSW

**Keywords**

rice, irrigation, permanent beds, sub-surface drip, rice-based cropping systems.

**Introduction**

Availability and certainty of supply of irrigation water is decreasing while the price is increasing. From a systems perspective, there may be advantages of growing rice on raised beds. The use of beds greatly improves surface drainage and establishment of both rice and other crops in the rotation, improving yields of crops grown after rice and increasing cropping flexibility.

Australian rice irrigation layouts have recently included bankless channel systems. These systems are a development of standard lasered contour bays in which the supply channel is incorporated into the field with no bank on the field side of the channel. This layout, when combined with permanent raised beds, offers the opportunity to move from rice to other crops without the need to change irrigation layouts. These layouts also offer the opportunity to furrow irrigate or flood each bay and manipulate water depth to protect against cold damage. Water use efficiency from a permanent bed cropping system and the potential for double cropping should increase, while landforming costs and groundwater recharge are likely to decrease.

The research reported here presents the results of the first rice crop in a cropping system experiment which aims to compare individual crop and total system performance of flat and permanent raised bed layouts with furrow and sub-surface drip irrigation systems. The effect of irrigation layout and system on rice WUE and crop phenology were explored.

## Methods

*Experimental Design*

The experiment was conducted in the Coleambally Irrigation Area, south-eastern Australia. The soil is an association of a transitional red-brown earth and self-mulching clay, typical of ricegrowing soils in this region. In August 2002, 1.84 m wide beds (centre to centre) were constructed running perpendicular to the slope of the field. Banks were constructed parallel to the beds to create 28 bays with an effective size of 140 m x 14.7 m. All bays (Flat and Bed) can be ponded with water to a depth of 20 cm, if and when required. In 8 of the bed bays, two drip lines were installed into each bed, 17 cm below the surface.

There were 4 layout/irrigation treatments (main plots) in a randomised block design with 4 replicates. Rice (cv. Amaroo) was sown at 140 kg/ha using a modified double disc seeder with row spacings of 15 cm for all treatments and 150 kg/ha of diammonium phosphate fertiliser (27 kg N/ha, 30 kg P/ha) was sown with the seed. All bays were irrigated for germination (22nd to 25th October) and received another 3 flush irrigations before irrigation treatments began. Variable establishment of plants in the furrows lead to their removal from the bed treatments.

*Layout/irrigation treatments*

1) Flat – Permanent flood was applied on 26$^{th}$ November, with water depth maintained between 3 and 5 cm after permanent flooding until 10 days after panicle initiation (PI), when it was raised to a minimum depth of 15 cm until the completion of anthesis.

2) Bed.ponded – The beds were ponded to a depth of 15 cm above the bed surface at the same time as the Flat received permanent flood. The crop used this ponded water, then water was maintained in the furrows until 14 days prior to PI. A second application of N was applied 10 days prior to PI and the bays flooded to 8 - 10 cm above bed surface. After the crop used this water, water was maintained in the furrows until 10 days after PI, when water depth was increased to a minimum of 15cm for the reproductive period.

3) Furrow – as for Bed.ponded until PI, then water was maintained only in the furrows until physiological maturity (PM).

4) Drip – as for Bed.ponded until PI, then water was supplied by the drip system until PM. The drip system was run overnight to replace the previous days evapotranspiration ($ET_o$ x 1.1 mm).

Each main plot was randomly split into 4 nitrogen (N) rate subplots. In the Flat treatment, urea was broadcast at 0, 60, 120, 180 kg N/ha onto the dry soil surface prior to permanent flood. At this time the Bed treatments received one third of the N applied to the flat plots (0, 20, 40, 60 kg N/ha as urea) to dry soil on top of the bed. The remaining two-thirds was broadcast onto the dry soil surface 14 days prior to PI.

## Results and Discussion

*Crop growth and yield*

Establishment on the beds was better than that on the flat treatments. The improved surface drainage of raised beds allows increased plant establishment compared to the flat, where reverse grades and hollows in the field can result in ponded water which reduces plant numbers. Establishment in the Drip plots was lower than the other beds due to major disturbance of the bed when the drip lines were installed.

DM production on the Flat treatment was always significantly higher than other treatments. The Bed treatments had a large furrow area with no plants, for which edge rows could not compensate. The Bed.ponded treatment had lower total DM and grain yield than the Flat treatment when calculated over the 1.84 m bed and furrow width (Table 1). However, when calculated over the actual area sown on the bed, the Bed.ponded treatment had higher total DM (3065 g/m$^2$) and quadrat grain yield (1350 g/m$^2$) compared to the Flat (total DM 2609 g/m$^2$ and quadrat yield 1174 g/m$^2$), respectively. The Drip treatment had significantly lower total DM than all other treatments (1830 g/m$^2$) (Table 1).

