Permanent beds for sustainable cropping

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IN A RICE HULL

- High wheat and barley grain yields were achieved in 2004 on both lateral raised beds and flat layouts in a year with no rainfall-induced waterlogging in winter and spring
- Good growth and grain yield of double-cropped soybean and barley were achieved on lateral beds in bays over two consecutive years (four crops)
- Rice yields on raised beds were low due to severe cold damage at the young microspore stage in 2005, and several management issues which will be addressed in the 2005–06 summer cropping season

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

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

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

Bankless channel irrigation layouts are commonly used within the Murrumbidgee and Murray valleys. Bankless channel layouts improve supply and drainage compared with other layouts, the bankless channel acts as both supply channel and drain for each bay and fewer irrigation structures are required. These layouts usually do not have a level basin within the bays but have a grade that is constant across the entire field (Figure 1, Section B-B). However the use of flat terraced bays is increasing in the Murrumbidgee Valley (Figure 1, Section B'-B').

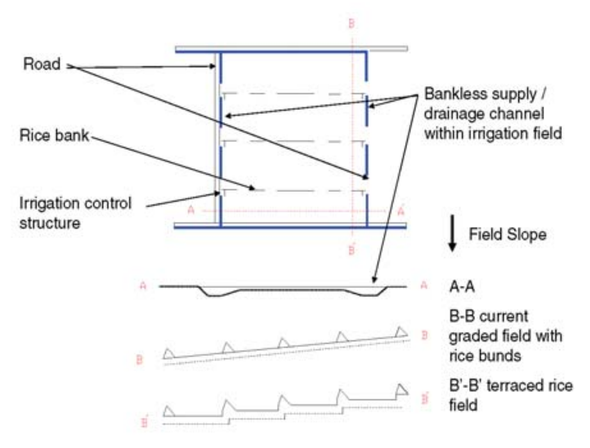

Figure 1 Plan and cross section views of a bankless channel with graded and terraced layout

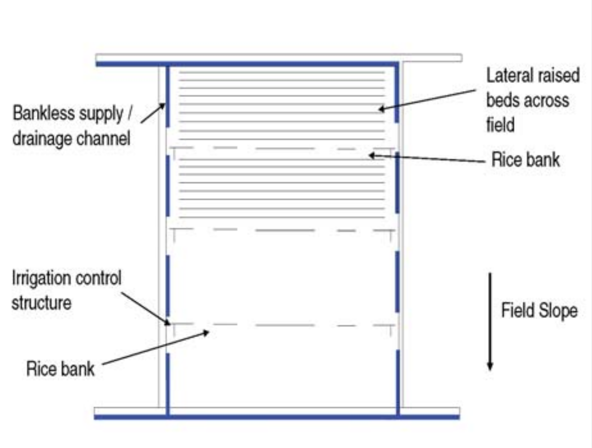

Figure 2 Raised beds located laterally within an existing bankless channel rice bay layout

Raised beds are increasingly being used for production of both winter and summer crops in the Murrumbidgee Valley, using traditionally formed beds that run down the slope of the field. The possibility of incorporating permanent lateral raised beds within a bankless channel field design (Figure 2) for use in rice-based cropping systems potentially negates the need to convert irrigation layouts between phases of the cropping rotation. In a bankless channel layout the beds are formed across the slope within the bays. With this layout it should be possible to grow an increased range of high yielding crops in rotation with rice.

Some maize producers are using raised beds within bankless channel field designs citing advantages of decreased labour requirement (no syphons) and faster water on/water off periods, suggesting reduced waterlogging, decreased opportunity for excessive infiltration and reduced costs.

Overall, permanent lateral bed farming may give rice growers the opportunity for a more diverse, profitable and sustainable cropping system.

The objective of this research is to assess the performance of both rice and subsequent crops on permanent lateral beds compared with the performance of crops on a conventional flat layout, in terms of agronomic, economic and environmental impacts.

Field trial description

A replicated field trial was established at the Murrumbidgee Shire Community Experimental Farm in the Coleambally Irriagtion Area in spring 2002. The trial consists of three irrigation treatments:

1. flat layout with flood irrigation
2. permanent lateral raised beds in bays with furrow irrigation
3. permanent lateral raised beds in bays with sub-surface drip irrigation

All treatments are set inside a bankless channel styled layout. Water application and drainage are measured on and off each bay.

