Permanent beds in bays for sustainable cropping

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in a rice hull

- High yields of wheat were achieved in 2005 on both raised beds and flat layouts – in a year without rainfall-induced waterlogging in winter or spring
- Rice yields on both raised beds and flat treatments were excellent during an exceptional rice growing season
- Rice yield from the bed systems is as high as that from conventional flat systems where rice is grown using permanent flooded conditions and ***deep*** water is applied during the early microspore stage

The objective of this research is to assess the performance of rice and crops following rice on permanent lateral raised beds compared with conventional flat irrigation layouts.

Permanent lateral beds in bays potentially offer several advantages over cropping on flat layouts, leading to:

- increased opportunity to easily switch between rice and other furrow irrigated crops
- increased water productivity and yields for rice and subsequent crops
- easier water management
- quicker field drying, greater trafficability and the increased use of ground equipment
- reduced recycling (pumping) costs in furrow irrigated crops.

The research reported here is part of a large project involving field experiments in varying irrigation systems in Australia and north west India, computer modelling of crop growth and development, and economic analysis of different cropping systems.

Rice-based farming systems traditionally use conventional irrigation layouts to grow rice and other crops in rotation. Of recent years, these systems are being conducted in a bankless channel irrigation design in the Murrumbidgee and Murray valleys. Raised beds are increasingly being used for production of both winter and summer crops in the Murrumbidgee Valley, with beds traditionally oriented down the slope of the field.

The ability to incorporate permanent beds within a bankless channel field design for use in rice-based cropping systems negates the need to convert irrigation layouts between different phases of the cropping rotation. To achieve this, permanent beds have been formed across the slope within the bays (lateral beds), allowing an increased range of high yielding crops to be grown in rotation with rice. Permanent lateral bed farming may give rice growers a more diverse, profitable and sustainable cropping system.

Field trial description

A replicated field trial was established at the Murrumbidgee Shire Community Experimental Demonstration Farm in the Coleambally Irrigation Area in spring 2002 (Figure 1). The trial consists of three irrigation treatments: flat layout, permanent lateral raised beds in bays and permanent lateral raised beds in bays with subsurface drip irrigation – all inside a bankless channel styled layout. Water application and drainage were measured on and off each bay.

In the 2002–03 irrigation season rice was grown on all treatments (Mathews *et al*. 2004). Since then a range of cropping rotations has occurred, the results of previous seasons being reported in the IREC *Farmers' Newsletter* No.s 168 and 171.

Figure 1: An aerial view of the research site at the Murrumbidgee Shire Community Experimental Demonstration Farm at Coleambally.

Wheat 2005

Wheat grown on the bed and flat treatments in 2005 was direct drilled with cv Chara at 115 kg/ha and 150 kg DAP/ha on 13 May 2005, following a pre-sowing irrigation on 5 May. Eight rows were sown on the top of the beds and one row in each of the bed shoulder/furrows using a Stubble King drill.

Germination and establishment of the wheat crop was excellent with 218 and 228 plants/m^2 in the bed and flat treatments respectively. Grazing of the plots by kangaroos until the break of season rains was a concern, and electric fencing had to be installed at the experimental site.

There were two regimes for nitrogen topdressing, one with all the nitrogen (125 kg N/ha) applied at growth stage Z31 (first node) and the other with nitrogen split, with 65 kg N /ha applied at Z31 and 60 kg N/ha at late heading.

Stripe rust was rife throughout the district during 2005 and although the seed had been treated with Jockey® (fluquinconazole), the crop became infected with stripe rust. Two aerial applications of Bumper® (propiconazole) were applied as the crop developed and appeared to satisfactorily control the stripe rust.

During the growing season a total of 285 mm of rainfall was recorded. The crop was irrigated pre-sowing and also had four spring season irrigations at intervals of 60 mm (ET minus rain). This scheduling ensured adequate soil moisture through the grain filling period.

Although irrigation water was ponded on the flat treatments for approximately 24 hours to simulate waterlogging conditions, the yields were higher (though not significantly) on the flat than on the raised beds. Given that the crop was well watered, the final yields on both the flat and on the raised beds were disappointing compared with yields achieved in the previous season. Split applications of nitrogen did not produce a difference in yields.

Dry matter accumulation at anthesis (Figure 3) and total dry matter accumulation (Figure 4) were not significantly affected by irrigation layout or nitrogen topdressing treatment.

Figure 2: Growth and development of the Chara wheat crop on the flat (left) and bed (right) treatments in late September was indicative of a high yield potential.

