Intensive rotations revisited

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in a nutshell

- A new project is rising to the challenge of seeing if $2000/ha can be earned on irrigation land each year
- The answer lies in flexible, well managed intensive cropping rotations, that grow two crops most years
- The concept is not new, and this article reviews grower practice and trial work that has been investigating intensive rotations since the 1970s

The Irrigated Cropping Forum has recently attracted GRDC funding for the project Lifting Irrigated Cropping Profitability and Water Use Efficiency, which has amongst its aims to push irrigated cropping returns to over $2000/ha per year by increasing understanding and adoption of higher value cropping rotations. Sounds ambitious but this could well be what's needed to keep irrigated farming communities alive and vital.

Articles on new cropping rotations have been published in the IREC *Farmers' Newsletter* over the past 20 years and are reviewed in this article.

What is a high value rotation?

When asked to define a 'high value rotation' most of us usually come up with 'intensive' or 'double cropping' somewhere in the answer, ie two crops rather than one grown in a 12-month period, such as soybeans (sown in December, harvested late April) followed by barley (sown in May, harvested late November).

To put a value on this rotation, the best gross margins (NSW DPI, 2006) for soybeans and barley grown on traditional irrigation layouts suggest a combined total return of $900/ha. Not bad! Not $2000 but not bad!

Throw in rare-but-achievable 4.5 t/ha soybean and 6 t/ha barley yields and the gross margin jumps to $1500/ha. Suddenly $2000/ha is looking a whole lot more achievable.

Perhaps with some cost cutting and the flexibility to incorporate higher value crops, farmers really can lift profitability?

Intensive rotations in the 1970s & 1980s

Martin Maynard, a farmer at Hay, tackled similar questions when faced with rising costs and stagnant prices in the 1970s (IREC *Farmers' Newsletter*, No. 137, 1991). He found he could increase farm gross margin by up to 50% by adopting a higher value rotation in conjunction with a system of permanent bed farming. The increase in gross margin resulted from growing more crops and cutting costs. In his new system eight crops were grown in six years compared to his previous rotation where only five crops were produced in six years (Table 1).

The new rotation system on permanent beds maintained yields but reduced the area of land undergoing heavy preparation by 60%, saving thousands of dollars in machinery operating costs. In time, yields began to increase as soil structure improved. With better root zone drainage not only was there more vigorous plant growth, but field trafficability improved leading to better timeliness of farming operations.

Water use efficiency was improved under the new system. The Maynards were able to fully irrigate crops like barley without worrying that the final watering may not be fully utilised if the barley ripened earlier than expected. Any soil moisture remaining would be used by the subsequent soybean or sunflower crop.

Today, especially in the Murrumbidgee Valley, intensive irrigated cropping systems usually implies some type of permanent bed layout with direct drilling, similar to that which evolved at Hay. It is important to note that while beds particularly suit the soils and landscape found at Hay, other systems including border check (maybe with controlled traffic and direct drilling) may be just as productive in areas where soils and fields are better drained. The bottom line is

Table 1: In the Maynard's new rotation, advantage was taken of the relatively short growing seasons of barley and soybeans to fit in an extra crop after maize or before wheat.

Rotation	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Old	maize	soybean	maize	wheat	wheat	
New	maize barley	soybean wheat	fallow fallow	maize barley	soybean wheat	fallow fallow

to use whatever system that provides and maintains optimal conditions for plant growth.

In Victoria, at Tatura (IREC *Farmers' Newsletter* No. 125, 1984) a program of double cropping on beds was established in the early 1980s, running for several years. The motivation for this work came from a desire to manage soils better and improve crop growth. The red brown earths of the district were prone to rapidly losing structure under conventional cultivation systems. In this situation, permanent beds with controlled traffic and minimum tillage were found to preserve soil structure.

This tillage system also permitted an easy transition to more intensive rotations. The crops grown included barley in winter and soybeans, maize or sunflowers in summer. All of these crops could be direct drilled into the beds without any major adjustments and so farmers had the flexibility to change from one crop to another as growing conditions or markets suited.