**Table 1. Effect of layout/irrigation treatments (mean of N rates).**

| | Establish. Plants m/row | PI DM g/m$^2$ | PI N uptake kg N/ha | Anthesis DM g/m$^2$ | Total DM g/m$^2$ | Grain Yield 14% t/ha | Water use Percentage of Flat | WUE T/ML |
|---|---|---|---|---|---|---|---|---|
| Flat | 42 | 652 | 108 | 1705 | 2609 | 12.7 | 100 | 0.68 |
| Bed.ponded | 58 | 463 | 81 | 1193 | 1999 | 10.2 | 97 | 0.56 |
| Furrow | 55 | 487 | 84 | 1324 | 1972 | 9.4 | 92 | 0.55 |
| Drip | 40 | 429 | 78 | 1155 | 1830 | 8.3 | 81 | 0.55 |
| lsd(P<0.05) | 9 | 22.5 | 6.9 | 55 | 75 | 0.4 | - | 0.07 |

Header grain yield of the Flat treatment (12.7 t/ha at 14 % moisture) was significantly higher than all other treatments. The Bed.ponded treatment yielded 10.2 t/ha, with the Furrow treatment yielding significantly less (9.4 t/ha) and the Drip the lowest at 8.3 t/ha (Table 1). Percent filled florets were significantly higher for the Flat treatment at 93.4% than all other treatments.

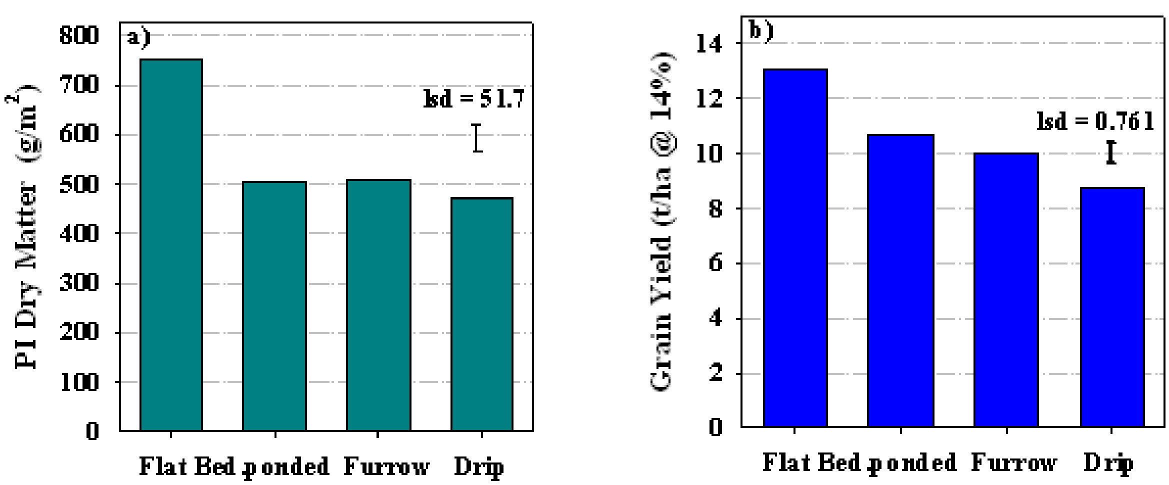


**Figure 1. a) Dry matter at panicle initiation for the 120 rate of applied nitrogen, b) Grain yield at 14% moisture for the 120 rate of applied nitrogen.**

Individual row measurements taken from the Flat and Bed.ponded buffer area (topdressed with 120 kg N/ha) indicated that the total DM of the middle rows on the bed (400 g/m row) was very similar to the individual rows on the Flat (392 g/m row). The two outside rows on the bed yielded 73% more total DM than the inside rows because there was less competition for light, water and nutrients compared to inner rows. However because of the wide furrows this compensation was not sufficient to give an equivalent yield to the flat layout.

*Crop phenology*

The bed treatments reached PI two days later than the Flat treatment (figure 2). The non-ponded treatments (Furrow and Drip) experienced a significantly greater delay in development during the period from PI to anthesis than the treatments ponded with 15cm of water (Flat and Bed.ponded). Plants in the Flat treatment reached PM 9 days faster than other treatments, which were not significantly different from each other when averaged over N rates. PM was significantly delayed by increasing rates of topdressed nitrogen (figure 2).