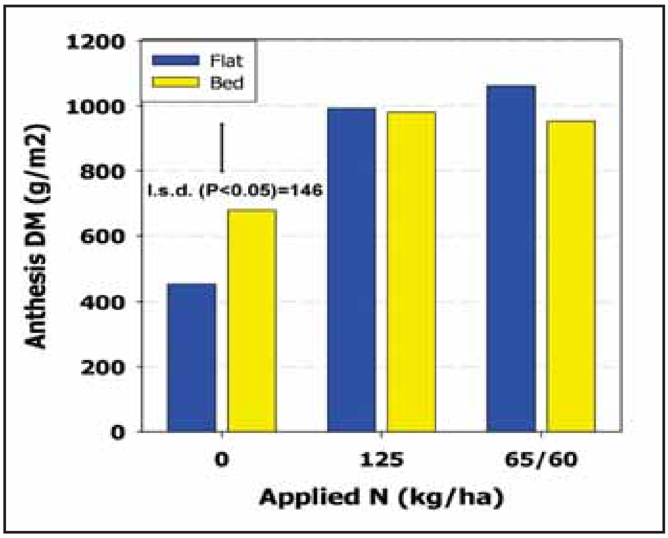

Figure 3: Dry matter accumulation by the wheat crop on bed and flat treatments at anthesis. There was a significant yield response to nitrogen but no difference between a single topdressing of 125 kg N/ha or a split application of 60 kg N/ha at tillering and 65 kg N/ha at later heading.

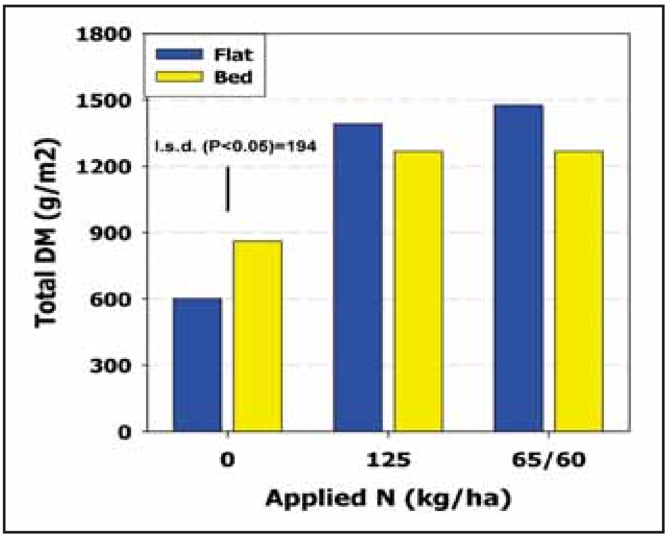

Figure 4: Total dry matter accumulation by the wheat crop on bed and flat treatments at physiological maturity. A significant yield response to nitrogen was measured but there was no difference between the timings of nitrogen application.

Harvest grain yield was 6.5 t/ha for the single nitrogen topdressing application (125 kg N/ha) and 6.8 t/ha for the split nitrogen (65/60) on the flat layout; and 6.15 t/ha for single and 6.04 t/ha for split on the beds. Flowering did not occur till 19 October (which presumably lead to higher temperatures during grain filling). Summation of solar radiation from head emergence to the end of grain fill indicated that compared with the 2004 season, the duration of grain fill was nine days less, suggesting the shortened grain filling period contributed to the less than expected yield.

Rice 2005-06

Rice (cv Quest) was direct drilled on 18 October 2005 into five crop sequence treatments as follows:

1. flat layout following wheat and a long fallow
2. bed layout with furrow irrigation following rice
3. bed layout with drip irrigation following rice
4. bed layout with furrow irrigation following soybeans
5. bed layout with drip irrigation following soybeans (these drip bays were furrow irrigated in this season and a mid-season draining was applied).

All stubbles were burnt prior to sowing although there was some residual stubble remaining at sowing.

Irrigation

A flushing irrigation to initiate germination was applied the following day. Permanent water was applied on 15–17 November following two flushing irrigations and two rainfall events. All treatments were flooded throughout the season, with the exception of treatment 3 (bed with drip following rice) which was flooded during early microspore and treatment 5 (bed with drip following soybeans and mid-season drainage) which was drained for eight days prior to panicle initiation.

Fertiliser

Diammonium phosphate (DAP) at 192 kg/ha (35 kg N/ha, 38 kg P/ha) was applied at sowing.

Four nitrogen topdressing rate treatments were applied: 0, 120, 180 and 240 kg N/ha (in total). Nitrogen was topdressed as urea, with two thirds at permanent flood and one third at panicle initiation.

Weed control

Pre and post sowing (pre-emergence) applications of glyphosate were applied for control of barnyard grass and ratooning rice. All weeds were effectively controlled by applications of appropriate herbicides.