Previous research

Irrigated crop rotation experiments were conducted by NSW Department of Primary Industries in the 1980s and 1990s at the Leeton Field Station (IREC *Farmers' Newsletter*, No.s 127, 128 & 134, 1985–89) and at the Yanco Agricultural Institute.

The Leeton experiment commenced in 1984 to learn more about the new permanent raised bed system. Researchers looked at six years of summer/winter cropping sequences on raised 1.5 m beds (Table 2). The trial area was on good cropping soil and the narrower beds were used because of the machinery available. Cropping intensity varied from one crop every two years (long fallow wheat) to two crops per year (wheat followed by maize, soybean, sunflower or millet). Stubble treatments were superimposed with 'burnt', 'left standing' or 'incorporated' treatments.

The Leeton experiment demonstrated that double cropping sequences could be successful. Wheat yields ranged from 4.6 to 6.0 t/ha which were good for that era. Rapeseed (canola) reached an excellent 3.3 t/ha. Maize yields however were lower than average, topping out at 6.8 t/ha. NSW DPI crop statistics for the MIA for the mid to late 1980s indicate average yields around 8.0 t/ha. Researchers chose a shorter season (hence lower yielding) maize variety for the Leeton experiment to try and fit in the winter cereal crop. Also, because the first maize crop followed fully irrigated wheat, they were not able to sow and water-up the next maize crop until late December in both years that the crop was grown.

One of the main challenges identified at the Leeton experiment involved the timing of operations and planting within desired sowing windows. It was difficult to always

Table 2: Eight rotations on permanent raised beds, investigated at Leeton Field Station 1984–90

	1984	1984–85	1985	1985–86	1986	1987	1987–88	1988	1988–89	1989	1989–90	1990
1	wheat	fallow	wheat	fallow	wheat	canola	fallow	barley	fallow	barley	fallow	wheat
2	wheat	fallow	fallow	fallow	wheat	canola	fallow	barley	fallow	canola	fallow	wheat
3	wheat	fallow	lupin	fallow	wheat	canola	fallow	barley	fallow	faba bean	fallow	wheat
4	wheat	fallow	canola	fallow	wheat	canola	fallow	barley	fallow	field pea	fallow	wheat
5	wheat	soybean	wheat	soybean	wheat	canola	soybeans	barley	soybean	barley	soybean	wheat
6	wheat	maize	wheat	maize	wheat	canola	soybeans	barley	soybean	barley	soybean	wheat
7	wheat	millet	wheat	millet	wheat	canola	sunflower	barley	sunflower	barley	sunflower	wheat
8	wheat	sunflower	wheat	sunflower	wheat	canola	sunflower	barley	sunflower	barley	sunflower	wheat

Figure 1: Faba bean yields of up to 6 t/ha make this crop a valuable addition to high value crop sequences

Figure 2: Harvesters can now be configured for controlled traffic systems such as this one harvesting faba beans

achieve appropriate maize dry-down without resorting to artificial drying. Any rain in May delayed summer crop harvest, pushing wheat sowing well into June. Eventually it was determined that the wheat-maize rotation (#6) just wouldn't fit and the researchers fell back to soybeans and sunflower.

In 2006, maize still causes problems with slow dry-down if planting is delayed. The missed wheat crop if maize is left to stand over winter needs to be weighed up against the costs of artificial drying. In the Murray Valley and northern Victoria, the long growing season of maize is overcome by cutting it for silage.

Results from this experiment highlight another challenge that still exists – what to do with stubble? At Leeton there was a reduced yield in winter crops by retaining stubble rather than burning. The early growth of summer crops was also reduced by presence of barley stubble.

Economic analysis

The Leeton Field Station experiment (IREC *Farmers' Newsletter* 134, p27–30, 1989) showed good financial returns for intensive cropping on permanent beds. All of the double crop rotations (except wheat–millet), had higher gross margins than the winter crop–fallow rotations. Highest gross margin per hectare was the wheat–maize rotation closely followed by the wheat–soybean rotation. However only a sequence of five crops (three winter and two summer) was analysed. After this, maize was dropped because its growing season was too long.

Using data from the experiment, the profitability of a hypothetical rice-wheat-pasture rotation was compared to an intensive bed cropping rotation (maize based, ten crops in six years). The modelled bed cropping rotation returned an operating profit 42% higher than the rice-based rotation.