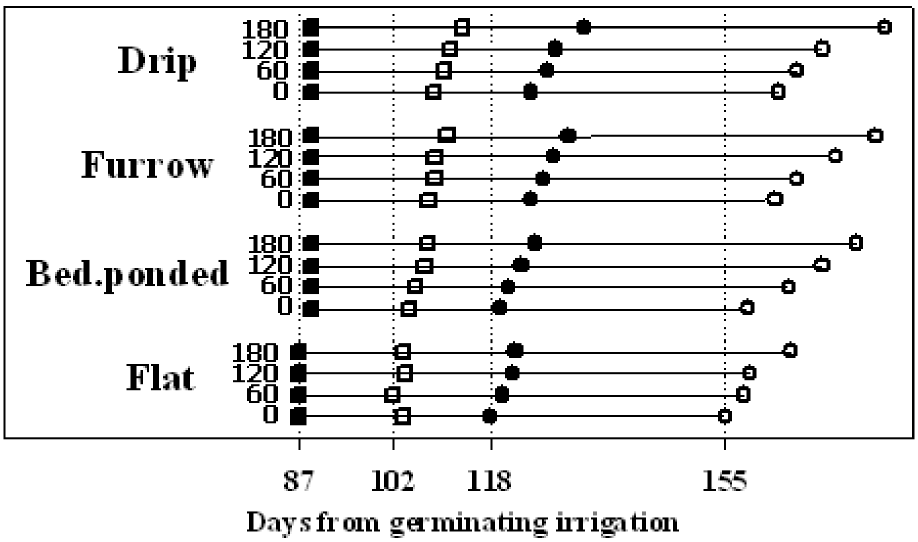


**Figure 2. Days from germinating irrigation to panicle initiation (■), early pollen microspore (□), anthesis (●) and physiological maturity (○) for four irrigation treatments and four rates of applied nitrogen.**

Delayed maturity of the bed treatments, particularly at very high N rates is an issue in developing high intensity cropping systems. Should double cropping opportunities be the main aim, then there may be no delay in maturity if grown as a normal combine sown crop that is flooded at the 3 leaf stage. However water savings are likely to be minimal in this crop. Increased rice crop duration may be counter productive to advantages provided by short season varieties in a double cropping raised bed system.

*Water use*

The Flat and Bed.ponded treatments were not significantly different in water use (mean of 18.4 ML/ha). The Furrow treatment (17.2 ML/ha) used significantly less water than the ponded treatments and the Drip had significant lower water use (15.1 ML/ha) than all other treatments. Soil water content was extremely low at the time of the germination irrigation and the soil profile had a likely storage capacity of > 120 mm at the end of the growing season. Water use for all plots was higher than normal due to high seasonal evaporation during the growing season (1650 mm) compared to the long term mean (1200 mm).

The difference in total water use between the flooded flat and furrow irrigated beds or sub-surface drip treatments is not as large as would have occurred if the irrigation treatments were carried through the entire crop growing period. The drip treatment did not start until 75 days after the germination irrigation due to technical problems. All bed treatments had 2 periods of significant ponding for reasons of weed control and nitrogen application efficiency. Water was applied to the beds to a depth of 15 cm during the first period of ponding (the same as the Flat treatment) and it took 14 days before the water level dropped back into the furrows, thus reducing potential water savings from all bed treatments. The increase in length of growing season for the bed treatments also increased the period of irrigation, further reducing the water savings from these treatments.

Water use efficiency calculated using the treatment yield averaged over the N rates, was significantly higher for the Flat treatment (0.68 t/ML) than all the other treatments. Our experiment gave no difference in WUE between any of the bed treatments, even though some treatments had reduced water use. The bed treatments had reduced water use, but the reduction in yield was proportionately higher. The bed treatments were inferior to the Flat treatment due to yield loss associated with wide furrows with no plants growing in them. If extra plant rows can be established on the bed shoulders, reducing the influence of the furrow, then WUE of the beds should be higher than the Flat treatment.

## Conclusions

High yielding rice crops have been successfully grown on raised beds. The incorporation of raised beds into a bankless channel layout provides the opportunity to pond water, assisting weed control at crop establishment. The width of the furrows (area not sown to rice) contributed to a yield reduction. Savings in irrigation water use are related to the amount of time a crop is intermittently irrigated and the longer ponding occurs (for example for weed control or to increase N application efficiency, or for protection of the crop against cold temperatures during the reproductive period) the less the opportunity to reduce water use.

Potential gains from growing rice on raised beds are considered to be associated with the farming system and include greater flexibility in crops that can be grown in rotation, double cropping and increased water use efficiency of the cropping system. Rice crops not ponded during the growing season were delayed in crop development, potentially negating any savings in water use and delaying harvest into autumn.

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