In the 2002–03 irrigation season rice was grown on all treatments, and was reported in *Farmers' Newsletter*, No. 165, pp 4–6, 'Permanent beds for sustainable cropping systems'. Since then a range of cropping rotations commenced with the 2003 winter crop and 2003–04 summer crops and was reported in *Farmers' Newsletter*, No 168, pp 25–27, 'Permanent beds for sustainable cropping systems on rice farms'.

A Stubble King seeder with adjustable spacing parallelogram disc sowing attachments has alleviated many of the establishment problems experienced in the past, associated with trying to simultaneously achieve good establishment in beds and furrows. It has allowed us to sow at the optimum depth on the beds, bed shoulders and furrows reducing the yield loss incurred on the beds in the past due to wide furrow areas with no plants.

Wheat and barley 2004

Winter crops of barley (Gairdner) and wheat (Chara) were established in 2004. A modified double disc no-till seeder achieved the desired seed depth on the reworked and reshaped beds, with seed sown into the bed shoulders and furrows (Figure 3). Sowing was followed by a germinating rainfall (around 24 May 2004) which allowed excellent wheat and barley plant establishment (Table 1), setting the opportunity for a high potential yield for both crops.

The Chara wheat was affected by stripe rust and was aerially sprayed once using Tilt® which gave good control.

Both crops were topdressed with 100 kg N/ ha at the Z31/32 stage (stem elongation) prior to irrigation, and were irrigated throughout spring to maturity at 70 mm cumulative ETo-rainfall for furrow/flood irrigation treatments. The drip irrigated bays were irrigated when soil moisture tension reached about -50kPa at 30 cm depth as indicated by the Gbug gypsum blocks.

Yield and input water productivity of wheat and barley were high and not affected by layout or irrigation (Table 1). Total

Figure 3 *Wheat and barley in 2004 showing the excellent plant establishment on the bed shoulders which contributed to excellent yields*

Figure 4 *Rice establishment was excellent but yields were severely reduced due to cold temperature damage during the young microspore stage*

rain during the season was only 161 mm, with no rainfall induced waterlogging, even on the flat treatments.

Rice 2004–05

Rice was grown only on raised beds, where we compared furrow and drip irrigated treatments (Figure 4).

Good initial rice plant stands were achieved (Table 1) using the Stubble King seeder with a parallelogram disc configuration. Direct drilling both beds and bed shoulders resulted in excellent crop establishment.

Urea was surface applied prior to permanent flood (100 kg N/ha). Further nitrogen (80 kg N/ha) was surface applied to both furrow and drip irrigated treatments prior to panicle initiation.

Barnyard grass and dirty Dora required multiple herbicide applications for reasonable control. There were problems with dirty Dora in the crop due to adjacent soybean crops limiting weed control options.

The drip treatment was never ponded whilst the furrow treatment was intermittently ponded until close to the young microspore stage, also known as EPM, when water depth was increased to about 15 cm.

Biomass production was low due to low mineralisation of soil nitrogen and high nitrogen losses due to several drying and ponding events associated with weed control management.

Rice yields were severely reduced by the cold temperatures experienced during the first week of February 2005. The severity of the cold temperature damage at the young microspore stage was indicated by the high percentage of unfilled florets (65% for drip and 41% for furrow) and very low harvest index (23% for drip and 35% for furrow treatment). Harvest index is the ratio of dry grain weight to total above-ground biomass (grain + straw). Yields were up to 6.1 t/ha in the flooded beds, higher than the 2004–05 CIA average district yield (5.7 t/ha) for Quest grown under conventional aerial sown rice conditions (continuous ponding and deep water at the young microspore stage).

Irrigation water delivery measurements were confounded by leaking banks due to holes created by yabbies, mice and mole crickets. This made maintaining deep water through the young microspore stage very difficult, so no water use or water productivity data for rice are presented.

Soybeans 2004–05

The soybeans were direct drilled into burnt untilled barley stubble (Figure 5) and grew well with acceptable yields for both furrow and drip treatments at 3.08 and 3.32 t/ha, respectively.

Water use was similar for furrow irrigated (5.7 ML/ha) and subsurface drip irrigated (5.6 ML/ha) treatments.