If the simple maize-wheat rotation could be made work given the length of each crop's growing season, then maize yields approaching 12 t/ha combined with wheat yields of 7 t/ha in a direct drill permanent bed system could achieve the $2000/ha goal (using NSW DPI budgets and prices, 2005). If farmers are flexible in terms of crop choice then fall-back options if sowing is delayed are soybeans or barley, which as mentioned earlier can give good returns.

The Yanco experiment

With the lessons of the Leeton experiment under their belts, researchers wanted to see how rice could fit into intensive cropping rotations (IREC *Farmers' Newsletters* No.s 131, 137,139, 1988–92). An experiment was set up at the Yanco Research Station and various rice-based crop sequences were analysed in terms of profitability and impact on soil fertility. The experiment commenced at a time of historically low rice prices and a major aim was to examine alternative

Table 3: Seven rotations investigating rice in intensive cropping systems at Yanco Research Station, 1986–91

	1986–87	1987	1987–88	1988	1988–89	1989	1989–90	1990	1990–91
1	rice		rice		rice		rice		rice
2	rice	triticale	fallow	triticale		pasture		pasture	rice
3	rice	pasture		pasture		pasture		pasture	rice
4	rice		rice	pasture		pasture		pasture	rice
5	rice		rice		rice	pasture		pasture	rice
6	rice	triticale		triticale		canola/barley		wheat	rice
7	rice		soybean/ sunflower	faba bean/ barley	soybean/ sunflower	peas/ barley	soybeans		rice

Figure 3: Chickpeas direct drilled into permanent beds that previously grew maize

Figure 4: Modern seeding equipment can handle tough soils and heavy stubbles

rotations that may lead to increased farm income. The experiment was established in 1986, with all rotations commencing with a rice crop and concluded in 1990–91 with a rice crop (Table 3).

The Yanco experiment showed that well managed intensive systems could achieve good yields. Rice was still yielding 11.5 t/ha after three previous consecutive rice crops. Winter cereals averaged 5.0–6.0 t/ha, canola 3.2 t/ha, soybeans and sunflower 2.0–3.0 t/ha each.

A whole farm economic model was used to determine operating profits for all rotations. On a simple gross margin basis, the intensive rotation (#7) had the highest return. Total gross margin for the most successful of the double crop rotations ranged from $2800 to $3000 for the five year period or just over $600/ha/year (note that these returns are based on 1990–91 costs and prices). However if machinery and labour overheads were included in the model, the traditional rotations (#3 and #6) came out best.

The intensively cropped rotations which excluded pastures were highly exploitive of soil nutrients, particularly nitrogen. Soil ammonium measured before the final rice crop in the intensive cropping rotation (#7), had one of the lowest levels – second only to the continuous rice treatment.

The experiment also looked at the effects of stubble management on crop yield. Burning stubble achieved higher yields in rotations #2, #6 and #7 basically because better plant establishment was achieved when sowing into zero stubble.

Recent developments

The rice in the Yanco trial was grown "on the flat" but in recent years a few farmers have been taking up the challenge of integrating rice into permanent bed systems (IREC *Farmers' Newsletter*, No. 161, 2002). These growers have established permanent beds within "bankless channel" layouts.

The attraction of the system is the flexibility to grow rice and be able to follow with a winter crop on beds. In wet winters wheat on beds performs better than flat border check layouts. The labour saving with the watering of beds in bankless channel layouts is seen as a major attraction compared to watering by siphons. Challenges to beds included machinery traffic during the rice harvest, especially turning at the ends of bays and also having harvesters and chaser bins with wheel spacings suited to the beds.

Permanent beds for sustainable cropping systems are being investigated at the Coleambally demonstration farm (IREC *Farmers' Newsletter* No. 165, 2004). This ongoing trial commenced in 2002 and looks at rotations on three layouts – beds with furrow irrigation, beds with sub surface drip and conventional border check. Initial results are very encouraging and there is no doubt that findings from this experiment will help shape future irrigated crop production methods.