Rice growth and yields

Seasonal conditions favoured a high crop yield. The crop established and grew well in all crop treatments. Establishment counts indicated mean plant numbers of 240–300 plants/m^2 across the various treatments. These plant numbers are within the range recommended by *Ricecheck*.

In a favourable season for rice growth, the crop growth and nitrogen uptakes patterns at panicle initiation had treatment 1 (flat following wheat) producing the highest dry matter production, however the dry matter production was not significantly better than beds with furrow irrigation following rice (treatment 2) or soybeans (treatment 4) (Figure 7). The beds with drip following rice (treatment 3) and the beds with drip following soybeans, and with mid-season drainage (treatment 5) showed significantly less growth at panicle initiation compared with other treatments.

Nitrogen uptake was greatest in the flat following wheat (treatment 1) although not significantly better that either of the treatments involving soybeans (4 and 5), except at the highest applied nitrogen rate (Figure 8).

At physiological maturity, crop growth and grain yield could be separated into three general groups – rice on flat following wheat and long fallow, rice on beds following soybeans and rice on beds following rice. Total dry matter increased with increasing nitrogen application (Figure 9) for all treatments. Rice on beds after soybeans, either flooded or mid-season drained treatments, produced as much dry matter as rice on the flat, which was topdressed at 180 and 240 kg N/ha.


Figure 6: Rice establishment was excellent on the flat (left) and bed (right) treatments, as were final yields.

Rice grain yields increased with increased added nitrogen. Floret sterility was low in all treatments a reflection of favourable temperatures at the early microspore stage. The grain yield of the mid-season drainage treatment was lower at the highest nitrogen rate (240 kg N/ha) due to increased floret sterility. The grain yield of treatments with beds after rice, treatments 2 and 3, with furrow and drip irrigation respectively, were lower than all other treatments, especially at zero and low topdressed nitrogen rates (Figure 10). Grain yield of treatment 2, bed with furrow irrigation after rice was equal to that following wheat or soybean sequences, only at the highest topdressing rate (Figure 10).

Conclusion & other work

Since the project was established in 2000, the key findings have indicated that:

- rice yield from the bed systems is as high as that from conventional flat systems where rice is grown using permanent flooded conditions and *deep* water is applied during the early microspore stage
- satisfactory weed control can be achieved on bed systems by applying permanent flood at the 3-leaf stage using accepted herbicide regimes for drill sown rice
- rice yields following double-cropped sequences on beds were equivalent to those achieved following wheat and a long fallow on the flat.

We have estimated the potential financial benefits from the adoption of lateral permanent beds over different existing field layouts. Presently we are calculating the cost involved in the construction of beds from different selected layouts that would help to estimate the net benefits from the adoption of lateral permanent beds. The results of the economic analysis will be reported next year, along with overall field results, when the project is complete.

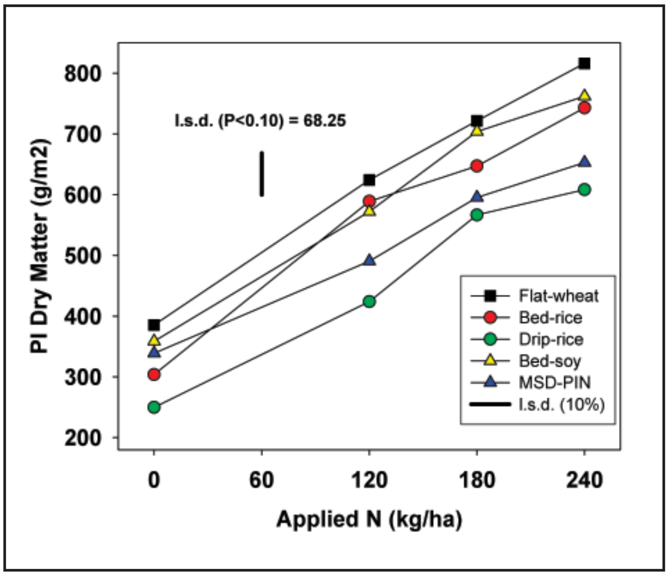

Figure 7: Dry matter accumulation at panicle initiation for all crop sequences, water management regimes and nitrogen topdressing rates