Water productivity was 0.54 t/ML and 0.6 t/ML for furrow and subsurface drip irrigated treatments, respectively. Water productivity for the furrow irrigated treatment was higher than in 2003–04 due to improved irrigation scheduling and similar in both years for the subsurface drip irrigated treatment.

Figure 5 *Djackal soybeans were sown at 4 rows per bed into burned untilled barley stubble*

Table 1

Establishment, total water use, grain yield and input water productivity (IWP) of wheat and barley on different irrigation and layout treatments.

Crop	Treatment	Establishment plants/m²	Yield (t/ha)	Water use (ML/ha)[1]	Input water productivity (irriagtion+rain) (t/ML)[1]
Wheat - Chara	Bed	166	7.36	5.04	1.46
Wheat - Chara	Flat	196	7.60	5.34	1.42
Wheat - Chara	Flat, fallow	196	7.32	5.41	1.35
Barley - Gairdner	Bed - furrow	125	6.56	4.47	1.47
Barley - Gairdner	Bed - drip	130	6.50	4.58	1.42
Rice - Quest	Bed - furrow	236	6.1	na	na
Rice - Quest	Bed - drip	225	3.5	na	na
Soybean - Djackal	Bed - furrow	26	3.1	5.7	0.54
Soybean - Djackal	Bed - drip	31	3.3	5.6	0.60

[1] Water Productivity (WP) values do not take into account the change in soil water content between sowing and harvest. This would decrease water use and increase WP proportionately.
na - not available

Wheat 2005

Wheat (cv. Chara) was direct drilled into bed and flat treatments on 13 May 2005 following a pre sowing irrigation. Eight rows were sown on the top of the beds and two rows in the bed shoulders. Germination and establishment were 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 has been a concern and the experimental site is now surrounded by an electric fence.

Economic analysis

The economic analysis associated with this research involves measurement of the benefits and costs of converting to permanent lateral bed layouts from different existing irrigation layouts, using a range of techniques including gross margin analysis, crop sequence gross margins, development/cash flow budgets and whole farm budgets.

A preliminary analysis has been done of the impact of switching to permanent beds from different existing field designs, eg non-landformed natural contour; laser landformed natural contour; laser landformed square contour and laser landformed square contour alternating with raised beds (Table 2). These designs account for 80% of the area under rice based farming systems in Australia. A typical cropping rotation for each irrigation layout was identified and crop sequence gross margins prepared and compared with the gross margin of a crop rotation on permanent lateral raised beds.

There is an increase in the present value of the aggregated crop sequence gross margin in the long term for progressively more-developed irrigation layouts (Table 2). While these preliminary results are very encouraging, they didn't take into account the development costs of the different layouts. The next steps are to undertake a benefit: cost analysis of such changes in an irrigation layout including development and operating costs and to identify and compare more rotations with varying lengths for each field irrigation design.

Next summer's plans

During the 2005–06 irrigation season, rice will again be grown on flat layouts with conventional irrigation management and on beds with furrow and sub-surface drip irrigation.

Acknowledgements

We would like to acknowledge the major funding bodies for their support of the project: including RIRDC, NSW Department of Primary Industries, CSIRO Land and Water, ACIAR and GRDC. Other contributors include: Rice CRC, Coleambally Irrigation, Murray Irrigation, Irrigated Cropping Forum and Murrumbidgee Shire Community Experimental Farm.

RIRDC Project DAN-201A

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Table 2
Effect of irrigation layout and cropping rotation on discounted long term gross margins for selected rice-based crop rotations

Irrigation design	Typical cropping rotation analysed	Rotation length (years)	Present value of the aggregated gross margins over 30 years ($/ha)
1. Non landformed natural contour	RRRF(OW)WWPPP	8	14,041
2. Laser landformed natural contour	RRRF(OW)WWPPP	8	15,595
3. Laser land formed square contour	RRRF(OW)WWPPP	8	17,815
4. Laser landformed square contour alternating with permanent raised beds	RRRFS/BSF	5	24,438
5a. Laser landformed lateral permanent raised beds	RRB/SB/S	4	24,953
5b. Laser landformed lateral permanent raised beds	RRRB/SB/S	5	27,009

R - rice, B - barley, S - soybean, W - wheat, OW - opportunity wheat, F - fallow, P - pasture