Several farmers in the Hay district currently practise some form of intensive crop rotation on beds. Many old and some new challenges confront them. They are still struggling with stubble management but now there is real pressure from urban communities to ban burning. Gone are the days of 120% water allocation year in, year out. Now there is a water market open to farmers, environmentalists and government bidders, placing farmer focus squarely on maximising returns per megalitre of water.

Compared to the 1980s, farmers now have access to quicker maturing crop cultivars, for example Djakal soybeans are one week earlier than Stephens and two weeks earlier than Bowyer and Curringa; the wheat varieties H46 and Ventura are June sowing options and even later sowing is possible with high yielding malt barley varieties like Buloke. Local farmer results with chickpeas on beds have been encouraging. Cotton yields of 12 bales/ha and more in this district in 2006 is confirmation that another high value crop is available. Similarly azuki beans and mung beans, although price-volatile, are other summer options.

Equipment technology has advanced to the point that factory warranted wide-track configured machinery is available "off the shelf" to suit controlled traffic situations like permanent beds. Developments in direct-drill seeding equipment have largely overcome any barriers to achieving accurate seed placement even in very heavy stubbles. Earthmoving contractors can now create elaborate terraced, roof-topped bankless channel layouts that may be the most flexible system of all.

Figure 5: A prototype seeder that may eventually help farmers deal with the issue of stubble retention in intensive systems

Figure 6: Maize growing on a bankless channel layout

Conclusion

High value rotations are really sequences of crops strategically selected on the basis of profitability, water availability and market signals. The crop sequence itself is just one part of a system that also depends on advanced soil and irrigation management to realise higher returns. However, like most things in farming, they won't suit everyone. For instance the uptake of bed systems in the Murray Valley is very low. The high proportion of land area to irrigation allocation and relatively large farm size has led to farmers using bigger, more efficient broadacre machinery to minimise overheads.

Previous research and farmer experience demonstrates that these intensive cropping sequences ***are*** technically feasible. The Yanco experiment and later work at Coleambally showed that high value crops such as rice can be combined with contemporary irrigation systems to offer farmers the flexibility to change or skip a crop as market opportunities or production threats arise.

The Leeton experiment highlighted that one of the biggest production threats is the mis-timed planting of one crop impacting on the next. Do some farmers deal with this by investing in more machinery or labour? Will others be content to be less intensive but confident of achieving the finer management details that deliver above average yields?

The Irrigated Cropping Forum's new project will answer these questions and more – adding to the evolution of high value irrigated cropping systems in the southern Murray-Darling Basin.

Further information

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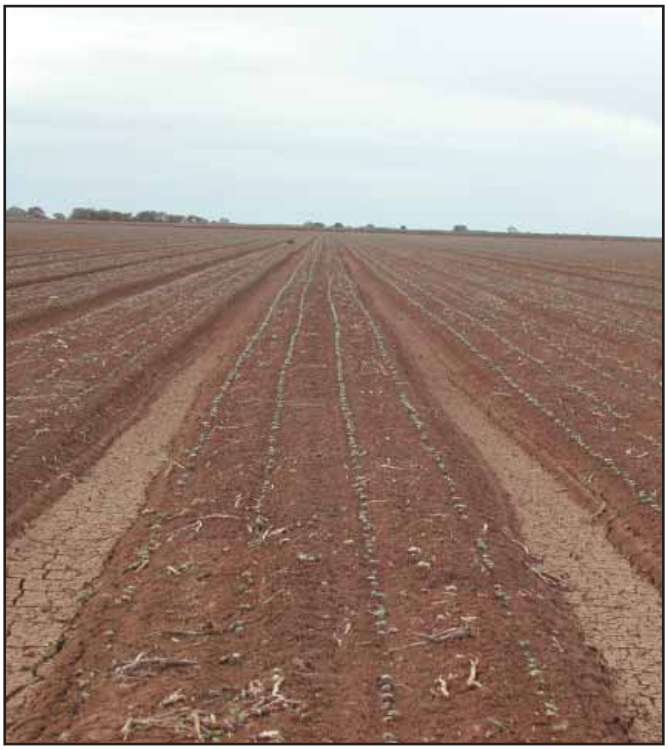

Figure 7: Cotton emerging on a raised bed layout