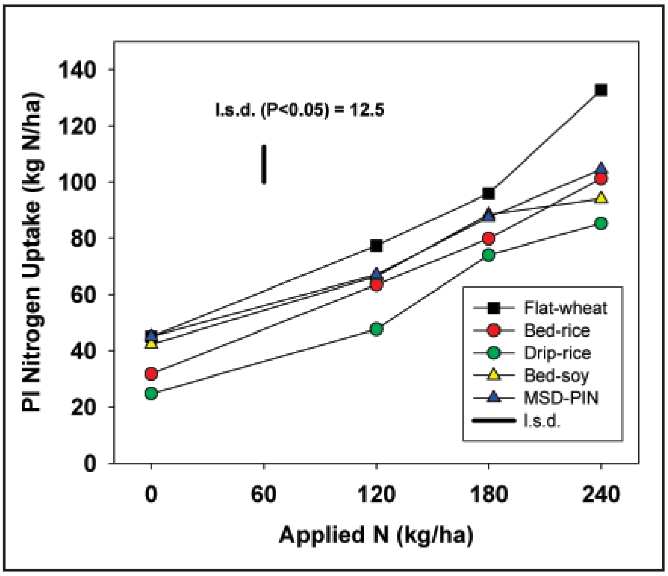

Figure 8: Nitrogen uptake at panicle initiation for all crop sequences, water management regimes and nitrogen topdressing rates

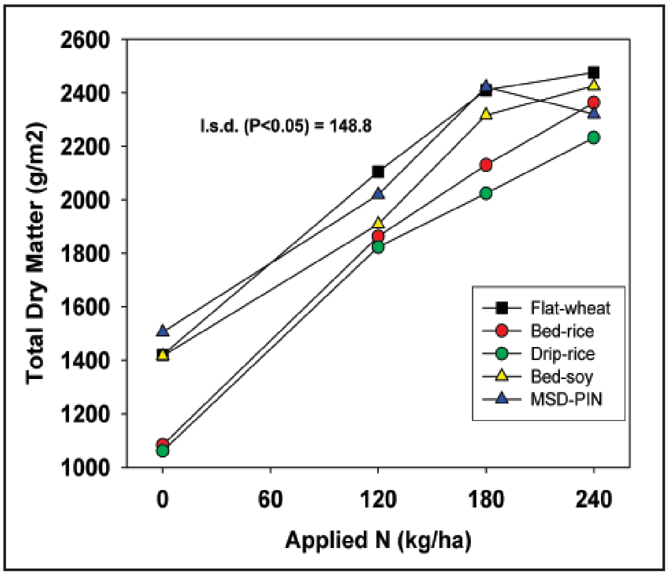

Figure 9: Total dry matter at physiological maturity for all crop sequences, water management regimes and nitrogen topdressing rates (MSD = mid-season drainage)

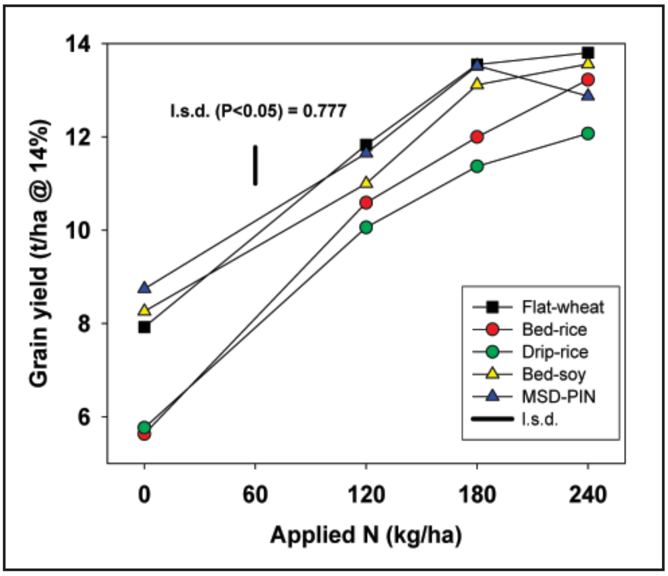

Figure 10: Grain yield (as measured using quadrats) for all crop sequences, water management regimes and nitrogen topdressing rates

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Further reading

Shayne Mathews, Geoff Beecher, Brian Dunn, John Thompson, Liz Humphreys & Daniel Johnston (2004). Permanent beds for sustainable cropping systems. IREC Farmers' Newsletter, Rice R&D edition, No. 165, pp 4-6.

Geoff Beecher, Brian Dunn, Shayne Mathews, John Thompson, Liz Humphreys & Daniel Johnston (2005). Permanent beds for sustainable cropping systems on rice farms. IREC Farmers' Newsletter, Rice R&D edition, No. 168, pp 25-27.

Geoff Beecher, Brian Dunn, Shayne Mathews, John Thompson, Rajinder Pal Singh, Liz Humphreys, Jagadish Timsina, Kieran O'Keefe & Daniel Johnston (2006). Permanent beds for sustainable cropping systems on rice farms. IREC Farmers' Newsletter, Rice R&D edition, No. 171, pp 24-27.

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